HM Government

TOGETHER FOR OUR PLANET

Net Zero Strategy: Build Back Greener

October 2021

Net Zero Strategy: Build Back Greener

Presented to Parliament pursuant to Section 14
of the Climate Change Act 2008

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ISBN 978-1-5286-2938-6

E02678428 10/21

Printed on paper containing 75% recycled fibre content minimum

Printed in the UK by HH Associates Ltd. on behalf of the Controller of
Her Majesty's Stationery Office

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Forewords

Foreword from the Prime Minister

Our strategy for net zero is to lead the world in ending our contribution to climate change, while turning this mission into the greatest opportunity for jobs and prosperity for our country since the industrial revolution.

Removing dirty fossil fuels from the global economy will lead to the creation of vast new global industries from offshore wind to electric vehicles and carbon capture and storage. By moving first and making the United Kingdom the birthplace of the Green Industrial Revolution we are building a defining competitive edge. Through our Ten Point Plan we have already attracted over £5.8 billion of new inward investment in just over ten months, and will create and support hundreds of thousands of new high skilled, high wage green jobs.

Over the last three decades we have already reduced our emissions by 44 per cent - while growing our economy by over 75 per cent – and this strategy sets out our plan for going the rest of the way. We will meet the global climate emergency but not with panicked, short-term or self-destructive measures as some have urged. Instead we will unleash the unique creative power of capitalism to drive the innovation that will bring down the costs of going green, so we make net zero a net win for people, for industry, for the UK and for the planet.

This strategy sets out how we will make historic transitions to remove carbon from our power, retire the internal combustion engine from our vehicles and start to phase out gas boilers from our homes. But it also shows how we will do this fairly by making carbon-free alternatives cheaper. We will make sure what you pay for green, clean electricity is competitive with carbon-laden gas, and with most of our electricity coming from the wind farms of the North Sea or state-of-the-art British nuclear reactors we will reduce our vulnerability to sudden price rises caused by fluctuating international fossil fuel markets.

The United Kingdom is not afraid to lead the charge towards global net zero at COP26, because history has never been made by those who sit at the back of the class hoping not to be called on. Indeed, as we set an example to the world by showing that reaching Net Zero is entirely possible, so the likes of China and Russia are following our lead with their own net zero targets, as prices tumble and green tech becomes the global norm.

For years, going green was inextricably bound up with a sense that we have to sacrifice the things we love. But this strategy shows how we can build back greener, without so much as a hair shirt in sight. In 2050, we will still be driving cars, flying planes and heating our homes, but our cars will be electric gliding silently around our cities, our planes will be zero emission allowing us to fly guilt-free, and our homes will be heated by cheap reliable power drawn from the winds of the North Sea. And everywhere you look, in every part of our United Kingdom, there will be jobs. Good jobs, green jobs, well-paid jobs, levelling up our country while squashing down our carbon emissions.

That is the clean and prosperous future that awaits every one of us as the UK leads the world in the race to net zero.

The Rt Hon Boris Johnson MP

Prime Minister

Foreword from the Secretary of State for Business, Energy & Industrial Strategy

Now is the time the world needs to go further and faster to tackle climate change. The UK is stepping up to that challenge. Here we set out our ambitious strategy – the first of its kind in the world of a major economy - to create new jobs, develop new industries with innovative new technologies and become a more energy secure nation with clean green British energy. At the same time we will reduce greenhouse gas emissions across the economy to reach net zero by 2050.

The UK has already taken bold steps towards net zero, including bringing forward the end of sales of new petrol and diesel cars to 2030. We have committed over £12 billion of domestic green investment since March 2020, and have doubled our International Climate Finance commitment to £11.6 billion between 2021-2025.

This Strategy sets out the next steps we will take to cut our emissions, seize green economic opportunities, and leverage further private investment into net zero. The policies and spending brought forward in the Net Zero Strategy mean that since the *Ten Point Plan* we have mobilised over £26 billion of government capital investment for the green industrial revolution. Along with regulations, this will support 190,000 jobs by 2025, and 440,000 jobs by 2030, and leverage up to £90 billion of private investment by 2030. This will put us on an ambitious path to meet our Sixth Carbon Budget and our Nationally Determined Contribution, cutting emissions by at least 68% by 2030 on 1990 levels, and reaching net zero by 2050.

We know economic growth and reducing emissions can go hand-in-hand. As we continue to build back better from the COVID-19 pandemic, we will fuel a Green Industrial Revolution, creating jobs and business growth opportunities, and establishing the UK as a global leader in the technologies to tackle climate change. We will deliver the commitments in the Prime Minister's *Ten Point Plan* and *Build Back Better: our plan for growth*, and go further to build a resilient economy and level up the UK.

The changes will have wider benefits for the public and businesses alike. We will all enjoy cleaner air, increased biodiversity and improved access to green spaces. We will see greater efficiency in the way we travel and heat our buildings, which will be better protected from more extreme weather events. We will also put consumers at the heart of this transition, helping them make their homes warmer, more efficient, and ensure that they pay a fair, affordable prices for their energy.

But we cannot tackle climate change alone. We will take a coordinated approach, working across local and national government, the Devolved Administrations, and with businesses and civil society organisations. And we will make it easier and fairer for individuals, businesses and households to decarbonise, so that our whole society can work together to reduce emissions. This strategy demonstrates how the UK is leading by example, with a clear plan for the future.

The Rt Hon Kwasi Kwarteng
Secretary of State for Business, Energy & Industrial Strategy

Executive Summary

What is net zero and why do we need to act?

From heating our homes to filling up our cars, burning fossil fuels releases the greenhouses gases that increase global temperatures. We are already seeing the effects here in the UK, with devastating floods in the West Midlands in January and torrential downpours submerging London Underground stations earlier this summer.

People are rightly concerned, with the latest IPCC report showing that if we fail to limit global warming to 1.5°C above pre-industrial levels, the floods and fires we have seen around the world this year will get more frequent and more fierce, crops will be more likely to fail, and sea levels will rise driving mass migration as millions are forced from their homes. Above 1.5°C we risk reaching climatic tipping points like the melting of arctic permafrost – releasing millennia of stored greenhouse gases – meaning we could lose control of our climate for good.

But the good news is that there is, still, a path to avoid catastrophic climate change. The science could not be clearer: by the middle of this century the world has to reduce emissions to as close to zero as possible, with the small amount of remaining emissions absorbed through natural carbon sinks like forests, and new technologies like carbon capture. If we can achieve this, global emissions of greenhouse gases will be 'net zero'.

Delivering this requires urgent global action, including ending coal fired power generation, retiring petrol and diesel engines from all cars, and halting deforestation. These are the steps that the UK is calling for at COP26, the global climate change talks in Glasgow next month.

Why should the UK act first?

Since 1990 the UK has almost halved our greenhouse gas emissions. Thanks to the efforts of successive governments, we are almost half-way to ending the UK's domestic contribution to man-made climate change, and in 2019 the UK became the first major economy in the world to legislate to finish the job with a binding target to reach net zero emissions by 2050.

We are proud to lead the world in ending our own contribution to climate change, not just because it is the right thing to do, but because we are determined to seize the unprecedented economic opportunity it brings. We want to build back better from the pandemic by building back greener and levelling up our country with new high skilled, high wage, sustainable jobs in every part of our United Kingdom.

Removing dirty fossil fuels will require the transformation of every sector of the global economy. It means no longer burning fossil fuels for power or heating; it means new ways of making concrete, cement, steel; it means the end of the petrol and diesel engine. These changes are already beginning to happen. Renewable energy is now the cheapest source of power across two-thirds of the globe. Clean, cheap power is already driving the decarbonisation of heavy industry around the world. Almost all major car companies are now developing or producing zero emissions vehicles as battery technology improves and costs reduce.

The question is whether the new clean machinery of the net zero future will be "made elsewhere" or "made in Britain". By moving first, the UK can get ahead of the pack and make the birthplace of the industrial revolution the home of the new Green Industrial Revolution.

Indeed, as we produce more of our own electricity – from wind farms in the North Sea and state-of-the-art British nuclear reactors – families will be much better protected from energy price spikes caused by volatile international fossil fuel markets. At the same time, by getting ahead of the curve in driving down the costs of the latest clean technology, more consumers will enjoy more efficient cars and heating systems sooner. Furthermore, by accelerating the deployment of cheap renewable power, and rolling out further energy efficiency measures, government decarbonisation policies mean that the average consumer energy bill in 2024 will likely be cheaper than it would otherwise have been.

We have shown the world that green and growth go hand in hand, and as a result other countries are already following our lead with their own net zero targets. When the UK was confirmed as host of COP26, less than 30% of global GDP was signed up to net zero or carbon neutrality targets. Today, in part again because of UK leadership, that figure is now over 80% – and rising.

The Ten Point Plan for a Green Industrial Revolution

Last year, the government kick-started its mission to get ahead of the pack, by setting out a *Ten Point Plan for a Green Industrial Revolution*. Our ambition was to create the conditions for the private sector to invest with confidence, unleashing the unique creativity of capitalism to generate and grow new green industries.

We mobilised £12 billion of government investment, shared some of the risks of pioneering new industries, and began to introduce regulations to assure industry of the future demand for green products – such as through our decision to end the sale of new petrol and diesel cars by 2030. We have also invested in the skills the British workforce will need for these new high wage green jobs, though our Lifetime Skills Guarantee, and we are helping investors to access capital for green projects by making the City of London the global centre of Green Finance.

At the Global Investment Summit in October 2021, the Prime Minister announced a package of 18 deals worth £9.7 billion that will support green growth and create an estimated 30,000 UK jobs. This is on top of the £5.8 billion already committed for sustainable projects since the Prime Minister launched his *Ten Point Plan* in November 2020. Now we need to build on this progress with a strategy to take us to net zero by 2050.

Our Strategy for Net Zero

Since 1990 the UK has reduced our greenhouse gas emissions by 44%, while growing our economy by over 75%. This strategy sets out this Government's long-term plan to finish the job and end the UK's domestic contribution to man-made climate change by 2050.

Although every study shows that the costs of inaction on climate are far greater, there will, of course, be costs to the investments needed to make this transition happen. So we will approach these with four key principles:

1. **We will work with the grain of consumer choice:** no one will be required to rip out their existing boiler or scrap their current car

2. **We will ensure the biggest polluters pay the most for the transition** through fair carbon pricing

3. **We will ensure that the most vulnerable are protected through Government support** in the form of energy bill discounts, energy efficiency upgrades, and more

4. **We will work with businesses to continue delivering deep cost reductions in low carbon tech** through support for the latest state of the art kit to bring down costs for consumers and deliver benefits for businesses.

This strategy is a long-term plan for a transition that will take place over the next three decades. Many of the policies in the strategy will be phased in over the next decade or longer. Given our success in decarbonisation to date we are confident in our approach, but this strategy does not intend to predict the exact shape of the British economy in 2050 and neither should it.

We are making the decisions that are needed now to drive investment into new low carbon technologies and as these develop and we test our approach, we will make informed decisions over how we scale to reach net zero by 2050.

We have consistently underestimated how quickly the costs of clean technology would fall to date. There will be many more decisions to take, and many more steps on the journey to the finish line. But this strategy marks the beginning of the end of the UK's domestic contribution to climate change.

What is in the Strategy?

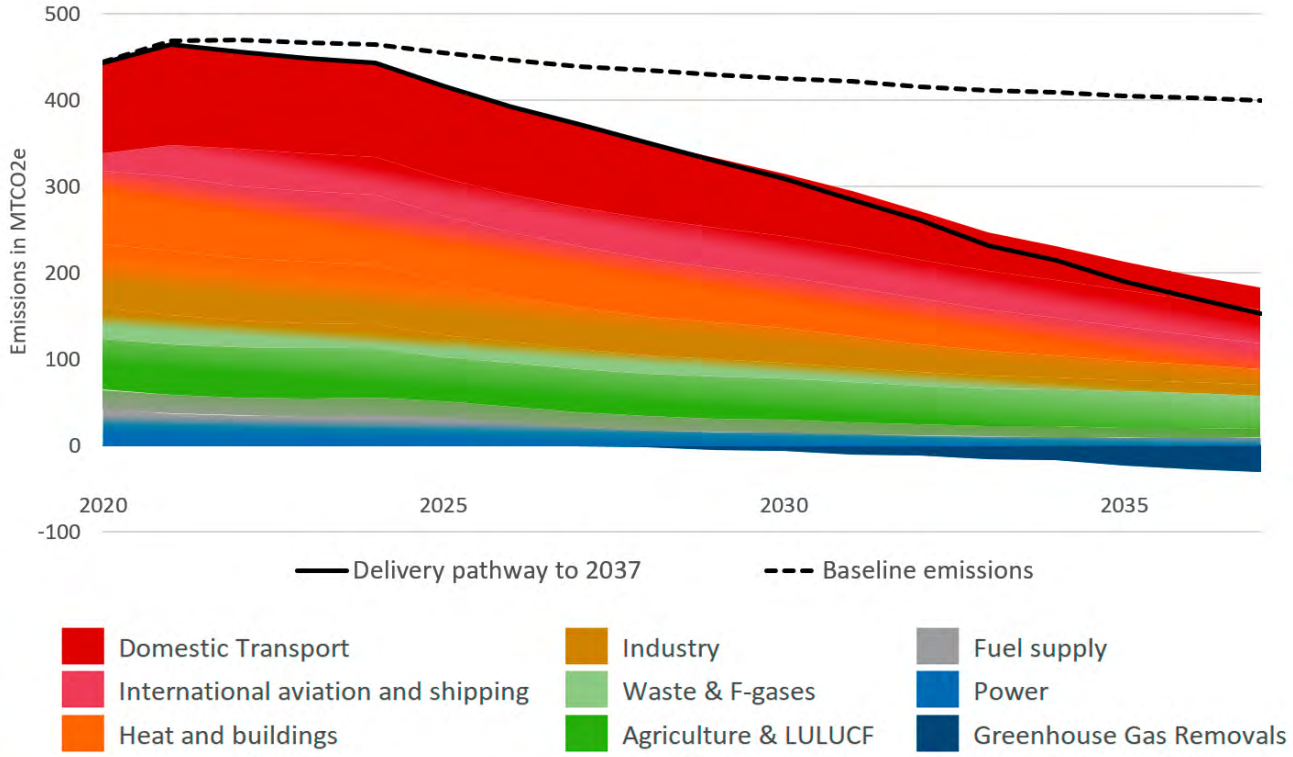
Ending the UK's contribution to climate change is a long-term shift, and the Climate Change Act breaks up this challenge into bitesize chunks – five-year long carbon budgets.

We have hit all of our carbon budgets to date. **This document sets out clear policies and proposals for keeping us on track for our coming carbon budgets, our ambitious Nationally Determined Contribution (NDC), and then sets out our vision for a decarbonised economy in 2050.**

Whilst there are a range of ways in which net zero could be achieved in the UK, we set out a delivery pathway showing indicative emissions reductions across sectors to meet our targets up to the sixth carbon budget (2033-2037). This is based on our current understanding of each sector's potential, and a whole system view of where abatement is most effective. But we must be adaptable over time, as innovation will increase our understanding of the challenges, bring forward new technologies and drive down the costs of existing ones.

The policies and spending brought forward in the Net Zero Strategy mean that since the *Ten Point Plan*, HMG has mobilised £26 billion of government capital investment for the green industrial revolution. Along with regulations, this will support up to 190,000 jobs by 2025, and up to 440,000 jobs by 2030, and leverage up to £90 billion of private investment by 2030.

Figure 1: Indicative delivery pathway to 2037 by sector



Source: BEIS Analysis (2021)

So this strategy sets out our plans for reducing emissions from each sector of our economy, while hoovering up any remaining emissions with greenhouse gas removals – either natural, like trees, or technological, using carbon capture. This is an historic plan. Taken together the transitions set out below for every sector of the UK economy meets Carbon Budgets 4 and 5, and puts us on the path for Carbon Budget 6 – and ultimately on course for net zero by 2050.

Power

The policies and proposals for power in the Net Zero Strategy will …

Support for up to 59,000 jobs in 2024 and up to 120,000 jobs in 2030	Start to mobilise additional public and private investment of £150-270 billion, in line with our 2037 delivery pathway	Fully decarbonise our power system by 2035

The net zero economy will be underpinned by cheap clean electricity, made in Britain. A clean, reliable power system is the foundation of a productive net zero economy as we electrify other sectors – so **we will fully decarbonise our power system by 2035**, subject to security of supply. Our power system will consist of abundant, cheap British renewables, cutting edge new nuclear power stations, and be underpinned by flexibility including storage, gas with CCS, hydrogen and ensure reliable power is always there at the flick of a switch. The transformation of the power sector will bring high skill, high wage job opportunities right across the UK.

Key policies:

- By 2035 the UK will be powered entirely by clean electricity, subject to security of supply.
- Secure a final investment decision on a large-scale nuclear plant by the end of this Parliament, and launch a new £120 million Future Nuclear Enabling Fund, retaining options for future nuclear technologies, including Small Modular Reactors, with a number of potential sites including Wylfa in North Wales.
- 40GW of offshore wind by 2030, with more onshore, solar, and other renewables – with a new approach to onshore and offshore electricity networks to incorporate new low carbon generation and demand in the most efficient manner that takes account of the needs of local communities like those in East Anglia.
- Moving towards 1GW of floating offshore wind by 2030 to put us at the forefront of this new technology that can utilise our North and Celtic Seas – backed by £380 million overall funding for our world-leading offshore wind sector.
- Deployment of new flexibility measures including storage to help smooth out future price spikes.

Fuel Supply & Hydrogen

The policies and proposals for fuel supply and hydrogen in the Net Zero Strategy will…

Support up to 10,000 jobs in 2030 in fuel supply	Start to mobilise additional public and private investment of £20-30 billion, in line with our 2037 delivery pathway	Deliver 5 GW of hydrogen production capacity by 2030, whilst halving emissions from oil and gas

While electricity will be the primary source of energy, we cannot rely on it alone. Many sectors require low carbon energy, including those where electrification is not a viable option, making the supply of cleaner fuels essential to achieving net zero. Building on commitments in the *North Sea Transition Deal*, we will significantly reduce emissions from traditional oil and gas fuel supplies, whilst scaling-up the production of low carbon alternatives such as hydrogen and biofuels. Current gas prices spikes underline the need to get off hydrocarbons as quickly as possible, but we will manage the transition in a way that protects jobs and investment, uses existing infrastructure, maintains security of supply, and minimises environmental impacts.

Key policies:

- We have set up the Industrial Decarbonisation and Hydrogen Revenue Support (IDHRS) scheme to fund our new hydrogen and industrial carbon capture business models. We will be providing up to £140 million to establish the scheme, including up to £100 million to award contracts of up to 250MW of electrolytic hydrogen production capacity in 2023 with further allocation in 2024.
- Introducing a new climate compatibility checkpoint for future licensing on the UK Continental Shelf and regulating the oil and gas sector in a way that minimises greenhouse gases through the revised Oil and Gas Authority strategy.

Industry

The policies and proposals for industry in the Net Zero Strategy will…

Support up to 54,000 jobs in 2030 in industry	Start to mobilise additional public and private investment of at least £14 billion in industry, in line with our 2037 delivery pathway	Deliver four carbon capture usage and storage (CCUS) clusters, capturing 20-30 MtCO2 across the economy, including 6 $MtCO_2$ of industrial emissions, per year by 2030

We will decarbonise industry in line with our net zero goals whilst simultaneously transforming our industrial heartlands by attracting inward investment, future-proofing businesses, and securing high wage, high skill jobs. We will do this by supporting industry to switch to cleaner fuels; helping them improve their resource and energy efficiency, and through fair carbon pricing to drive deep decarbonisation of industry. Growing new industries in low carbon hydrogen alongside CCUS and renewable energy will put our industrial 'SuperPlaces' at the forefront of technological development – accelerating decarbonisation in 'clusters', which account for approximately half of the UK's industrial emissions. These clusters could have the opportunity to access support under government's CCUS programme, which includes the £1 billion CCS Infrastructure Fund and revenue support mechanisms.

Key policies:

- Following the Phase 1 of the Cluster Sequencing process, the Hynet and East Coast Clusters, will act as economic hubs for green jobs in line with our ambition to capture 20-30 MtCO2 per year by 2030. This puts Teesside and the Humber, Merseyside and North Wales, along with the North East of Scotland as a reserve cluster, among the potential early SuperPlaces which will be transformed over the next decade.
- Future-proofing industrial sectors, and the communities they employ through the £315 million Industrial Energy Transformation Fund (IETF), (£289 million for England, Wales and Northern Ireland, £26 million for Scotland).
- Incentivise cost-effective abatement in industry at the pace and scale required to deliver net zero, through the UK ETS by consulting on a net zero consistent UK ETS cap (in partnership with the Devolved Administrations).

Heat and Buildings

The policies and proposals for heat and buildings in the Net Zero Strategy will…

Support up to 100,000 jobs n the middle of the 2020s and up to 175,000 in 2030	Start to mobilise additional public and private investment of approximately £200 billion, in line with our 2037 delivery pathway	Set a path to all new heating appliances in homes and workplaces from 2035 being low carbon

Reaching net zero means tackling all sources of emissions – and heating for homes and workspaces makes up almost a third of all UK carbon emissions. So we will improve the energy efficiency of housing and non-domestic properties across the UK, ensuring they require less energy to heat, making them cheaper to run and more comfortable to live and work in while reducing our dependence on imported energy. We are setting the ambition that, by 2035, once costs have come down, all new heating appliances installed in homes and workplaces will be low-carbon technologies, like electric heat pumps or hydrogen boilers. We will take a decision in 2026 on the role of hydrogen heating. Crucially, this will be a gradual transition that works with the grain of consumer choice. But the costs of low carbon technology can fall quickly – working with industry, we expect a heat pump to be as cheap to buy and run as a gas boiler this decade. We want to reduce electricity costs so when the current gas spike subsides we will look at options to shift or rebalance energy levies (such as RO and FiTs) and obligations (such ECO) away from electricity to gas over this decade. This will include looking at options to expand carbon pricing and remove costs from electricity bills while ensuring that we continue to limit any impact on bills overall. We know that in the long run, green products are more efficient and cheaper, and we are putting fairness and affordability at the heart of our approach.

Key policies:

- An ambition that by 2035, no new gas boilers will be sold.
- A new £450 million three-year Boiler Upgrade Scheme will see households offered grants of up to £5,000 for low-carbon heating systems so they cost the same as a gas boiler now.
- A new £60 million Heat Pump Ready programme that will provide funding for pioneering heat pump technologies and will support the government's target of 600,000 installations a year by 2028.
- Delivering cheaper electricity by rebalancing of policy costs from electricity bills to gas bills this decade.

- Further funding for the Social Housing Decarbonisation Scheme and Home Upgrade Grants, investing £1.75 billion. Additional funding of £1.425 billion for Public Sector Decarbonisation, with the aim of reducing emissions from public sector buildings by 75% by 2037.
- Launching a Hydrogen Village trial to inform a decision on the role of hydrogen in the heating system by 2026.

Transport

The policies and proposals for transport in the Net Zero Strategy will …

Support for up to 22,000 jobs in 2024 and up to 74,000 jobs in 2030	Start to mobilise additional public and private investment of around £220 billion, in line with our 2037 delivery pathway	Remove all road emissions at the tailpipe and kickstart zero emissions international travel

We will transform our cities and towns with greener, faster and more efficient transport. Our streets will be cleaner and people healthier from breathing cleaner air, walking and cycling more. Our zero emissions vehicle (ZEV) mandate will guarantee greater number of zero emission vehicles on our roads, unlocking the transformation of our road transport. Additional funding will support our automotive sector to stay at the cutting edge and capture jobs of the future. Significant new investment in vehicle grants and electric vehicle infrastructure will ensure that we see even more green vans delivering our goods and big improvements in local public chargepoint provision. We will increase the share of journeys taken by public transport, cycling and walking, electrifying more railway lines, investing £3 billion to transform bus services and £2 billion for cycling. We will build on our strong maritime heritage and the success of the Clean Maritime Demonstration Competition to deliver a more ambitious multi-year programme for the sector. Setting out an ambitious position on SAF will set us on a path to decarbonise this challenging sector. Accelerating the decarbonisation of transport will save lives and significantly reduce noise, making our urban centres more enjoyable places to live.

Key policies:

- A zero emission vehicle mandate to improve consumer choice and ensure we maximise the economic benefit from this transition by giving a clear signal to investors. This will deliver on our 2030 commitment to end the sale of new petrol and diesel cars, and 2035 commitment that all cars must be fully zero emissions capable.
- Further funding of £620 million for zero emission vehicle grants and EV Infrastructure, including further funding for local EV Infrastructure, with a focus on local on street residential charging.
- Allocating a further £350 million of our up to £1 billion Automotive Transformation Fund (ATF) to support the electrification of UK vehicles and their supply chains.
- Building on the success of our £20 million zero emission road freight trials, we will expand these to trial three zero emission HGV technologies at scale on UK roads to determine their operational benefits, as well as their infrastructure needs.

- £2 billion investment which will help enable half of journeys in towns and cities to be cycled or walked by 2030.
- £3 billion to create integrated bus networks, more frequent services and bus lanes to speed journeys.
- Transformation of local transport systems, with 4,000 new zero emission buses and the infrastructure to support them, and a net zero rail network by 2050, with the ambition to remove all diesel-only trains by 2040.
- Building on the success of the Clean Maritime Demonstration Competition, we will be extending this to a multi-year programme, delivering real-world demonstrations and technology trials of clean maritime vessels and infrastructure to decarbonise the maritime sector. This is part of our commitment to a UK Shipping Office for Reducing Emissions.
- Significant investment in rail electrification and city rapid transit systems.
- Aim to become a world-leader in zero emission flight and kick-starting the commercialisation of the UK sustainable aviation fuel so people can fly, and connect without guilt. Our ambition is to enable delivery of 10% SAF by 2030 and will be supporting UK industry with £180 million funding for the development of SAF plants.

Natural Resources, waste and fluorinated gases

The policies and proposals for natural resources, waste, and fluorinated gases in the Net Zero Strategy will…

New employment opportunities across the UK. Afforestation in England could support up to 1,900 jobs in 2024 and 2,000 jobs in 2030	Start to mobilise additional public and private investment of approximately £30 billion, in line with our 2037 delivery pathway	Treble woodland creation rates in England, contributing to the UK's overall target of increasing planting rates to 30,000 hectares per year by the end of this Parliament

Halting climate change and protecting the natural world are two sides of the same coin, so we will restore our countryside to reduce emissions, sequester carbon and build our resilience to climate change at the same time. We will support farmers to implement a range of low carbon farming practices that can help increase productivity and enable more efficient use of land, such as through agroforestry. We will increase tree planting to sequester carbon, and protect and restore our peatlands. As part of reforms to the resources and waste system, we also will move towards a circular economy, improve resource efficiency, and achieve near elimination of biodegradable waste to landfill. We will continue to phase down the use of F-gases in line with domestic regulations and international commitments.

Key policies:

- Supporting low-carbon farming and agricultural innovation through the Farming Investment Fund and the Farming Innovation Programme to invest in equipment, technology, and infrastructure to improve profitability, benefit the environment and support emissions reductions.
- We will boost the existing £640 million Nature for Climate Fund with a further £124 million of new money, ensuring total spend of more than £750 million by 2025 on peat restoration, woodland creation and management – above and beyond what was promised in the manifesto. This will enable more opportunities for farmers and landowners to support Net Zero through land use change.
- Restoring approximately 280,000 hectares of peat in England by 2050 and trebling woodland creation rates in England, contributing to the UK's overall target of increasing planting rates to 30,000 hectares per year by the end of the Parliament.
- £75 million on net zero related R&D across Natural Resources, Waste & F-gases, to inform our pathway to 2037.

- To support our commitment to explore options for the near elimination of biodegradable municipal waste to landfill from 2028, we are bringing forward £295 million of capital funding which will allow local authorities in England to prepare to implement free separate food waste collections for all households from 2025.

Greenhouse Gas Removals

The policies and proposals for GGRs in the Net Zero Strategy will provide…

New, highly skilled, jobs in our industrial heartlands	Start to mobilise additional public and private investment of around £20 billion, in line with our 2037 delivery pathway	An ambition to deploy at least 5 $MtCO_2$/year of engineered GGRs by 2030.

Our most important step to achieving net zero is to take ambitious decarbonisation measures across society. However, greenhouse gas removals (GGRs) will also play a critical role in balancing residual emissions from the hardest to decarbonise sectors such as aviation, agriculture, and heavy industry. Our innovation-led approach position the UK as a global leader in this rapidly developing sector.

Government intervention in the short term will support early commercial deployment of GGRs, with an ambition to move towards a market-based framework for GGRs. This will support our delivery of net zero emissions and position us to export our skills and expertise, capitalising on economic opportunities for the UK and supporting the global shift to net zero.

Key policies:

- Delivering £100 million of investment in GGR innovation could enable further deployment of GGRs, which in turn will leverage private investment and demand for transferrable engineering expertise from the UK's oil and gas sector.
- Explore options for regulatory oversight to provide robust monitoring, reporting and verification (MRV) of GGRs, following the recommendations of the BEIS-led MRV Task & Finish Group involving experts from industry and academia.

Supporting the transition with cross-cutting action

We will maximise the opportunities of this transition, and make sure we are geared up to deliver these changes by also taking cross-cutting action. As the host nation for COP26 in Glasgow this year, we will use our global platform to continue to urge countries to set targets to get to net zero by 2050, and more ambitious 2030 emissions reduction targets to get us there. We will back innovation and our world-leading green finance sector. We will support each stage of the innovation chain to drive down costs and bring through key technologies and ideas to meet net zero. We will work with the private sector to leverage private investment to provide the finance needed, while providing the conditions for green finance to flourish.

We will put consumers at the heart of the transition and our goal is to make choosing green options significantly easier, cheaper, and more rewarding. We will back training and skills, supporting workers to retrain and upskill and build low carbon industries with strong UK supply chains that are resilient to changes. We will also take a place-based approach to net zero, working with local government to ensure that all local areas have the capability and capacity for net zero delivery as we level up the country. And Government is leading the way – embedding climate into our policy and spending decisions, increasing the transparency of our progress on climate goals, and providing funding to drive ambitious emissions reductions in schools and hospitals.

Key policies:

- Deliver at least £1.5 billion of funding to support net zero innovation projects.
- Use the UK Infrastructure Bank (UKIB) to crowd in private finance, support more than £40 billion of investment, and pull through low carbon technologies and sectors to maturity and scale.
- Introduce a new Sustainability Disclosures Regime, including mandatory climate related financial disclosures and a UK green taxonomy.
- Reform the skills system so that training providers, employers and learners are incentivised and equipped to play their part in delivering the transition to net zero.
- Publish an annual progress update against a set of key indicators for achieving our climate goals.

Delivering the Prime Minister's Ten Point Plan

In the past year, we have already taken important action on climate change, delivering on the commitments in the Prime Minister's Ten Point Plan.

***56,000 jobs** have been protected and created over the last ten months, since the publication of the Prime Minister's Ten Point Plan and wider green agenda - with some already on line and others set to come on line over the coming decade*

We committed to…	Since then we have…
Point 1: Advancing Offshore Wind, *including:* – 40GW of offshore wind by 2030 including 1GW of floating wind (wind turbines generating electricity in water depths) – £160 million into modern ports and manufacturing infrastructure – The Offshore Transmission Network Review	– Supported manufacturers via government investment schemes. Six manufacturers have already announced major investments in the UK offshore wind sectors and delivering up to 3,600 jobs by 2030. – Built our Offshore Wind capacity to 10.5GW, enough in 2020 to power 4.5 trillion LED light bulbs. This increased our share of electricity generated by Offshore Wind from 1% to 13% over the last decade. – Kicked off the biggest-ever round of our flagship renewable energy scheme for low carbon electricity (Contract for Difference) with £200 million for offshore wind projects and £24m for floating offshore wind. – Launched a £17.5 million competition to support innovative floating wind ideas from industry and joined the ORE Catapult's FOW Centre of Excellence, contributing £2 million. – Leveraged over £1.5 billion investment into our offshore wind industry, following the £160 million to upgrade ports and infrastructure. – Published the *Offshore Transmission Network Review*, setting out two initial policy consultations to move to a coordinated approach for both in-flight and future offshore wind projects.
Point 2: Driving the Growth of Low Carbon Hydrogen, *including:* – An ambition for 5GW of low carbon hydrogen production capacity by 2030 – £240 million Net Zero Hydrogen Fund – Hydrogen trials to test use of hydrogen in heating	– Published the *Hydrogen Strategy*, setting out our comprehensive approach to growing the UK hydrogen economy. – Commenced an allocation process for electrolytic hydrogen in 2022 to award up to 100MW of contracts in 2023 and up to 400MW of contracts in 2024 and announcing a funding envelope in 2022 that will enable us to award the first contracts to CCUS-enabled hydrogen from 2023 through the Cluster Sequencing process, to deliver up to 1GW of CCUS-enabled hydrogen. – Following our consultation on a proposed hydrogen business model, design of the £240 million Net Zero Hydrogen Fund and on a UK low carbon hydrogen standard. – Invested £3 million to kick start the Tees Valley hydrogen transport hub, which is building early collaborations and operational learning. – Announced a £60 million competition to fund projects to develop innovative low carbon hydrogen supply solutions. – Started preparations for a hydrogen heating neighbourhood trial in Levenmouth, Fife led by SGN following funding awards by Ofgem and Scottish Government.

We committed to…	Since then we have…
Point 3: Delivering New and Advanced Nuclear Power, *including:* – Pursuing large-scale nuclear projects, subject to value for money – Legislating for a new financing model for nuclear projects – £385 million Advanced Nuclear Fund to enable up to £215 million into Small Modular Reactors – £170 million for a R&D programme on Advanced Modular Reactors	– Announced our aim to bring at least one large-scale nuclear project to the point of Final Investment Decision by the end of this Parliament, subject to value for money and all relevant approvals. Entered into negotiations with the developer of Sizewell C power station in December 2020. – Launched a Call for Evidence on Government's preference to explore the potential of High Temperature Gas Reactors (HTGRs) to enable an AMR demonstration by the early 2030s.
Point 4: Accelerating the Shift to Zero Emission Vehicles, *including:* – End the sale of new pure petrol and diesel cars and vans by 2030 and consult on phase out for diesel HGVs – £1 billion to support electrification of UK vehicles and their supply chains – £1.3 billion to accelerate the roll-out of charging infrastructure – Publish a Green Paper in 2021 on the UK's post-EU emissions regulation	– Announced we will introduce a ZEV mandate to deliver our end of sales dates for new petrol and diesel cars and vans. – Announced funding for the UK's first large-scale gigafactory as part of the Automotive Transformation Fund. The investor has committed to creating 1,000 jobs which will be realised during the period to 2025/26 as the facility is built and becomes operational. – Secured an additional 950 jobs through other automotive projects, for a total of 1,950 jobs to be realised through to 2025/26. – Built on existing successful projects, such as the Advanced Propulsion Centre - according to participating companies, APC projects agreed this year will support up to 5,200 direct jobs. – Seen increased demand for ZEVs – industry figures state that nearly one in ten of all new cars sold so far this year in the UK is fully electric and over 650,000 plug-in cars have been registered in the UK since 2010. – For this financial year, committed £70 million to roll out home, on-street and workplace chargepoints. – 70% of motorway service areas now have plans to install at least 6 high-powered chargers by 2023. – Announced the winners of the £20 million Zero Emission Road Freight Trials – projects that will help to design and develop cost-effective, zero emission HGVs and refuelling infrastructure. – Consulted on the phase out of non-zero emission HGVs.

We committed to…	Since then we have…
Point 5: Green Public Transport, Cycling and Walking, *including:* – £120 million to begin introducing at least 4,000 zero emission buses – Billions of pounds in enhancements and renewals of the rail network – £5 billion to support buses, cycling and walking	– Launched the National Bus Strategy and a consultation on phase out of new non-zero emission buses and the £120 million Zero Emission Bus Regional Area (ZEBRA) scheme to support local transport authorities outside London. – Supported Coventry to become UK's first all-electric bus city, with £50 million to fund up to 300 electric buses and charging infrastructure. – Committed £17.5 billion in the November 2020 Spending Review in capital funding for renewals, upgrades, and enhancements of the existing rail network up to 2024. – Delivered more than 300 walking and cycling schemes.
Point 6: Jet Zero and Green Ships, *including:* – A Jet Zero Council – £15 million to support production of Sustainable Aviation Fuels – £20 million for the Clean Maritime Demonstration Programme	– Consulted on our proposals for reaching net zero aviation by 2050 and following a consultation on a UK Sustainable Aviation Fuels (SAF) mandate, confirmed our ambition for it to enable delivery of 10% SAF by 2030 , and we will make £180 million available to support the development of the UK SAF industry. – Announced the shortlist for the £15 million Green Fuels, Green Skies competition, to support UK pioneers in Sustainable Aviation Fuels. – Co-invested £150 million per year through the Aerospace Technology Institute to support greener aircraft technology like Rolls-Royce's next gen UltraFan jet engine which aims to cut emissions by 25% and ZeroAvia's zero-emission hydrogen-propulsion system. – Allocated up to £23 million of match-funding to 55 projects through the Clean Maritime Demonstration Competition to support the development of zero emission technologies and greener ports.
Point 7: Greener Buildings, *including*: – Ambition to install 600,000 heat pumps per year by 2028 – Energy efficiency funding, including the Public Sector Decarbonisation Scheme and Social Housing Decarbonisation Fund – Strengthened energy efficiency requirements for private sector landlords	– Supported approximately 45,000 jobs in greener buildings in the first year since the Ten Point Plan was launched.[1] – Announced that we will tighten Minimum Energy Efficiency Standards to ensure that landlords can no longer let properties covered by the Domestic Minimum Energy Efficiency Standards Regulations if they have an EPC rating below E, unless they have a valid exemption in place. – Allocated £1 billion funds from the Public Sector Decarbonisation Scheme, supporting up to 30,000 jobs.[2] – Awarded £62 million to 19 projects in the Social Housing Decarbonisation Fund Demonstrator, with over 2,300 homes in the process of being improved.

We committed to…	Since then we have…
Point 8: Investing in Carbon Capture, Usage and Storage, *including* – Commitment for two industrial clusters by mid 2020s, and an aim for four sites by 2030, capturing up to 10Mt CO2 emissions per year – £1 billion CCUS Infrastructure Fund	– We have set up the Industrial Decarbonisation and Hydrogen Revenue Support (IDHRS) scheme, providing up to up to £140 million to fund our new hydrogen and industrial carbon capture business models. – Announced £19.5 million of grant funding for projects developing novel CCUS technology and processes that reduce the cost of deployment. – Kicked off the process to decide the first carbon capture cluster locations in our industrial heartlands. – Published details of the design of funding mechanisms, including the business model for CO_2 transport and storage, industrial CCUS, power CCUS, as well as the CCS Infrastructure Fund.
Point 9: Protecting Our Natural Environment, *including* – £5.2 billion for flood and coastal defences – New National Parks and Areas of Outstanding Natural Beauty – £40 million second round for the Green Recovery Challenge Fund – Establish 10 long-term Landscape Recovery projects over the next four years	– Supported an estimated 850 jobs in environmental protection and enhancement. – Launched the floods investment programme that is on track to better protect 336,000 properties from flooding. – Natural England has set out plans to start the process to designate four new areas of outstanding natural beauty - Yorkshire Wolds AONB, Cheshire Sandstone Ridge AONB, an extension to the Surrey Hills AONB, and an extension to the Chilterns AONB. – Announced 90 projects awarded grants under round 2 of the £80 million Green Recovery Challenge Fund (GRCF). Across all 159 projects, the GRCF is set to plant almost 1 million trees and create and retain up to 2,500 jobs. – Held three Landscape Recovery market engagement events and, subject to feedback, we aim to open applications for the first wave of pilot projects later this year. – Launched several schemes under the Nature for Climate Fund to expand our pipeline of tree planting and peatland restoration projects in England, including the new England Woodland Creation Offer and Tree Production Innovation Fund.

Point 10: Green Finance and Innovation, *including*
– £1 billion Net Zero Innovation Portfolio (NZIP), including £100 million for Direct Air Capture and other Greenhouse Gas Removal (GGR) technologies
– UK's first Sovereign Green Bond
– Green Jobs Taskforce
	– Launched the Net Zero Innovation Portfoliow, providing funding for low-carbon technologies and systems across the areas of the *10 Point Plan*, including:
	  – Up to £68 million across two competition streams for Longer Duration Energy Storage Demonstration.
	  – Funding for the first phase of GGR studies, which could remove between 100 and 1,000 tonnes of CO_2e per year in 2025.
	– Issued £10 billion Sovereign Green Bond, to raise money for green government projects like zero-emission buses, offshore wind, and decarbonising homes.
	– Launched the Green Jobs Taskforce in November 2020, which reported 15 recommendations in July 2021.

Endnotes

[1] Estimate based on internal HMG analysis.

[2] This figure is already included in the headline 45,000 figure for greener buildings.

Why Net Zero

Chapter 1

Levelling up the country, ending our domestic contribution to climate change, and leading the world to a greener, more sustainable future

The case for action

1. We are at a crossroads in our history. As we recover from the impact of the pandemic on our lives and livelihoods, we know that it will not be enough to go back to the way things were before. The science is clear, we know that human activity is changing our climate and that this will have a devasting impact on human lives, the economy, and the natural world – ranging from the extinction of some species and the melting of ice caps to extreme weather patterns threatening our homes, businesses, and communities.[1] As the latest report by the Intergovernmental Panel on Climate Change (IPCC) shows,[2] this is no longer a challenge for tomorrow: we are already seeing the impacts today with increased incidence of events such as extreme heat, floods, and wildfires across the globe. We need to act urgently and reduce emissions globally to limit further global warming. The landmark 2015 Paris Agreement agreed to hold the increase in the global average temperature to well below 2°C above pre-industrial levels, and to pursue efforts to limit it to 1.5°C.

The UK's net zero target

The UK was the first major economy to create a legally binding target to bring greenhouse gas emissions to net zero by 2050. This target was set considering the latest scientific evidence and was recommended by the Climate Change Committee (CCC), the UK's independent climate advisory body. The net zero target also responds to the overwhelming public support for acting on climate change. In recent surveys of the UK public, 80% of participants expressed concern about climate change.[3]

Government is committed to ambitious decarbonisation measures across society. However, we know that this does not mean emissions will drop to *absolute* zero by 2050 – we acknowledge that sectors such as industry, agriculture, and aviation are difficult to decarbonise completely. Greenhouse gas removals (GGR), like trees and carbon capture and storage technology, are therefore essential to compensate for the residual emissions arising from these hard to decarbonise sectors, so we can reach *net* zero by 2050.

2. The sooner we act on climate change the lower the costs will be. Globally, the costs of failing to get climate change under control would far exceed the costs of bringing greenhouse gas emissions down to net zero. The Office for Budget Responsibility concluded that there could be significant fiscal benefits from early action to transition to net zero, meaning the costs will be lower than if we delay.[4] Delaying action would only serve to put future generations at risk of crossing critical thresholds resulting in severe and irreversible changes to the planet, the environment, and human society. On the other hand, early and ambitious action would help protect lives and livelihoods, while maximising the co-benefits for people, society, the environment, and the economy.[5] As part of the transition to net zero emissions, we will transform our energy system away from fossil fuels to low carbon sources of energy, such as renewable electricity generated in the UK. This will ensure sustainable and affordable energy supplies and protect consumers by reducing our exposure to volatile international fossil fuel markets which have caused the recent spike in gas prices.

3. The UK has long led the way in tackling climate change, and immediate action to reduce emissions brings enormous economic opportunities to revitalise our economy and deliver on our priority to level up the country. Across the globe, as governments, people and businesses rise to this challenge, a growing global green economy has the potential to create millions of new jobs. We are uniquely placed to seize this once-in-a generation opportunity and deliver a transition to net zero that has the potential to create thousands of jobs in every part of the UK.

4. We must, therefore, build back better. Our vision, building on the Prime Minister's *Ten Point Plan for a Green Industrial Revolution*, is to level up our country with new green jobs, end our contribution to climate change, and reverse the decline of our natural environment, leading the world to a greener, more sustainable future.

Plan for Growth and green sector vision

This strategy sets out how we will build on the Prime Minister's *Ten Point Plan* with our vision to create new jobs and net zero industries as we meet our climate targets. In turn, this will support levelling up the country, and put the UK at the forefront of the global green markets.

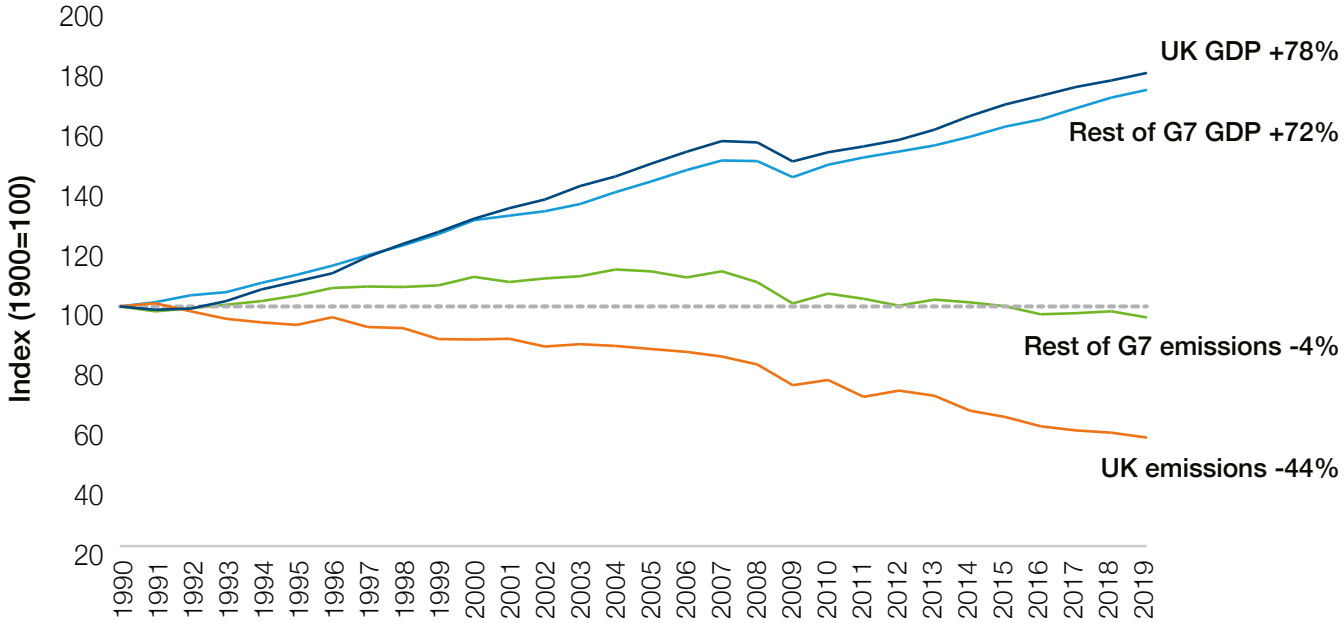
We are laying the foundations for businesses to invest in the UK's green economy, taking action to ensure we have the right skills to deliver a green industrial revolution and committing to work with industry to develop sector and supply chain action plans in areas where the UK has an economic advantage.

Build Back Better: Our Plan for Growth sets out the Government's commitment to supporting future growth sectors based on the UK's comparative advantage and growth potential, and commits to publishing sector visions across these sectors. This strategy articulates our vision for the green economy. We will build on this with more detail in further Sector and Supply Chain Development Plans – such as the CCUS supply chains roadmap published earlier this year, and the Hydrogen Sector Development Action Plan which we will publish in 2022.

Driving a green industrial revolution and levelling up the UK

5. The UK has long proved that tackling climate change and delivering economic growth can go hand in hand. Between 1990 and 2019, we cut emissions faster than any other G7 country, a 44% reduction.[6] We achieved this whilst growing our economy by 78%.[7] Our latest official estimates show that 410,000 people work in the UK's low carbon economy and its supply chains across the country, with an estimated turnover of £42.6 billion in 2019.[8] These numbers are even higher once we account for the jobs and economic activity supporting broader environmental policies such as climate adaptation and biodiversity.

Figure 2: UK vs Rest of G7 GDP and GHG Emissions[9]



Source: The World Bank, UNFCCC National Inventory Submissions, ONS, BEIS Greenhouse Gas Inventory.

6. As the world moves to tackle climate change, new opportunities will arise for UK companies in domestic and international markets. Updated analysis, based on the BEIS Energy Innovation Needs Assessment (EINA) suggests key net zero aligned sectors in the UK could contribute up to £60 billion of gross value added (GVA) a year by 2050.[10]

7. We have immediate opportunities to capitalise on our core strengths: the largest market for offshore wind in the world, a world-class oil and gas sector, and the City of London is long established as a leader in green finance.[11] In the long term, evidence from the Energy Innovation Needs Assessment (2019) and subsequent analysis, point to domestic and export opportunities for the UK in electric vehicle technologies and manufacturing, the next generation of offshore wind (including new approaches such as floating offshore wind), carbon capture, usage and storage (CCUS), low carbon hydrogen, smart energy systems and storage, and direct air carbon capture and storage (DACCS).

8. The opportunities for British innovation, expertise, and products will not just be confined to these shores. The value of goods and services exported by UK low carbon and renewable energy businesses exceeds £7 billion.[12] The net zero transition will create new growth opportunities for UK based companies, such as Livingstone based FoundOcean and Trelleborg's North West England based operation, who won contracts with the support of UK Export Finance (UKEF) to supply Taiwan's growing offshore wind market.

9. These opportunities show that net zero and levelling up go hand in hand. Delivering net zero allows us to boost living standards by supporting jobs and attracting investment in the green industries of the future, which can be in areas that need this the most. Crucially, delivering net zero also involves supporting workers employed in high carbon industries that will be affected by the transition, by giving them the skills they need to make the most of new opportunities in the green economy. But the link between net zero and levelling up is wider than just the economy, net zero can deliver wider benefits for people and communities across the UK by helping spread opportunity and restore pride in place.

10. We are already taking action to make the most of these opportunities. We have embedded a net zero principle in our levelling up funding initiatives, such as the Levelling Up Fund and the Towns Fund, so that these schemes can contribute to meeting our net zero targets and help places to reduce their carbon impacts. Later this year, we will publish a Levelling Up White Paper. This will build on the actions the government is already taking to both deliver net zero and level up across the country, including the ones set out in this strategy, and set out new interventions to improve livelihoods and drive economic growth in all parts of the UK.

Maximising opportunities after leaving the EU

Following the UK's departure from the European Union in January 2020 the UK now has the flexibility to determine our own decarbonisation pathways to 2050, in a way that fully utilises the unique strengths and opportunities of UK diplomacy, industry and innovation.

Since leaving the EU, the UK has built on our climate leadership, demonstrating an independent and ambitious approach to meeting our 2050 target:

- Setting an ambitious Nationally Determined Contribution (NDC) under the Paris Agreement, committing to the fastest rate of reducing emissions on 1990 levels of any major economy.
- Setting out ambitious plans with bold policy action across key sectors of the economy, such as the Prime Minister's *Ten Point Plan for a Green Industrial Revolution*, the *Energy White Paper*, *North Sea Transition Deal*, *Industrial Decarbonisation Strategy*, *Transport Decarbonisation Plan*, *Hydrogen Strategy*, and the *Heat and Buildings Strategy.*
- Establishing a UK Emissions Trading Scheme (UK ETS), to replace the UK's participation in the EU ETS, that demonstrates the UK's commitment to carbon pricing as an effective tool that will help fulfil our climate change objectives. The UK ETS will be aligned to our net zero target, giving industry the certainty they need to invest in low carbon technologies.

Supporting green jobs across the UK

11. Last year, the Prime Minister set out his *Ten Point Plan for a Green Industrial Revolution*, laying the foundations for a green economic recovery from the impact of COVID-19, outlining how we will level up the country and put the UK at the forefront of the growing global green economy.

12. This strategy builds upon that approach: the package of policies will support up to 190,000 jobs by the middle of the 2020s and up to 440,000 jobs in 2030. These jobs will contribute to our wider ambition of 2 million green jobs by 2030, which also factor in employment that contributes to other environmental goals. Updated analysis suggests that around 56,000 green jobs have been secured or created across the UK economy, with some being already online and others in the pipeline over the next decade.

13. There will be opportunities for each region of the UK. For example, we are supporting new investment in hydrogen and CCUS into industrial clusters across the UK. We are also driving the electrification of vehicles impacting manufacturing and supply chains in Wales, the Midlands and North East England, developing Gigafactories in the UK, accelerating the roll out of charging infrastructure across the UK, and supporting roll-out of zero emission buses which would boost manufacturers in Scotland and Northern Ireland. We are also supporting the development of new offshore wind power off the coast of England, Scotland, and Wales; and already investing in nuclear power in the South East and West of England.

14. The impact of the transition to net zero on the UK's labour market could be significant: with one estimate suggesting up to 20% of the workforce could see demand for their skills affected, either positively or negatively.[13] Furthermore, as set out by HM Treasury's *Net Zero Review*, although the net macroeconomic impact is likely to be small in 2050 relative to total growth over the period, impacts between and within regions over the next three decades can vary. Our approach will need to reflect that benefits and impacts of the transition will be dependent on individual household characteristics, such as their housing type and current vehicle usage, to support those low-income households most affected by individual technology transitions.

15. Our approach to supporting green jobs, attracting private investment, and tackling climate change will benefit the whole of the UK, including areas where a large proportion of people are currently employed in high-carbon sectors. However, while employment opportunities in green industries will emerge, high-carbon sectors will have to adapt or decline, resulting in a need to transition local labour markets to ensure people have the right skills to make the most of these opportunities.

16. Our sector deals, including on nuclear, offshore wind, automotive and the North Sea Transition Deal considered the skills needs and support for the labour market transition to net zero on a sectoral basis. The North Sea Transition Deal, for example, will support workers, businesses, and the supply chain throughout the transition by harnessing the sector's existing capabilities, infrastructure, and private investment potential to exploit new and emerging technologies such as hydrogen production, CCUS, offshore wind and decommissioning. Through the Deal, the sector, government, and unions will work together over the next decade and beyond to deliver the skills, innovation, and new infrastructure required to decarbonise North Sea production.

17. Our Automotive Transformation Fund and industrial clusters framework will help these industries, transition to a sustainable future. We are also taking action to enable local employers to set out their green skills needs, and support workers to gain the skills they need to access green jobs - such as through our Skills Bootcamps.

18. Supporting innovation will also help unlock jobs across low carbon sectors. For example, our portfolio of net zero innovation will provide at least £1.5 billion of government funding to help commercialise clean technologies and boost private investment across the UK.

Examples of clean growth investment across the UK

Scotland, Aberdeen

Scotland has a technology hub for offshore wind, including the first successful floating turbines in Aberdeen. The city is benefiting from funding for the Aberdeen Energy Transition Zone and the Global Underwater Hub, as well as the Net Zero Technology Transition Programme.

Scotland, Orkney

Hydrogen in an Integrated Maritime Energy Transition' project £1.6 million from the UK Government match-funding a £2.3 million project to develop hydrogen-based clean maritime solutions.

Wales

South Wales Industrial Cluster Nearly £20 million to support the deployment of decarbonisaton infrastructure will go to the South Wales Industrial Cluster which aims to create a net zero industrial zone from Pembrokeshire to the Welsh/English border by 2040.

Wales, Cwmbran

EPIC - Electric Powertrain Integration for heavy Commercial vehicles £31.8 million project (£15.8 million from the UK government) to develop lightweight electric powertrains for heavy goods to manage extreme levels of electrical power.

Northern Ireland, Belfast

Wrightbus zero-emission buses £11.2 million from the UK Government to develop hydrogen-fuel technology.

North West

Ellesmere Port plant transforming to build electric vans £100 million from Stellantis to build electric vans, safeguarding 1,000 jobs.

North West, Greater Manchester

People Powered Retrofit £1 million from the UK Government to support initial business development, leading to 1,150 homes retrofitted and 3,500 local contractors retrained over the next five years.

West Midlands

Public Sector Decarbonisation Scheme £2 million from the UK Government to Windsor Academy Trust for heat decarbonisation and energy efficiency measures across seven schools.

South West & East of England

£84.6 million invested by government and industry in 3 ambitious aerospace R&D projects based in Bedford, Bristol and Cranfield to help the industry build back greener.

South West, Somerset

Hinkley Point C Nuclear Power Station) £3.5 billion already spent with companies in the South West and 12,786 jobs created so far, including 787 apprentices.

- Heat Pumps
- CCUS
- Offshore Wind
- Automotive
- Rail
- Waste and Circular Economy
- Climate Change Adaptation
- Heat Networks
- Retrofit
- Nuclear
- Aerospace
- Forestry
- Oil and Gas
- Science and Innovation
- Low Carbon Hydrogen
- Electricity Networks
- Green Finance
- Maritime
- Agriculture
- Steel
- Public Transport and Cycling
- Onshore Wind
- Solar
- Tidal
- Smart Systems
- Nature Conservation & Restoration

UK-wide

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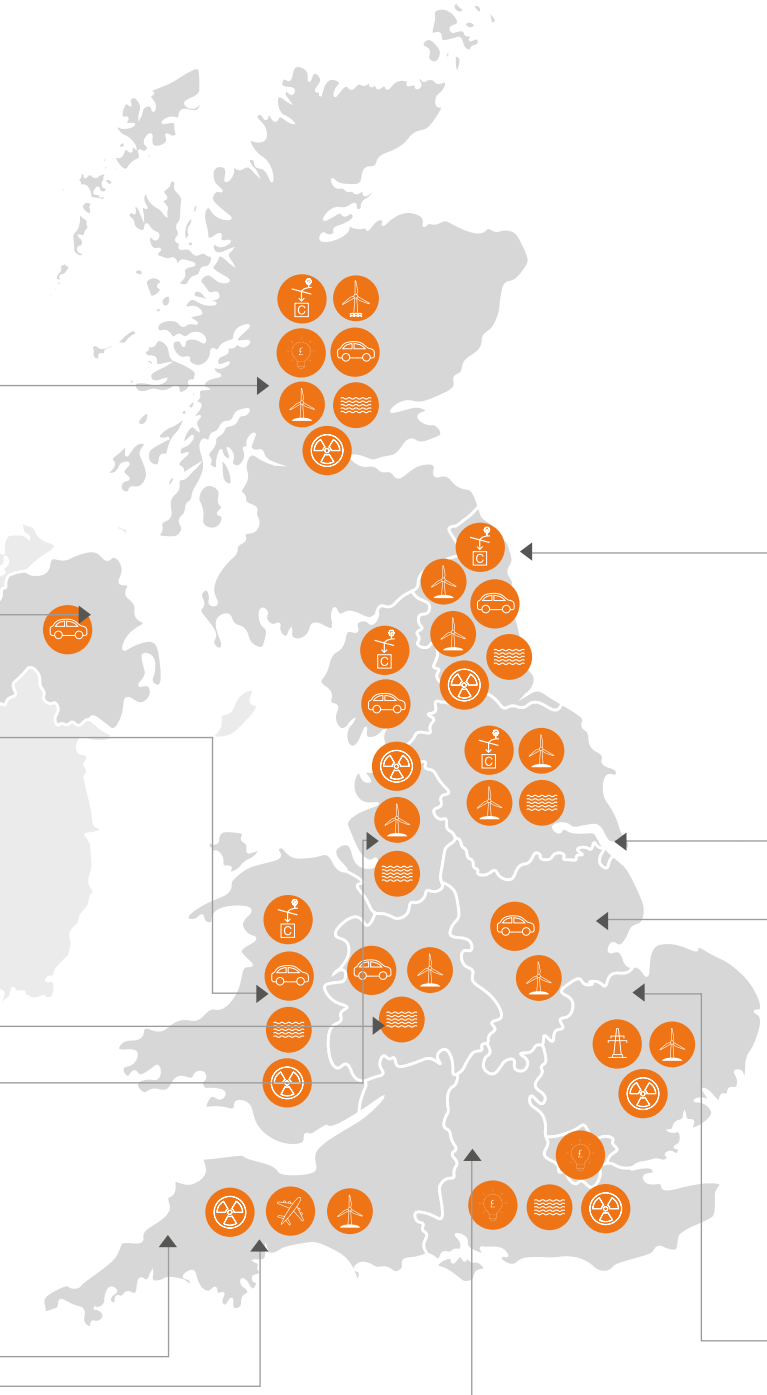

North East, Teesside

Whitetail Clean Energy
8 Rivers Capital and Sembcorp Energy UK's 300MW NET power plant, creating over 2000 construction and 200 operational jobs.

North East

Transforming automotive manufacturing
£1 billion announced by Nissan and Envision AESC to create an electric vehicle manufacturing hub supporting 6,200 jobs.

North East

Gateshead District Energy Scheme £5.9 million of UK government funding for heat network project with mine water source heat pump connecting 5 buildings and up to 1,250 new homes to the Gateshead District Energy Scheme.

Yorkshire and the Humber

Able Marine Energy Park
Up to £75 million from the UK Government to facilitate a c.£500 million offshore wind manufacturing port hub, supporting up to 3,000 local jobs.

Yorkshire and the Humber

Siemens Gamesa offshore wind factory expansion
£186 million from Siemens Gamesa to expand their offshore wind turbine blade factory, creating and safeguarding up to 1,080 local jobs.

East Midlands

Tackling Climate Change on the River Rase £200,000 from the UK Government for nature-based solutions in the River Rase catchment helping climate adaptation.

East of England

Advanced Greenhouses
£120million from Greencoat Capital backed by UK pension funds to build 2 greenhouses (covering 72 acres) warmed by heat pumps utilising warm waste water, creating 360 new green jobs and 120 seasonal jobs.

Midlands, Coventry

Coventry will be the first zero emission bus town awarded ten of millions to replace the entire local operator bus fleet with electric buses.

Case Study: North East of England

This region is leading the way in championing new technologies, whether it is electric vehicles (EVs), carbon capture, hydrogen, or renewables. Research undertaken for government indicates that the North East could gain an extra 27,000 jobs by 2050 arising from UK climate action.[14] The research indicates that the gains to the region over time come to a large extent from specific investments needed for the UK to meet net zero, rather than baseline economic growth. In depth interviews with regional and industry stakeholders has also revealed a real and justified optimism about the region's potential to level up due to the Green Industrial Revolution and remain an attractive location for people to live and work.

The optimism is backed by significant investments in offshore wind and EV manufacturing. Spurred on by our 40 GW offshore wind deployment plans and £160 million investment in ports and manufacturing, we have seen almost £1.5 billion in investment in our offshore wind manufacturing capabilities. Recently announced projects include GE Renewable Energy's plans for a new blade factory in Teesside, South Korea's SeAH Wind, and GRI Renewable Industries' construction of factories in the Humber and Smulders (Newcastle), and the expansion of Siemens Gamesa's existing site in Hull.[15] Combined these projects will support up to 3,600, direct green jobs.

Nissan and Envision AESC have reaffirmed their belief in the region and in Britain's plans to shift to EVs, through their £1 billion flagship investment to establish an Electric Vehicle Hub in Sunderland. The hub will bring together electric vehicles, renewable energy, and battery production. Nissan will invest up to £423 million to produce a new-generation all-electric vehicle in the UK. Envision AESC will invest £450 million to build the UK's first large-scale Gigafactory.

Leveraging private investment

19. We estimate that additional capital investment must grow from present levels to an average of £50-60 billion per year through the late 2020s and 2030s. Most of this investment will come from the private sector, providing new opportunities for businesses and investors. Over the same period, we could see additional resource savings of around £180 billion as a result of our reduced use of oil and natural gas.

20. The policies and spending brought forward in the Net Zero Strategy mean that since the *Ten Point Plan*, HMG has mobilised £26 billion of government capital investment for the green industrial revolution. Along with regulations, this will support up to 190,000 jobs in 2025, and up to 440,000 jobs in 2030, and leverage up to £90 billion of private investment by 2030.

21. Development of existing clean energy industries can give a sense of the scale of investment we will likely need to develop and grow new low carbon sectors. According to Wind Europe[16], from 2010-20 the UK leveraged around £47 billion in our world leading offshore wind industry, almost half of all European investment in the sector. As existing strengths expand and newer strengths emerge, we will work with industry, investors, and innovators to mobilise the private investment required to deliver net zero.

22. Government has an important role to play in ensuring a comprehensive financing offer, long-term investment signalling and fit-for-purpose business models coupled with investment from numerous private sources. We will work to create an attractive environment to secure the right investment in UK projects, with benefits to UK business and communities. By building on our strengths, including potential for rapid scale up across the domestic value chain, and coupling this with a strategic approach from government on policy and investment, we can create the right conditions to unlock the significant scale of private investment that will be needed.

23. Recent steps include establishing a new Office for Investment (OFI), which will support high value investment opportunities into the UK which align with key government priorities. The new UK Infrastructure Bank will provide leadership to the market in the development of new technologies, particularly in the scaling early-stage technologies that have moved through the R&D phase. With an initial £12 billion of investment the Bank will crowd in private investment to accelerate our progress to net zero whilst helping to level up across the UK. (See *Green Investment* chapter for more detail).

Creating wider benefits for society, the economy and the environment

24. Acting on climate change also brings the opportunity for wider benefits for our society individual wellbeing,[17] economy, and environment from improving public health to protecting biodiversity. These include:

- ✓ Cleaner air and less noise pollution, by replacing fossil fuels with renewables for generating electricity and moving to electric vehicles.
- ✓ Better insulated homes will reduce energy consumption and lower bills, alongside health benefits.
- ✓ Opportunities to tackle mitigation and adaptation together, and bring wider benefits. For example, sustainable land management can reduce emissions from land, assist adaptation, improve food security, and protect wildlife.[18]
- ✓ Supporting biodiversity by planting woodlands and restoring peatlands.
- ✓ Physical and mental health benefits, and better connectivity to jobs, public services, and each other, by promoting more walking and cycling, and improving access to green spaces.

25. We know central government cannot and should not deliver these benefits by acting alone. We want to work in partnership with people and communities across the country. To do so, we will empower local leaders to kickstart their own net zero initiatives, taking responsibility for improving their areas and shaping their own futures.

UK framework for ending our domestic contribution to climate change

26. The UK has long been a global leader in tackling climate change. The 2008 Climate Change Act sets the legal framework for reducing emissions across the UK economy. In 2019, we became the first major economy to legislate to reach net zero by 2050.

27. On our pathway to net zero, the UK has interim targets called carbon budgets and Nationally Determined Contributions (NDCs). Carbon budgets restrict the total amount of greenhouse gases that the UK can emit over five-year periods, ensuring continued progress towards our long-term climate target. NDCs are commitments made by Parties to the Paris Agreement. They show how Parties intend to reduce their greenhouse gas emissions to meet the temperature goal of the Paris Agreement.

28. In 2020, we communicated to the UN Framework Convention on Climate Change (UNFCCC) our NDC pledge to reduce UK emissions by at least 68% by 2030 on 1990 levels.[19,20]

29. In June 2021, the Government set in law the sixth carbon budget (CB6) limiting the volume of greenhouse gases emitted from 2033 to 2037. CB6 reduces emissions by approximately 78% by 2035 compared to 1990 levels. For the first time, this carbon budget formally incorporates the UK's share of international aviation and shipping emissions, enabling these emissions to be accounted for consistently with other emissions and demonstrating leadership in how we account for our emissions.[21]

30. This strategy sets out the action we will take to keep us on track for the UK's carbon budgets and 2030 NDC, and establishes our longer-term pathway towards net zero by 2050. The Net Zero Strategy will be submitted to the UNFCCC as our second Long-Term Low Greenhouse Gas Emission Development Strategy under the Paris Agreement.

Emission reduction targets in Scotland, Wales, and Northern Ireland

The UK Government's net zero target covers the whole of the UK. All parts of the UK have an integral role to play in delivering the UK-wide carbon budgets on the path to net zero by 2050. Each nation faces different challenges based on the share of its emissions from hard-to-treat sectors. For example, Northern Ireland has a higher proportion of its total emissions from agriculture (29%), compared to the UK overall (11%).[22]

Scotland

The Climate Change (Emissions Reduction Targets) (Scotland) Act 2019, which amends the Climate Change (Scotland) Act 2009, sets targets to reduce Scotland's emissions of all greenhouse gases to net zero by 2045 at the latest, with interim targets for reductions of 75% by 2030 and 90% by 2040 and annual targets for other years. Scotland's net zero target is in line with the independent, expert advice of the Climate Change Committee.

The update to the Scottish Government's 2018-2032 Climate Change Plan sets out the pathway to its new and ambitious targets set by the Climate Change Act 2019. It is also a key strategic document for its green recovery from COVID-19.

Wales

In March 2021, the Senedd passed a suite of regulations to set a Net Zero Wales 2050 target, increase Wales decadal emissions targets, and set Wales Carbon Budgets 2 and 3 in line with them. Relative to the baseline established in legislation, the targets and budgets set in law are:

- Carbon Budget 2 (2021-25): 37% average reduction with a 0% offset limit
- Carbon Budget 3 (2026-30): 58% average reduction
- 2030: 63% reduction
- 2040: 89% reduction
- 2050: at least 100% reduction (net zero)

Welsh legislation requires Welsh Government Ministers to publish a plan for meeting each of its carbon budgets. *Net Zero Wales* will be published before COP26 and will set out the policies and proposals to meet Wales Carbon Budget 2 (2021-25) and set Wales on a longer-term pathway to net zero.

Northern Ireland

The current legislative framework for tackling climate change in Northern Ireland is the UK Climate Change Act 2008. Although this extends to Northern Ireland, it does not set a specific greenhouse gas emissions reduction target for Northern Ireland. It is implicit, and based on independent advice of the Climate Change Committee, that Northern Ireland contributes its fair share of required greenhouse gas emission reductions to meet the UK-wide net zero by 2050 target and the UK Government's 5-yearly carbon budgets set under the UK Climate Change Act. A Climate Change Act for Northern Ireland, whilst not yet introduced, is currently being progressed and remains a priority for delivery during the current Assembly mandate, by March 2022.

The Northern Ireland Executive is also currently developing a multi-decade Green Growth Strategy. This longer-term Strategy will be delivered through a series of Climate Action Plans, which will set out the actions to meet sector-specific greenhouse gas emission targets.

Leading the world to a greener, more sustainable future

31. The UK accounts for less than 1% of global emissions.[23] It is essential to enhance international collaboration with other countries and take urgent, concrete action globally to reduce emissions in the near-term. The 2020s is a critical decade in determining whether the Paris temperature goals can be kept within reach. The UK's role in international climate action is set out in the *International Climate Leadership and Collaboration* chapter.

32. The UK is leading the way in global climate action. Countries that are covered by a commitment to net zero or carbon neutrality now account for around 75% of global GHG emissions, and around 80% of global GDP. When the UK took the role of incoming COP Presidency in December 2019, coverage was less than 30% of world GDP. We have a unique opportunity to further this leadership through our G7 Presidency in 2021, and as the host and president of the COP26 summit, in partnership with Italy. The COP26 summit will bring together nearly 200 Parties to accelerate action towards the goals of the Paris Agreement and the UNFCCC, and our drive towards global net zero.

33. COP26 will be the forum to define the decisive decade of climate action and setting the path to global net zero emissions. The UK is urging all parties to demonstrate how they will reach net zero greenhouse gas emissions through near term 2030 NDC targets and Long-Term Strategies to 2050, protect people and nature from climate change impacts, fund climate action, and work together to deliver immediate steps to keep warming within 1.5°C. There will also be a renewed focus on accelerating near-term action in the top priority areas of coal phase out, zero-emission vehicles, climate finance, and halting deforestation.

34. The four goals for the UK's COP26 Presidency are:

a. **Mitigation: bring parties together to deliver commitments on mitigation.** All countries should come forward with ambitious 2030 climate plans (Nationally Determined Contributions, or NDCs) and long-term strategies to reach net zero greenhouse gas emissions, with the aim of keeping the goal of limiting global warming to 1.5°C in reach.

b. **Adaptation: establish a new consensus on protecting people and nature from climate change impacts.** All countries should come forward with ambitious adaptation plans and communications to help their societies and economies adapt to climate change.

c. **Finance:** To deliver on our first two goals, developed countries must deliver on their promise to mobilise at least $100 billion in climate finance per year by 2020, and through to 2025, to help developing countries tackle and adapt to climate change. International financial institutions must play their part and we need work towards unleashing the trillions in private and public sector finance required to secure global net zero.

d. **Collaboration: bring countries together to reach an outcome accelerating climate action and finalising the Paris Rulebook.** Use the power of a fair and inclusive Presidency to enhance international collaboration among policy makers, investors, business, young people, indigenous peoples, and civil society. This can help to solve key challenges and accelerate the delivery of the Paris Agreement goals, particularly: adaptation and resilience, nature, clean energy and transport, and finance.

35. In delivering net zero, the UK also has the opportunity to be at the forefront of large, expanding global markets and capitalise on export opportunities in low carbon technologies and services. This includes renewables, CCUS, hydrogen, smart energy systems and storage, Greenhouse Gas Removals (GGRs), Advanced Modular Reactors (AMRs), and transport. By leading the world in the transition to a net zero future, the UK will be well placed to benefit economically by leading in the export of sustainable technologies and solutions.

36. As the world economy moves to meet the Paris commitments, with over 80% of world GDP now committed to net zero, the UK will set a clear direction and give businesses the certainty they need to invest, grow, and develop the technologies of the future. Some commentators estimate global investment in energy supply and infrastructure to reach $92 trillion and $173 trillion over the next thirty years. To achieve this level, the global economy will need to more than double annual investments from around $1.7 trillion per year to between $3.1 and $5.8 trillion per year on average.[24]

37. This strategy sets out our approach to reaching net zero emissions and securing the vast wider benefits as we transition to a greener, more sustainable future. We urge other countries to follow this example with ambitious commitments at COP26 and detailed plans to deliver on them.

Endnotes

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[20] The UK NDC is based on territorial emissions – greenhouse gases emitted from sources within the UK – so does not include emissions from international aviation and shipping. This is in line with international reporting requirements, international expectations, and advice from the Climate Change Committee.

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The Journey to Net Zero

Chapter 2

1. Transforming the UK's economy over the next three decades to reach net zero will be a journey of unprecedented opportunity and change. Our greenhouse gas emissions have fallen by more than two-fifths in the last thirty years, with particular progress in the decarbonisation of our electricity system, but we need to go further and faster in the next thirty years, right across the economy.[1] It will mean developing and rolling out new, innovative, and climate resilient technologies; embracing new ways of doing things – from new ways of travelling, heating our homes, and using our land; and creating new industries and jobs through our green industrial revolution.

2. The policies to drive these changes, and the opportunities arising for individuals and the UK economy, are set out across the remaining chapters of this Strategy. This chapter first explores what reaching net zero by 2050 could mean for the UK; potential scenarios of how we will get there; and an indicative pathway to deliver on our ambitious carbon budgets along the way, while navigating the inherent uncertainty. We look at this journey from a whole-economy perspective, considering the key interactions between sectors, technologies and the energy system that need to be planned for as we decarbonise.

The UK's Net Zero Future

Our **industrial heartlands** are reinvigorated, with **innovation** and **private investment** in clean technologies – such as wind, carbon capture and hydrogen in multiple locations across the UK including the North East; or the manufacture of batteries and electric vehicles in the Midlands.

Our **green economy** and its **supply chains** provide sustainable jobs for highly-skilled workers – in construction, manufacturing, engineering, science, nature conservation, finance and more, across the economy and the UK, including in rural areas.

Our **businesses** are delivering the latest low carbon technologies, services and innovations for the UK and export markets; and are more resilient to the global net zero transition.

Our **homes** are warm and comfortable, powered and heated by clean, affordable energy.

Our **journeys** are made in zero emission vehicles, with trains, ships and planes running on new low carbon energy sources.

Our **towns and cities** have cleaner air for everyone, and support walking and cycling with benefits for health.

Our **goods** are designed to last longer and be more efficient, while being used, repaired and remanufactured within a circular economy.

Our **natural environment** is protected, enhanced, and more diverse, with healthy ecosystems and increased biodiversity, supporting a sustainable rural economy and providing wider benefits, including improved mental health and protection from risks like flooding and overheating.

A systems approach to the net zero journey

3. The characteristics of the net zero challenge – requiring action by multiple parties across the public and private sectors, delivery at pace, and management of large uncertainties – underline the need for strong coordination in policy development and clear signalling to markets. Government taking a systems approach to policy will help to navigate this complexity. We must consider the environment, society, and economy as parts of an interconnected system, where changes to one area can directly or indirectly impact others. This will help to ensure we design policy to maximise benefits, account for dependencies, mitigate conflicting interests and take account of learning as we go. It reduces the risk of unintended consequences, ensuring individual decisions designed to help achieve net zero do not end up hindering it or other important objectives.

4. A systems approach does not attempt to design a 'perfect' net zero end-state thirty years into the future. It aims to enable innovative and desirable solutions to be developed, and to ensure that decisions are made when needed, based on the best evidence available at that time and with the fullest possible range of considerations brought to bear. This includes taking a dynamic approach to policymaking and updating our assumptions on an ongoing basis; considering public reactions to a policy; accounting for where a particular investment or technology deployment may affect another sector's decarbonisation; and considering the net costs and benefits across different parts of the economy and environment.

5. We have implemented several key elements of a systems approach, including:

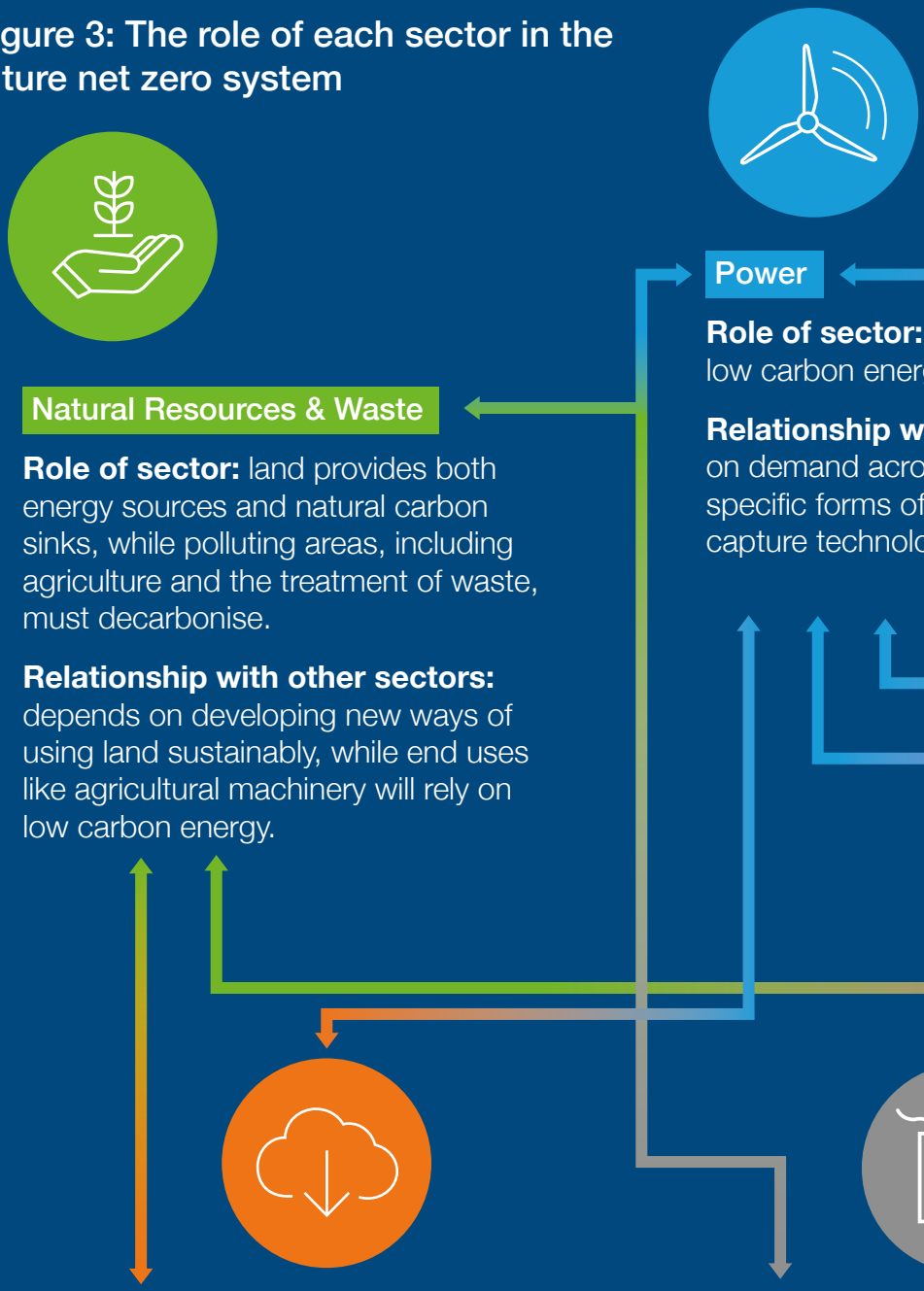
- Establishing forums for delivering shared net zero goals and identifying key issues through cross-system governance structures, including two new Cabinet committees;
- Working towards a shared understanding of interdependencies and risks across different parts of the net zero challenge, for example through £2 million funding from the Shared Outcomes Fund to develop systems tools;
- Testing and determining feasible net zero scenarios with our whole energy systems modelling suite, and supporting our work to identify high leverage, systemic actions such as CCUS that will be necessary in a wide range of scenarios.

6. Work will continue to develop this approach further. This Strategy encompasses changes from across the system that will need to be delivered to achieve net zero.

7. As summarised in Figure 3 below, each sector of the economy will play a vital role in the future net zero system, and these are highly connected – changes in one area can directly or indirectly impact others.

8. Applying a systems approach to policymaking can help to address complex policy challenges, including to identify interdependencies. The case study below for electric vehicles demonstrates the need to understand the complex interactions which drive change. Government will continue to test and update its understanding of systems and how they relate to one another, which forms an important part of how we will monitor delivery, explored further in the *Embedding net zero in government* chapter.

Figure 3: The role of each sector in the future net zero system



Power

Role of sector: generates electricity to meet low carbon energy demand across all sectors.

Relationship with other sectors: depends on demand across end use sectors, while specific forms of generation can use carbon capture technology, hydrogen, and waste.

Natural Resources & Waste

Role of sector: land provides both energy sources and natural carbon sinks, while polluting areas, including agriculture and the treatment of waste, must decarbonise.

Relationship with other sectors: depends on developing new ways of using land sustainably, while end uses like agricultural machinery will rely on low carbon energy.

Greenhouse Gas Removals

Role of sector: alongside natural carbon sinks, engineered removals deliver negative emissions, either directly from the air or as a co-benefit of methods to generate power, fuels and products.

Relationship with other sectors: compensates any residual emissions to ensure a net zero system. Engineered removals also use electricity.

Industry

Role of sector: develops cleaner ways to produce the wide range of products we all rely on, from food and drink to iron and steel.

Relationship with other sectors: depends on low carbon energy supply from power and hydrogen, as well as the use of carbon capture technology alongside power, hydrogen and greenhouse gas removals.

Heat & Buildings

Role of sector: our public, business, industrial and residential buildings, as well as products we use for cooking and everyday living, move to green forms of energy.

Relationship with other sectors: depends on low carbon energy, while different heat options will in turn affect the development of supply sectors.

Transport

Role of sector: all forms of travel that keep modern society moving – road, rail, aviation, and shipping – run on green forms of energy.

Relationship with other sectors: depends on low carbon energy, while different transport options will in turn impact the development of supply sectors.

Fuel Supply & Hydrogen

Role of sector: supports energy supply, especially in areas that are harder to electrify such as heavier transport. Oil and gas play a far reduced role where needed and abated by carbon capture technology where possible.

Relationship with other sectors: depends on demand across end use sectors, while different types of hydrogen production use electricity, carbon capture, and biomass.

Case study of a 'systems approach': Electric Vehicle (EV) roll out

The transition to EVs is central to decarbonising road transport. Higher sales of EVs means overall electricity demand will increase, requiring greater electricity generation and grid capacity. Over the lifetime of an EV, overall carbon emissions are already significantly lower than a traditional internal combustion engine car and, as the electricity grid continues to decarbonise, the lifetime of emissions from driving an EV reduce. The transition to EVs therefore has a potential knock-on impact on the industrial sector and its wider supply chains, particularly in certain regions of the UK, for example creating additional demand for new wind turbine manufacture and installation.

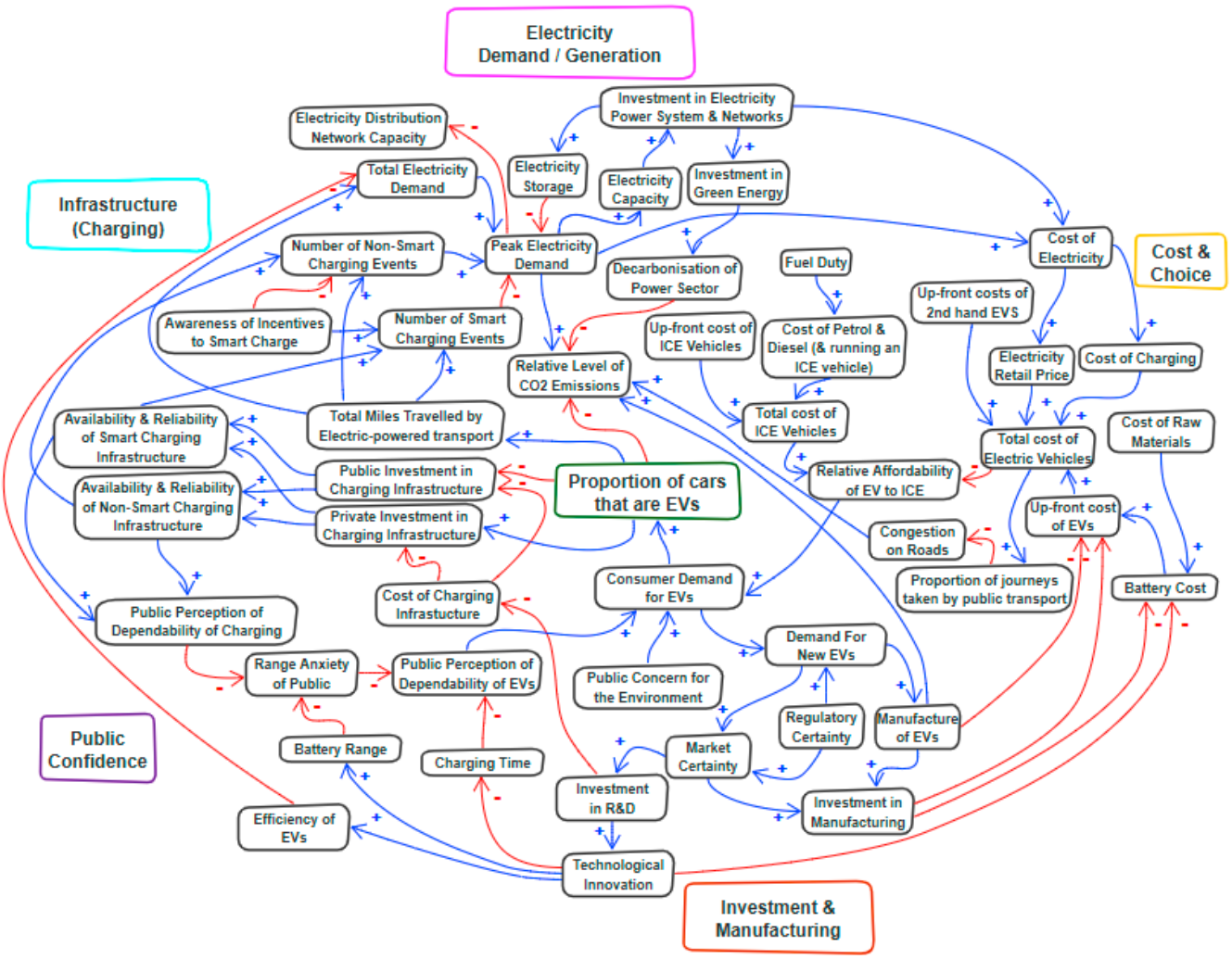
More EVs will affect both the scale and nature of electricity demand, including the timing and scale of peaks, as patterns of charging behaviour develop (e.g. many people choosing to charge at the end of the working day). The changes this could bring need to be carefully thought through, and opportunities seized. For example, innovative technology could support smoothing of electricity demand, by allowing electricity stored in batteries to be fed back into the grid at times of low renewable generation or high demand (vehicle-to-grid technology). Smart charging (enabled by regulations that Government plans to lay later this year) will also help to move demand away from peak times as well as helping consumers to benefit from lower cost off-peak electricity.

The roll out of EVs will have an impact on demand for petrol and diesel, with potential to impact through the supply chain, from production to processing, distribution and retail. Uptake will also have an impact on R&D, investment, and manufacturing of both EVs, and the infrastructure required to use them. The effect of investment in these areas would be wider availability of the infrastructure required for charging, reduction in the cost of manufacturing, and further advances in EV technology.

Manufacturing costs will likely fall as production increases at scale and investment in R&D will bring down the costs of components. Wider availability of reliable charging infrastructure should remove range anxiety for EV drivers and streamlining payment methods should improve the consumer experience. These two factors will then encourage further take up of EVs with these sets of relationships representing positive feedback loops.

The examples above are a significant simplification of some of the interactions between sectors as EV roll out progresses. The below systems map shows a more granular picture, though this is also a simplification and some variables will have other influences that are not displayed here.

Figure 4: Example of a 'systems map' showing some interactions to consider in the roll out of electric vehicles



Pathways to net zero by 2050

Key features of the net zero transition

9. There are a range of ways in which net zero could be achieved in the UK. Our exact route will depend on the availability and deployment of key technologies, supported by long-term market growth, as well as the extent to which individuals and businesses adopt green choices. Our approach must consider physical factors, such as land availability and climate change risks like drought and flooding. As a principle, we will pursue options that leave the environment in a better state for the next generation by improving biodiversity, air quality, water quality, natural capital, and resilience to climate change where appropriate.

10. As we increase our efforts to decarbonise domestically, we must ensure production, and the associated greenhouse gas emissions, does not shift to other countries with lower climate obligations. In the *Net Zero Review* we consider the carbon leakage risk facing UK businesses on a sectoral basis and discuss the approaches to help address this risk.[2] In addition to encouraging our trading partners to increase their own efforts, we are engaging with industry to better understand the risks and consider the full range of options to address these, including through the UK Emissions Trading Scheme, discussed further in the *Industry* chapter.

11. While there are significant costs in reaching net zero, the cost of inaction is much higher. The Office for Budget Responsibility's recent report showed unmitigated climate change resulting in "debt spiralling up to around 290% of GDP thanks to the cost of adapting to an ever hotter climate and of more frequent and more costly economic shocks".[3] In addition to reducing the risks of catastrophic climate change, net zero will also bring significant benefits and opportunities, such as economic growth and jobs in new green sectors, reducing air pollution with benefits for health, and enhancing biodiversity. We also expect costs to continue to fall as green technology advances, industries decarbonise, and private sector investment grows. Recent cost benefit analysis for the sixth carbon budget[4] suggests that the significant benefits of net zero more than offset the costs, resulting in a net benefit.

12. Most costs are the additional capital costs (and associated financing) of low carbon technologies, although significant fuel savings help to offset these. We estimate that the net cost, excluding air quality and emissions savings benefits, will be equivalent to 1-2% of GDP in 2050. Our approach will need to reflect that benefits and impacts of the transition will be dependent on individual household characteristics, such as their housing type and current vehicle usage, to support those low-income households most affected by individual technology transitions. The government's approach will also support the principle that those who produce the pollution should bear the costs of managing it. Further information on the economic impacts is set out in HM Treasury's *Net Zero Review*, which informs our approach to achieving a transition that works for households, businesses and public finances, and maximises economic growth.

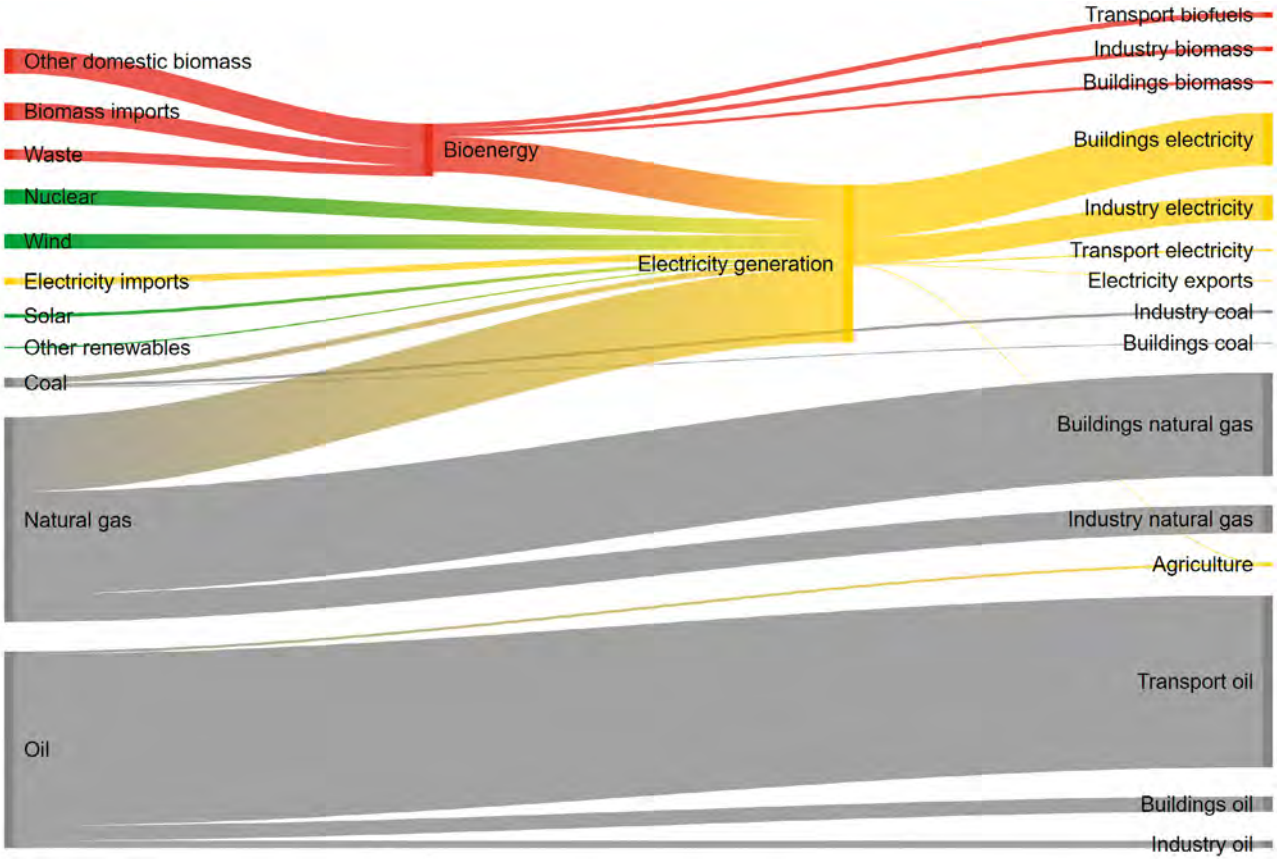
13. The exact technology and energy mix in 2050 cannot be known now, and our path to net zero will respond to the innovation and adoption of new technologies over time. We expect, however, to rely on the following key green technologies and energy carriers, which interact to meet demand across sectors and to remain low carbon.

- **Electricity** from low carbon generation and storage technologies meets higher demand for low carbon power in buildings, industry, transport, and agriculture;

- **Hydrogen** can complement the electricity system, especially in harder to electrify areas like parts of industry and heating, and in heavier transport such as aviation and shipping. A range of low carbon production methods could be used;[5]
- **Carbon capture usage and storage** (CCUS) can capture CO_2 from power generation, hydrogen production, and industrial processes – storing it underground or using it. This technology also supports negative emissions from engineered greenhouse gas removals – bioenergy with carbon capture and storage (BECCS) and Direct Air Carbon Capture and Storage (DACCS);
- **Biomass** combined with CCUS can remove carbon from the atmosphere and support low carbon electricity and hydrogen generation. Biomass and other wastes can also support low carbon fuels for industry, buildings, and transport.

14. These new technologies could transform our energy system by 2050. Electricity, low carbon hydrogen, and BECCS could all scale up, while reliance on fossil fuels will drop considerably and can be combined with carbon capture technology to abate emissions, with any residual emissions offset by greenhouse gas removals.

Figure 5: 2019 energy generation and end uses[6]



Illustrative 2050 scenarios

15. Modelling illustrative net zero scenarios allows us to explore possible energy and technology solutions in 2050, better understand important system-wide interactions, and identify features common to all options. Below we show three modelled scenarios all reaching net zero by 2050 through the same pace of decarbonisation, which demonstrate a range of practical ways in which net zero could feasibly be delivered with technology and resources known today.[7] They do not represent 'most likely' or 'preferred' solutions, and the actual position in 2050 may also vary outside of these scenarios. There is a great deal of uncertainty inherent in any modelling as far into the future as 2050, which is highly sensitive to economic, societal, and technological developments – see the *Technical Annex* for details of the modelling.

2050 Scenario 1: High electrification

Explores the impact of widespread electrification to support transport, heating, and industry decarbonisation, relative to other scenarios, with deep decarbonisation of electricity supply.

This pathway sees UK electricity generation increasing to around 690 TWh, more than doubling from today,[8] and low carbon hydrogen production scaling up to 240 TWh by 2050. Sectors such as road transport and buildings reach near zero emissions, through widespread electrification, with small residual emissions possible in personal and heavy goods transport; while the majority of buildings use electric heating, with the remainder using connected low carbon district heat networks. Industry emissions are near zero, through the full suite of green technologies (electricity, hydrogen, and CCUS), alongside energy efficiency measures. Electricity generation is overwhelmingly decarbonised, through widespread deployment of renewables alongside other low carbon generation including nuclear power and gas with CCUS. Residual emissions remain in aviation, agriculture, and waste, though these reduce from today's levels through, for example, sustainable aviation fuels, more efficient farm practices, and reduction in landfill waste. These emissions are balanced by significant afforestation, together with engineered removals (primarily BECCS but also DACCS).[9]

Figure 6: High electrification scenario: energy generation and end uses in 2050

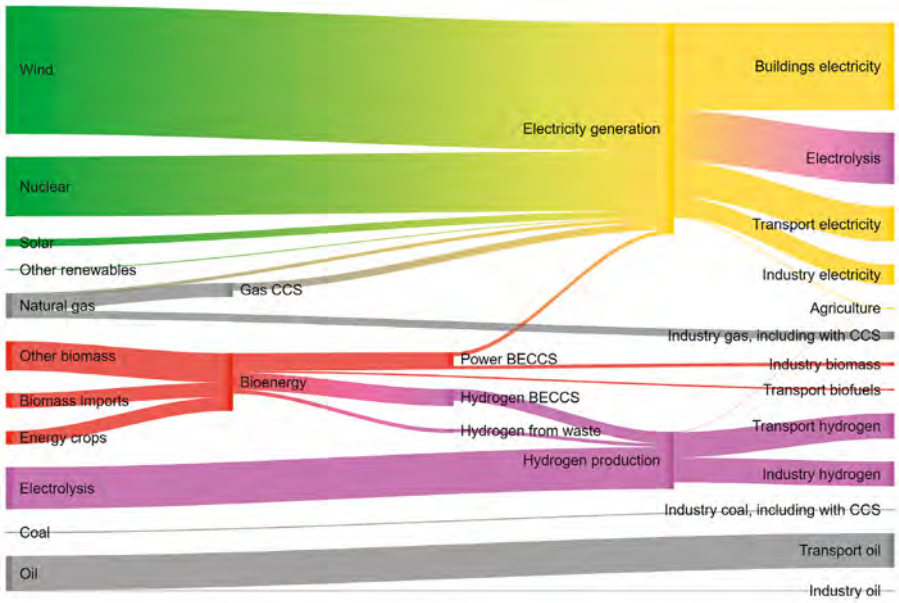
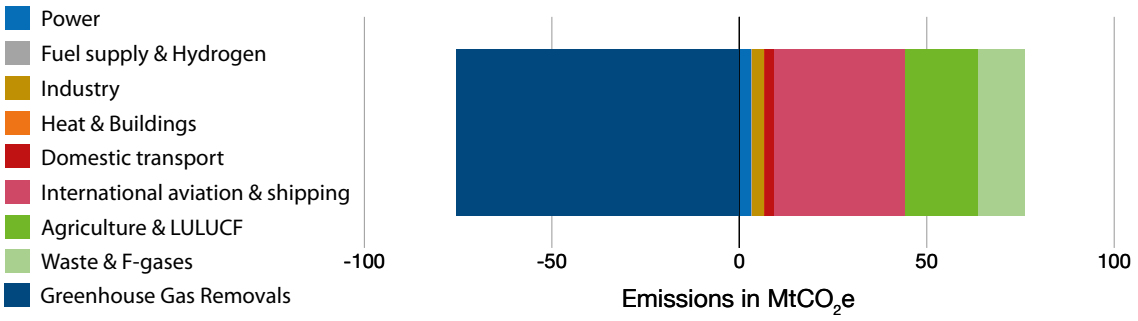


Figure 7: High electrification scenario: residual emissions in 2050



2050 Scenario 2: High resource

Explores the impact of using low carbon hydrogen more extensively, particularly for decarbonising buildings, power, and heavy vehicles. It also assumes higher levels of tree-planting are achievable, increasing the 'negative emissions' available from land-use sinks.

This pathway sees low carbon hydrogen generation increasing to around 500 TWh. As hydrogen is the main energy source for heating, electricity demand and therefore generation is lower than in scenario 1 at 610 TWh. Electricity and district heat still play a role in both residential and non-domestic buildings but the majority of building heat demand is assumed to be met by hydrogen. End users of energy (e.g. transport and buildings) reach similar levels of decarbonisation as in scenario 1. In heavy transport, there is a shift to increased use of hydrogen. Compared to scenario 1, greater levels of tree planting allow for slightly higher residual emissions to remain, primarily in hydrogen production. Engineered removals are at a similar scale to scenario 1 to offset remaining residual emissions in the hardest-to-decarbonise sectors of aviation and agriculture.

Figure 8: High resource scenario: energy generation and end uses in 2050

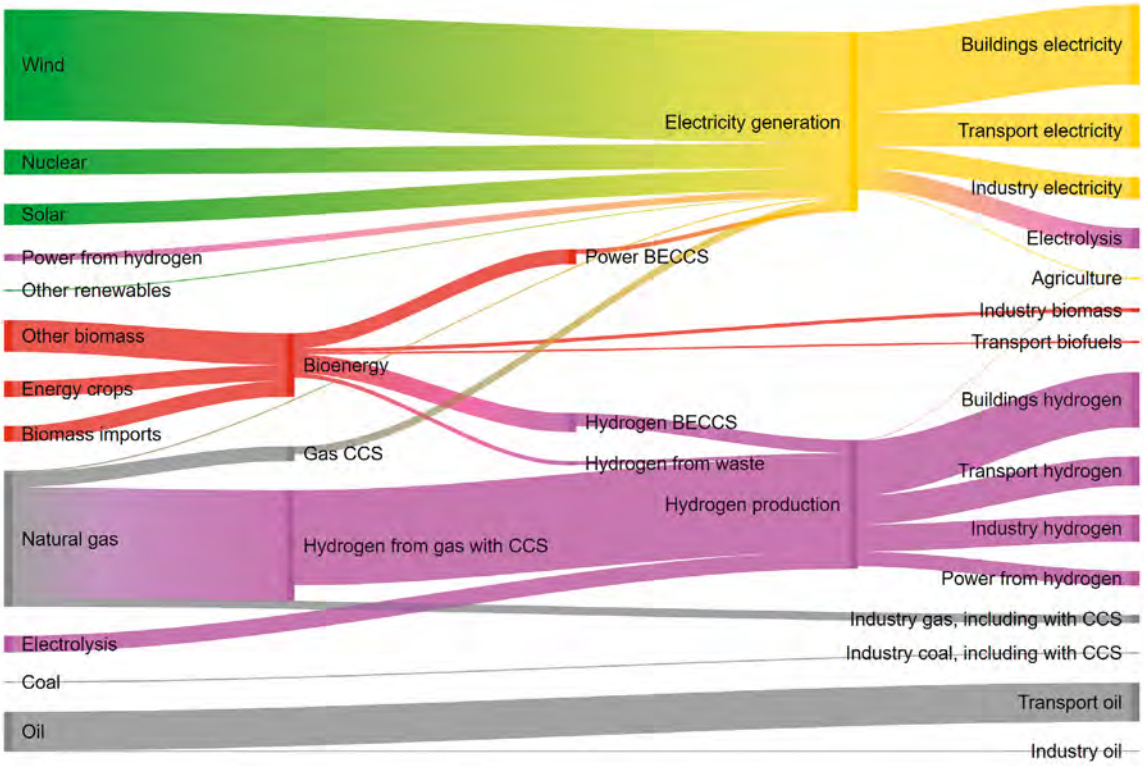
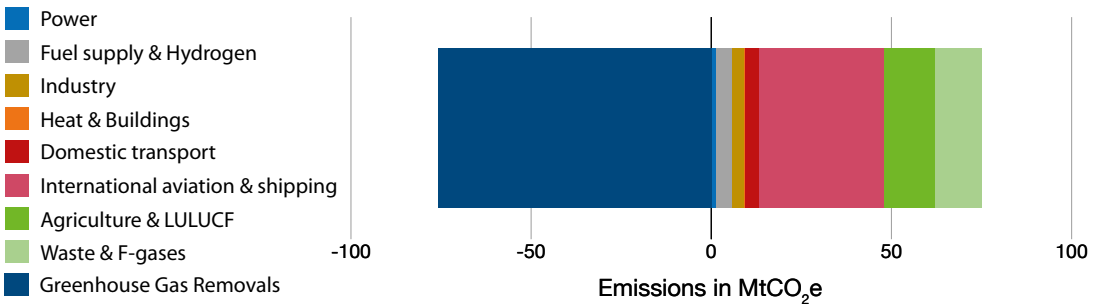


Figure 9: High resource scenario: residual emissions in 2050



2050 Scenario 3: High innovation

Explores a world in which successful innovations enable lower residual emissions to be reached in aviation, while higher capture rates increase the impact of carbon capture technologies, with higher levels of DACCS deployed over the 2040s.

In scenarios 1 and 2, end users of energy such as transport, industry, and buildings are decarbonised extensively, while accounting for residual emissions in aviation and baseline assumptions on the technological potential for carbon capture. In this scenario more optimistic assumptions around carbon capture and aviation, such as the availability of sustainable fuels at scale and zero emission aircraft, cause a divergence from scenarios 1 and 2 in the deployment of certain technologies. With lower residual emissions in aviation and improvement in capture or negative emission potential, end use sectors such as transport, buildings, agriculture and industrial dispersed sites can decarbonise to a lesser extent. This pathway sees electricity and low carbon hydrogen generation requirements in between the two scenarios explored previously, at 670 TWh and 330 TWh respectively.

Figure 10: High innovation scenario: energy generation and end uses in 2050

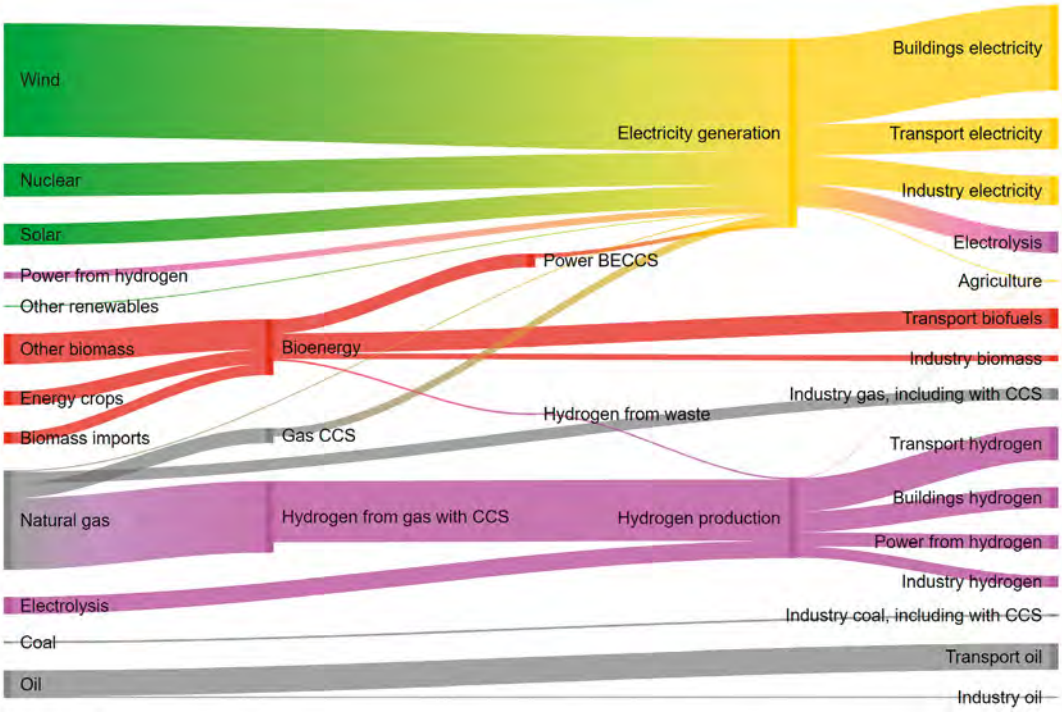
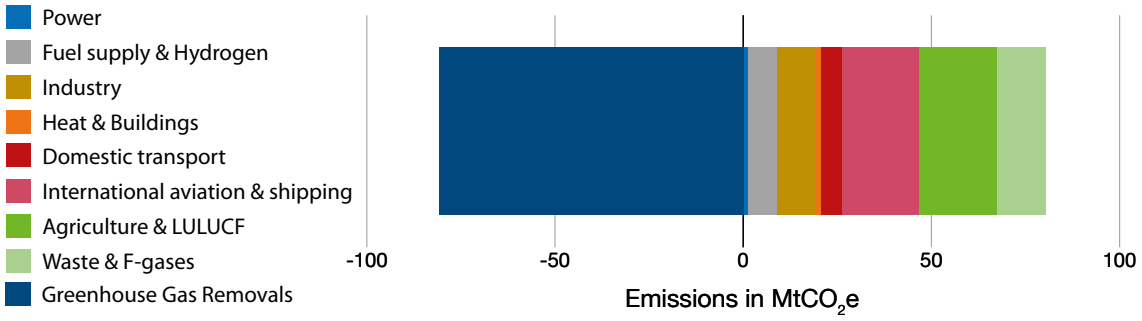


Figure 11: High innovation scenario: residual emissions in 2050



Insights from potential 2050 outcomes for net zero journey

16. Despite the uncertainties, we can draw some broad conclusions from the illustrative scenarios above to help shape our approach to net zero:

- Extensive decarbonisation is required across transport, buildings, and industry, given the need to account for possible residual emissions in agriculture, aviation, waste, and heavy industry and possible limitations on deployment of greenhouse gas removals;
- Given this, extensive energy efficiency measures across these sectors are likely to be beneficial to bring down energy demand and cost across the system. Every scenario sees overall energy demand from end use sectors reduce substantially;
- Different technologies for these sectors can be accommodated (for example, predominantly electric heat pumps or hydrogen for heating), meaning wide ranges of possible electricity and hydrogen demand remain plausible;
- Both electricity and hydrogen demand grow significantly from today, and need to be produced with very low levels of emissions by 2050. Biomass also becomes a key energy carrier to enable engineered removals and support low carbon fuel production;
- Given the need to plan for some residual emissions, it is appropriate to plan for use of greenhouse gas removals. The carbon capture processes needed for this are likely to play a significant role in wider decarbonisation, for example in power;
- Primary energy sources increase in number and diversify, including a range of renewables, and from biomass and waste. This diversified system for energy generation also becomes more interdependent to ensure security of supply.

Indicative delivery pathway to 2037

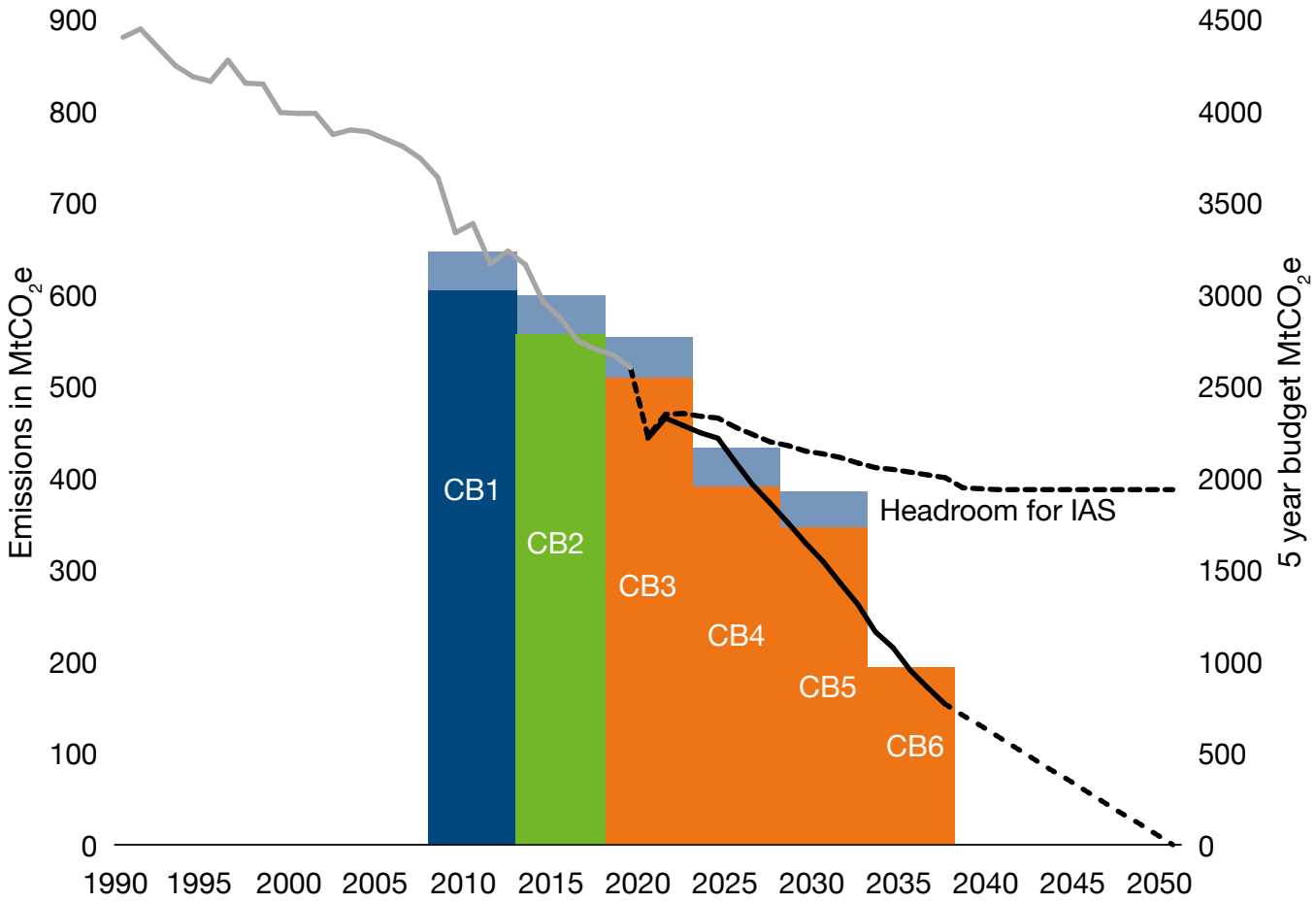
An indicative pathway meeting our emissions targets up to Carbon Budget 6

17. Drawing on the insights from our illustrative 2050 scenarios, we have developed a delivery pathway: an indicative trajectory of emissions reductions which meets our targets up to the sixth carbon budget ending in 2037. This is broadly consistent with all three 2050 scenarios and follows decarbonisation that we aim to achieve through this Strategy. The uncertainties inherent in our 2050 scenarios also apply to our 2037 delivery pathway. It is designed only to provide an indicative basis on which to make policy and plan to deliver on our whole-economy emissions targets. The exact path we take is likely to differ and must respond flexibly to changes that arise over time.

18. The pathway is based on our understanding now of the potential for each sector to reduce emissions up to 2037, considering the balance between sectors that is optimal for the entire economy in terms of delivery and cost. Emission reductions beyond our existing policies combine evidence on theoretical potential for abatement with judgements about barriers to delivery, the rate at which low carbon options could be adopted in practice and timescales for key decisions. We take an economy-wide view, including to balance end use sector demands with supply side considerations, such as infrastructure and the operation of the electricity and other fuel supply sectors.

19. As a general principle, our indicative pathway to 2037 prioritises emissions reductions where known technologies and solutions exist and thereby minimises reliance on the use of greenhouse gas removals to meet our targets. It is designed to drive progress in the short-term, while creating options in a way that seeks to keep the range of options presented in the illustrative 2050 scenarios open. The *Embedding Net Zero in Government* chapter sets out how Government will monitor progress to ensure we stay on track for our emissions targets and respond to developments affecting our long-term goals.

Figure 12: Indicative emissions reductions to meet UK carbon budgets and NDC[10]



2025 – 55% reduction (excluding international aviation and shipping emissions)

2030 – NDC target for at least 68% reduction (excluding international aviation and shipping)

2035 – 78% reduction (including international aviation and shipping)

2050 – 100% reduction

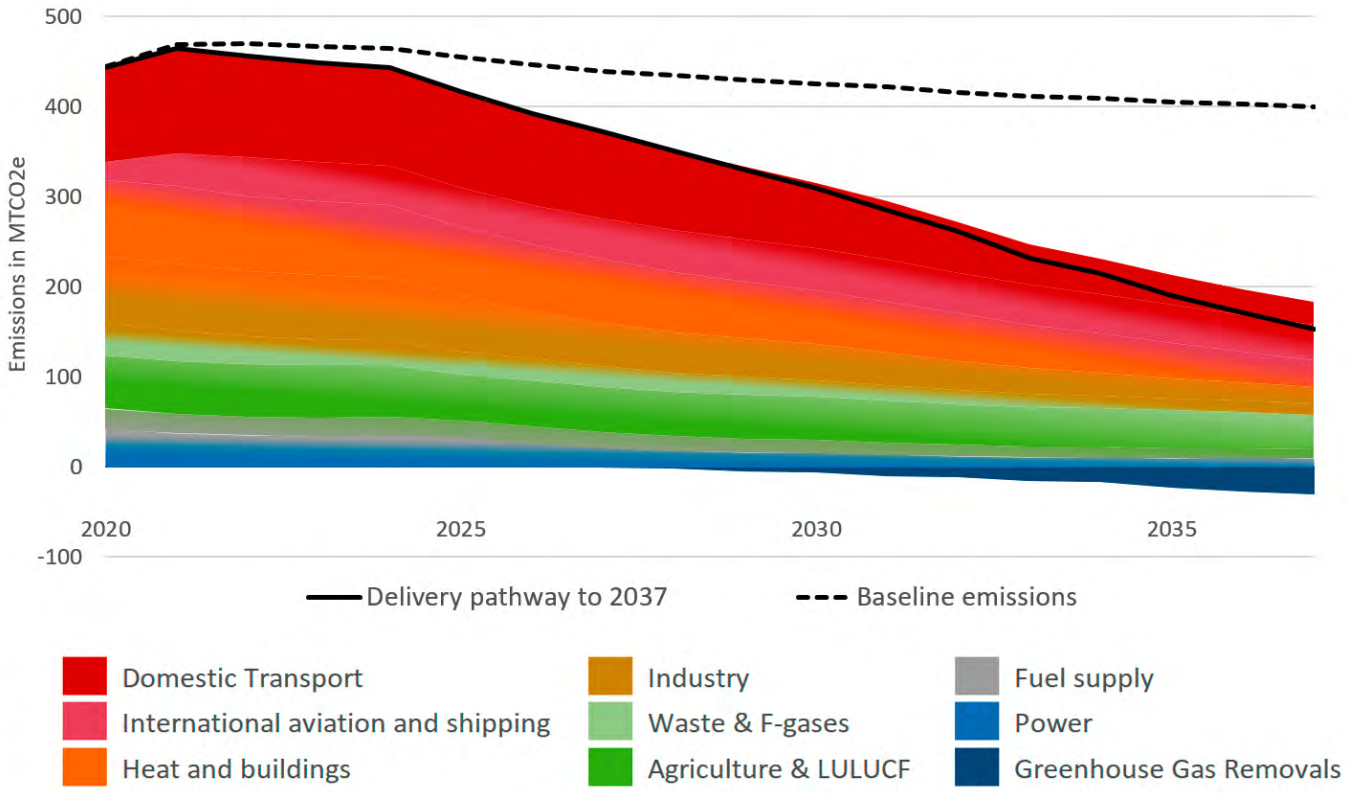
To meet whole-economy net zero target

Indicative sectoral decarbonisation pathways

20. Broken down by sector, our indicative delivery pathway implies the reduction in emissions up to 2037. These indicative sector pathways, presented as ranges for residual emissions to reflect the inherent uncertainty, help to drive change and to plan how we can remain on track to meet our targets.

Given the interdependencies and interactions within and between sectors, the exact areas for emissions savings may shift, as our understanding increases. These pathways are therefore not predictions or targets: the emissions savings ultimately contributed by each sector are likely to differ as we respond to real-world changes.

Figure 13: Indicative delivery pathway to 2037 by sector



Source: BEIS analysis

21. The pathway considers that sectors have the potential to make progress at different rates, for example, depending on the availability and deployment of technological solutions; development of supply chains, financing, and infrastructure; and the need to overcome wider delivery barriers. These constraints and action to overcome them are summarised below and explored in more detail in subsequent chapters.

Sector	% of UK emissions (2019)[11]	Expected reduction by 2035 from 1990	Key features of the delivery pathway to 2037
Power	11%	80-85%	By 2035, all our electricity will need to come from low carbon sources, subject to security of supply, moving to a fully decarbonised power system whilst meeting a 40-60% increase in demand. Expected residual emissions will be limited to CCUS plants, unabated gas, and energy from waste. This means increased investment in the grid network, electricity storage solutions and flexible grid management, to ensure decarbonisation without risking security of supply.
Fuel supply and Hydrogen	5%	53-60%	Large potential from electrification of oil and gas installations and addressing venting and flaring in the existing fuel supply sectors where demand is expected to fall over time. Emissions savings in the incumbent fuel supply sector will be marginally offset by emissions expected from low carbon hydrogen and fuel production, which will enable significant emissions savings through fuel switching across a range of end use sectors. Hydrogen production is expected to establish in the 2020s before a significant ramp up in the early 2030s, using a range of production methods to meet demand.
Industry	15%	63-76%	Deep decarbonisation through resource and energy efficiency, fuel switching, and CCUS deployment are all required, starting with industrial clusters and major emitters, such as the steel sector. Decarbonisation of smaller and more dispersed sites will also be needed, placing demands on associated infrastructure.

Heat and Buildings	17%	47-62%	Addressing heat emissions will require a substantial increase in the uptake of low carbon heating up to 2035, when all new installations will be net zero compatible. In any heat pathway, improved energy efficiency – through investment in buildings fabrics and better product standards – will reduce overall energy use and costs. Advanced smart meters will inform consumers and businesses about their energy use, encouraging energy-saving behaviour.
Transport[12]	32%	47-59%	Road transport is transformed through increasing use of zero emission vehicles, driven in part by ending the sale of new petrol and diesel cars and vans by 2030 and supported by increasing the share of trips taken by cycling, walking, and public transport. Progress is expected to decarbonise aviation and shipping through efficiency improvements and the uptake of low carbon fuels. These will require international coordination.
Natural Resources	20%	39-51%	Increased afforestation and peat restoration contribute significantly, though with long lead-in times. By 2035, perennial energy crop and short rotation forestry can contribute significantly to carbon sequestration, with potential to support power, fuel supply, industry, and transport through BECCS and generation of biofuels. Waste emissions reduce with increased diversion of municipal biodegradable waste streams away from landfill, and potential savings from other parts of the sector, such as wastewater. Use and therefore emissions of F-gases continues to reduce in response to future control measures. Agriculture emissions are largely from livestock and nutrient management. The pathway assumes emissions will be reduced through improved and innovative farming practices.
Greenhouse Gas Removals	Not applicable		Deployment of BECCS and DACCS. Deployment dependent on development of UK CCUS infrastructure and the availability of suitable, sustainable, and low-cost biomass feedstocks.

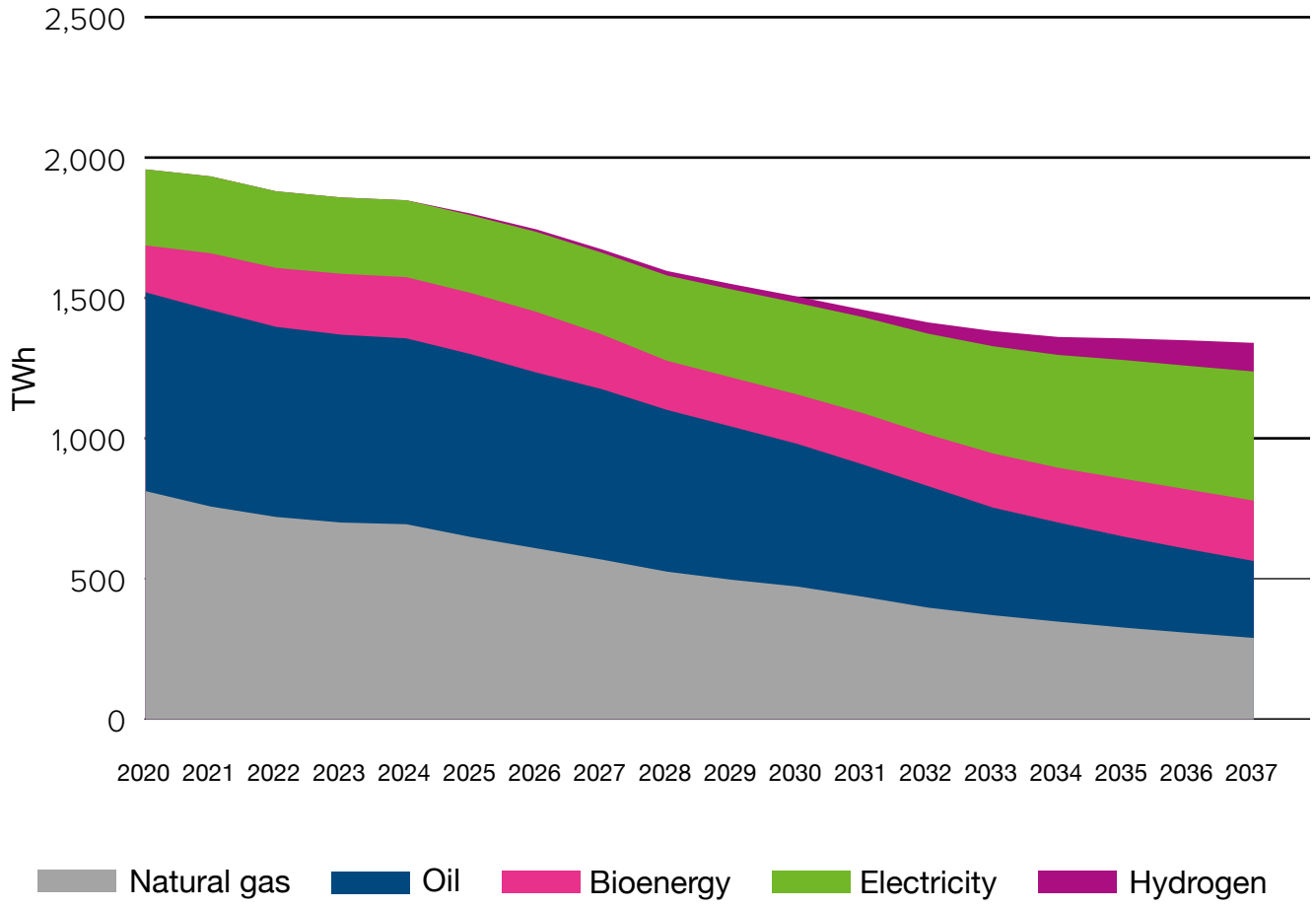
22. The changes we expect in sectors will evolve over time. In some cases, alternative measures within a sector could achieve broadly the same level of emissions abatement. In other cases, we will need to respond to strategic decisions that government makes in the future. One of the most significant decisions that will affect our pathway will be on the balance of types of low carbon heating solutions, mainly electricity and hydrogen, deployed in buildings. The *Heat and Buildings Strategy* commits to strategic decisions on the relative roles of hydrogen and electrification for on-grid homes by 2026 and the relevant sector chapter in this strategy explores alternative options that are consistent with the level of ambition implied by our delivery pathway.

Key energy changes and deployment implied by the delivery pathway

23. Assumed energy demand in our pathway is based on government's central assumptions about required technology uptake, with a variation to reflect the outstanding strategic decision on the potential role of hydrogen to heat buildings. We expect both natural gas and oil demand to more than halve by 2037 while overall, energy demand reduces significantly through increased efficiency and fossil fuels are replaced by new sources of energy. Electricity generation increases to meet a larger share of energy demand, and low carbon hydrogen grows from a near zero base to play a significant role from the 2030s.

24. Decisions in 2026 around hydrogen's role in providing heat in buildings will have a substantial impact on relative hydrogen and electricity demands – Figure 14 shows a scenario where hydrogen is not used to heat buildings, which is predominantly decarbonised via electrification through heat pumps. In a scenario where hydrogen has a more significant role in decarbonising heat in buildings, hydrogen demand would increase by 70 TWh by 2035 and electricity demand would decrease by 20 TWh (due to the high efficiency of heat pumps more hydrogen is required to produce the same amount of heat). Beyond heat, the indicative delivery pathway describes just one scenario for potential hydrogen demand in industry, transport, and power – the *UK Hydrogen Strategy* takes a wider view to consider greater ranges for hydrogen use in all sectors.[13]

Figure 14: Energy demands up to 2037 assumed by delivery pathway



Source: BEIS analysis

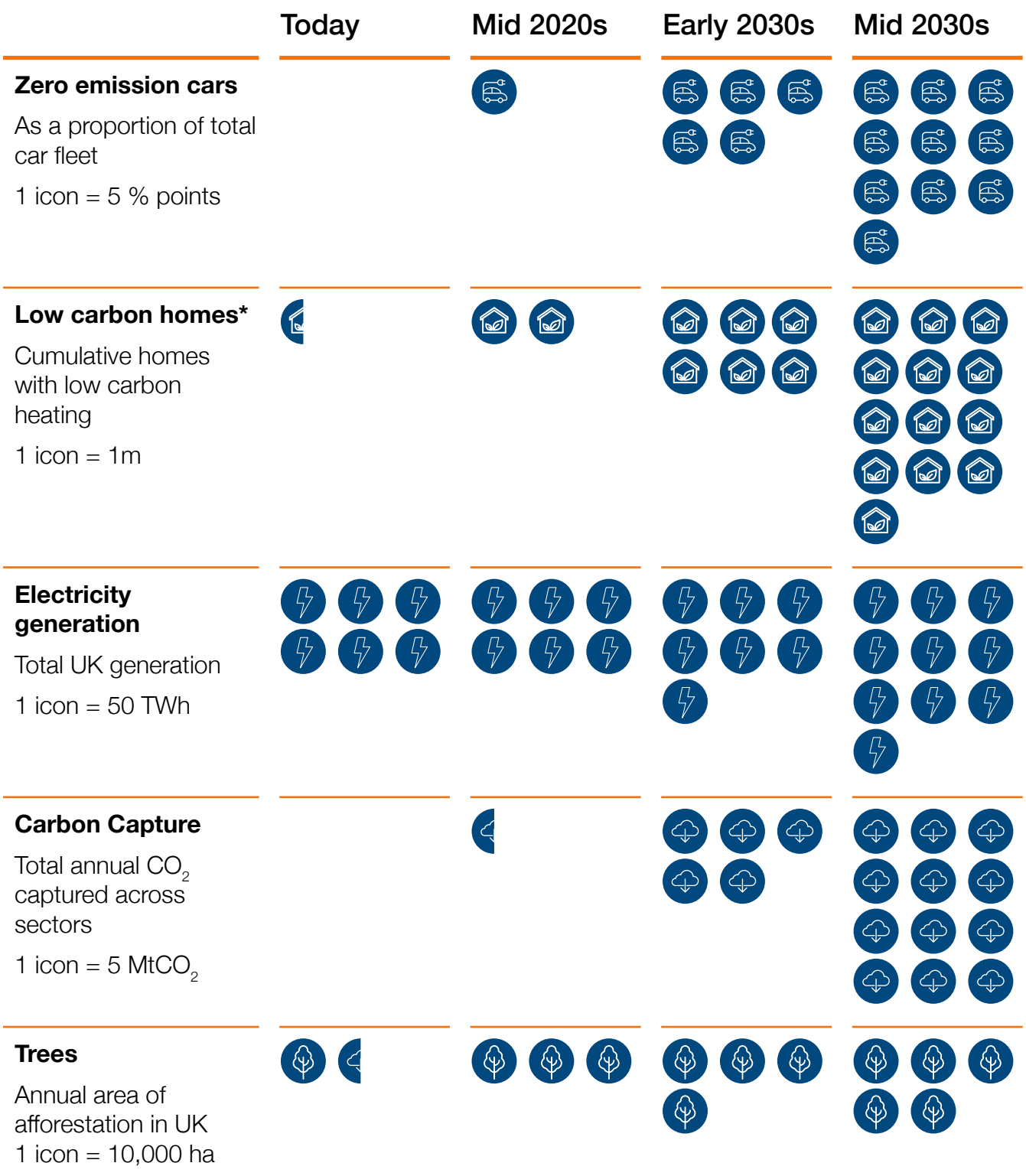
Note: for illustrative purposes, this shows energy demands in a scenario in which electricity is predominantly used to heat buildings. See the Technical Annex for hydrogen for heat scenario.

25. Meeting the increasing demand for low carbon energy across the economy relies on scaling up significantly, the new green technologies and energy carriers identified above. While the deployment of these will respond to changes over time, our indicative pathway suggests they are central to decarbonisation over the next 15 years:

- **Electricity** sees an expected 40-60% increase in demand by 2035, all met from low carbon sources to bring forward the government's commitment to a fully decarbonised power system by 15 years, subject to security of supply;
- **Hydrogen** production capacity ambition for 5 GW by 2030, which is expected to increase to around 10 or 17 GW by 2035 (depending on the role of hydrogen for heat);
- **Carbon capture** is expected to need to reach capacity for a total of ~20-30 $MtCO_2$ per year by the early 2030s across the economy – more than double what was set out in the *Ten Point Plan* – and at least ~50 $MtCO_2$ by the mid-2030s;
- **Biomass** is anticipated to need increases in feedstock supply from the 2020s to support BECCS deployment through various routes for use in 'hard-to-decarbonise' areas. These resources will be explored in the *Biomass Strategy.*

26. Figure 15 below shows some wider illustrative deployment of technologies or measures assumed in our pathway to demonstrate a sense of the scale and pace of change required. These are based on modelling assumptions, which are detailed in the *Technical Annex*, and do not represent targets – the delivery of such measures will depend on, and respond to, real-world change.

Figure 15: Illustrative examples of deployment implied by the delivery pathway



Note: For illustrative purposes, icons represent approximate and rounded figures from our modelling. Where there are ranges, an approximate central point has been shown.
** Homes with low carbon heating includes homes heated by heat pumps, hydrogen or connected to heat networks*

Essential activity driving the delivery pathway

27. It is, of course, impossible to predict every possible path to net zero that might arise over the next 30 years – we do not seek to do so. New innovations may emerge, enabling the market to move more quickly or at lower cost than expected, while in other areas progress may be hindered by unexpected deployment challenges as technologies are brought to scale. This Strategy does not attempt to ignore these uncertainties, but rather to plot a path which maintains flexibility in the future, while ensuring we do not delay the action we know is needed in the near-term. This aims to provide the certainty to drive forward investment and change, while allowing the market to respond to new opportunities and challenges which arise from the transition. The UK Emissions Trading Scheme is a crucial way in which we ensure that our pathway is rooted in cost-effective, market-led solutions.

UK Emissions Trading Scheme as a key driver of our path to net zero

The UK ETS, a 'cap and trade' scheme, is a market-based pricing mechanism to incentivise and control the reduction of emissions in a cost-effective way. A cap is set on the total amount of certain greenhouse gases that can be emitted by the sectors covered by the scheme over a given period. The cap is divided into allowances, and participants receive or purchase allowances which they can sell and buy with one another as needed. This UK ETS cap will reduce over time, providing a long-term market signal so companies can plan and invest in abatement accordingly – offering new trade and export opportunities. The cap is initially set 5% below the UK's notional share of the EU ETS cap for Phase IV of the EU ETS. We will consult in the coming months on an appropriate cap consistent with net zero.

The UK ETS acts as a cross-cutting policy lever to drive market-based abatement, incentivising industries to find the most cost-effective solutions to decarbonise. This ensures that, as industries develop lower carbon processes, our path to net zero adapts to cost-effective abatement routed in market-based solutions. We have committed to exploring expanding the UK ETS to the two thirds of uncovered emissions and we will provide a further update in due course. It remains important, however, that we develop policies which actively support and encourage sectors to decarbonise, rather than rely on applying an emissions cap and the consequent carbon pricing as our sole mechanism. Our delivery pathway provides a sound basis to underpin those policies to decarbonise, set out in the chapters that follow.

To mitigate the risk of carbon leakage, in which production and associated greenhouse gas emissions are offshored in ways that would not have happened if the pricing of emissions across jurisdictions was implemented in an equivalent way, we currently give at risk sectors a proportion of their allowances for free to reduce their exposure to the carbon price. We initiated a review of free allocation policy earlier this year with a call for evidence and plan to consult in the coming months, as part of a wider review into the UK ETS. This review will focus on how free allocations can be better targeted in line with a reduction to the overall cap, while still preserving the incentive to decarbonise.

28. Our analysis points to the following essential planks that we can be confident net zero will depend on. These underpin the chapters that follow in this Strategy.

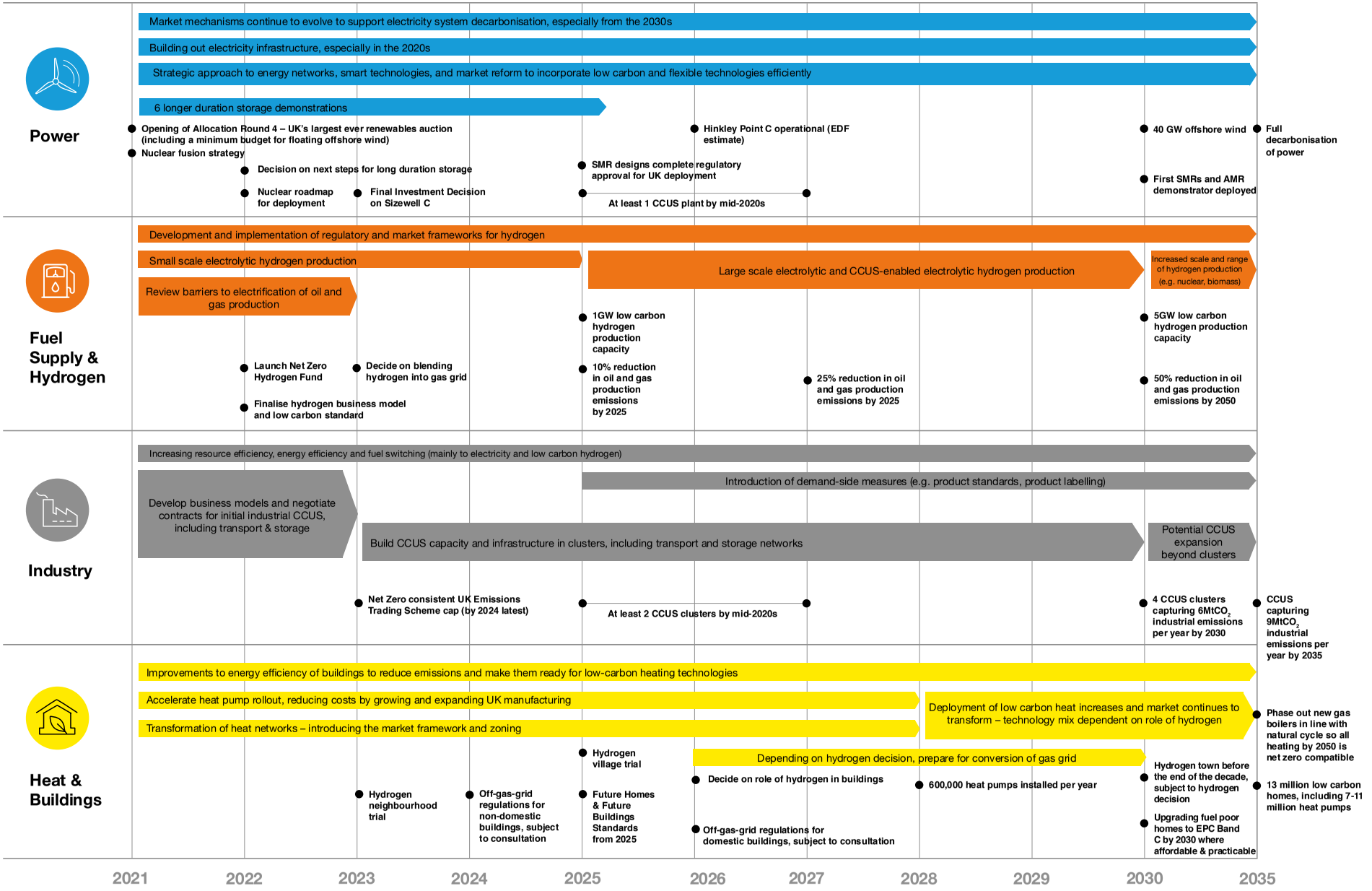
- **Integration of low carbon energy sources in a smart and flexible way.** For example, fully decarbonising our electricity system – in addition to renewables, nuclear, and power CCUS – could also rely on large-scale long duration storage, as well as use of BECCS and hydrogen-fired generation, to manage peaks in demand. Hydrogen could require substantial electricity for production via electrolysis, but in turn could help improve the efficiency of a high-renewables electricity system by using excess supply during periods of high generation and low demand, as well as further energy storage.
- **Increasing diversity of energy sources for end uses.** The removal of unabated fossil fuels from the system which currently supply most of the energy requirements in end use sectors, such as transport and heating, has potential to lead to a greater range of technologies and energy carriers playing a part in future. This could create some resilience, though there may not always be scope for direct substitution.
- **Increasing energy efficiency.** The low carbon energy system depends on overall energy demands reducing significantly. This means all demand sectors becoming far more efficient, through adoption of new technologies, better energy management, and direct investment in energy efficiency measures. Such measures can be considered 'low regret' to pursue throughout the transition and will, in turn, affect the level of energy supply and carbon capture required in the system.
- **Innovation for new technologies.** Green technology, including research and development into new options, is a cornerstone of the net zero journey. As well as the supply-side technologies discussed above, this also means new technologies in end use sectors – for example, installing zero carbon heating and delivering zero emission surface transport, while transforming the way we use natural resources, farm our land, and manage our waste. Different types of public and private support are required to develop nascent technologies and deploy known ones at scale. Government has a role to play in a financing offer, investment signalling, and developing business models.
- **Green investment.** Private investment will provide most of the financing needed to commercialise early technologies and scale low carbon sectors. We need additional net zero investment to reach c. £50-60 billion/year in the late-2020s and 2030s. However, public finance and public finance institutions will provide much of the early investment, intervention, and signalling that will create the conditions for an acceleration of net zero investment. This will also generate significant financial savings if achieved and accompanied by effective policy, thereby lowering the cost of capital for investment.
- **Demand-side changes and public engagement.** The rollout of low carbon solutions relies on positive public reception and demand to adopt them. Consumers need to have access to the right technologies, understand their benefits, and have confidence that they will be protected if they use them. The deployment of technologies should also respond to their reception by consumers, and go with the grain on consumer behaviour and trends. We also need our workforce to have the skills to meet increasing demand, including in areas such as housing retrofit, heat pump installation, electric vehicle manufacturing, charge

point installation and forestry. More widely, low carbon and environmental practices will require people and businesses to make green choices, and government has a role to play in making these as easy, attractive, and accessible as possible. The net zero journey must be a joint one and will be affected by how engaged and supportive the public are.

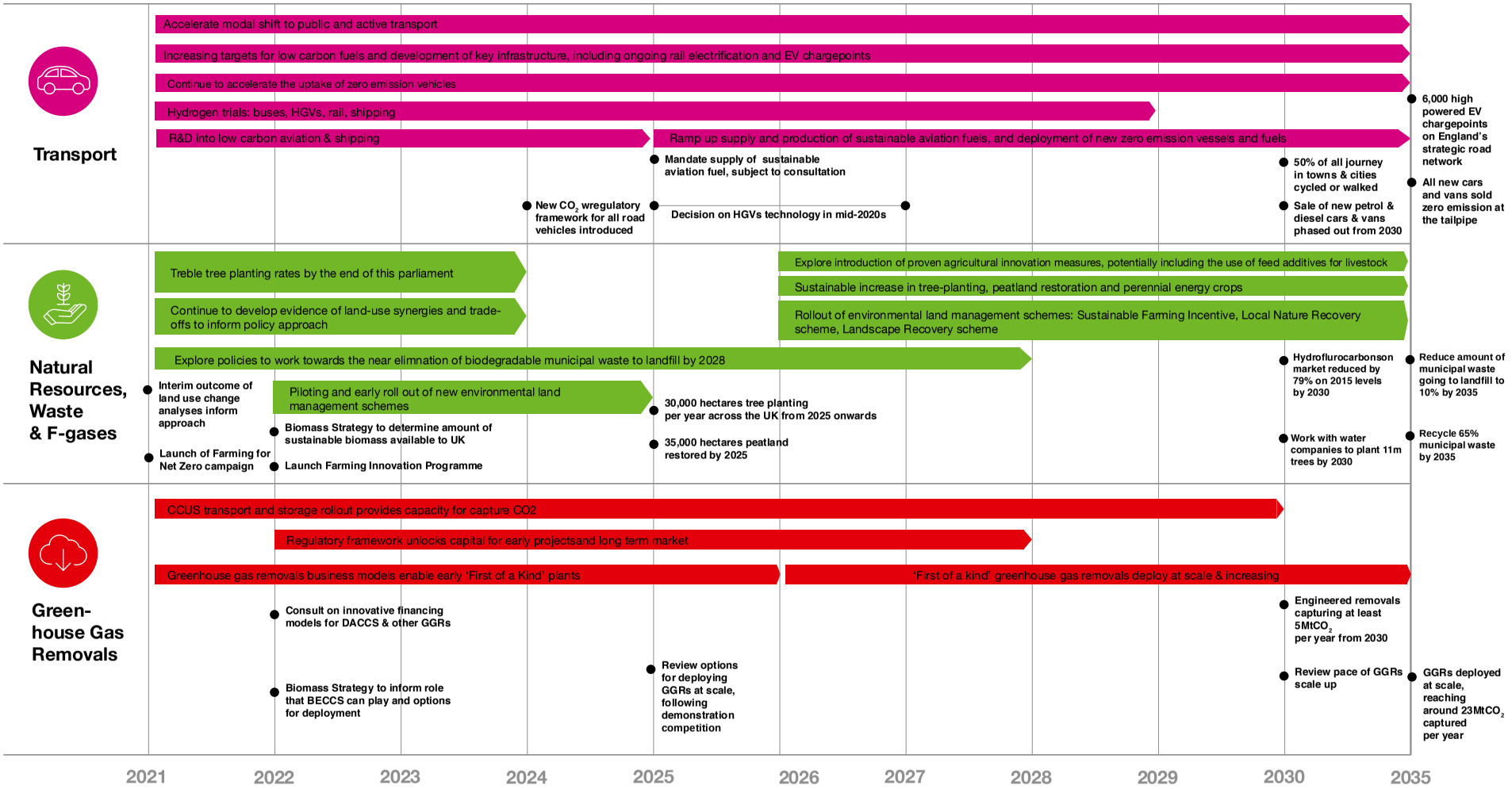
- **New standards and regulation.** In certain areas government will need to support and complement market-led decarbonisation with standards and regulation to ensure that, where appropriate, green options are pursued, while high carbon options are phased out. This will help to accelerate low regrets areas like energy efficiency, such as ensuring our homes are built to new standards, and high impact areas like zero emission vehicles. It will also ensure suppliers of higher-carbon technologies and fuels provide low carbon alternatives, driving deployment at scale.
- **Planning and infrastructure.** Low carbon solutions rely on transforming the infrastructure needed to deliver them. Increasing electricity generation needs to be accompanied by building out a flexible grid. Alongside dedicated hydrogen infrastructure, new CO_2 transport and storage infrastructure is needed for the use of CCUS which will require investment of around £15 billion from now to the end of the Carbon Budget 6 period. We need to ensure that low carbon energy generation can be connected to sources of demand geographically, which means improving knowledge of local circumstances and opportunities for generation. We also recognise the importance of the planning system to common challenges like combating climate change and supporting sustainable growth.
- **Sustainable use of resources.** Net zero will mean maximising the value of resources within a more efficient circular economy. It will need a significant increase in the use of certain types of resources – critical minerals like lithium, graphite, and cobalt, as well an increased demand on resources like copper and steel – from manufacturing green technologies to building large-scale infrastructure. This will require new robust supply chains and provide economic opportunities, but there will be environmental trade-offs, and potential negative impacts on habitats, biodiversity, and water resources to be managed carefully. For example, ammonia emissions from anaerobic digestion, which can use waste as a feedstock, can also affect biodiversity and health.
- **Understanding land use trade-offs.** Like other resources, our land is finite and competition for it will need to be managed as we rely on natural resources and use land for multiple new purposes, such as perennial energy crops and short rotation forestry for energy generation, while allowing for afforestation and peatland restoration to sequester and avoid emissions. We will also need to ensure net zero is compatible with wider uses of land such as agriculture, housing, infrastructure, and environmental goals. These land use challenges are exacerbated by the impact of climate change on the availability of productive land and water in future.

29. These features underpin the critical activity driving decarbonisation across sectors of the economy. A summary is provided below up to 2035, which is not exhaustive but focuses on the new technologies which need to be developed and deployed over the next decade. Policies and proposals to detail *how* this activity is achieved are set out in subsequent chapters.

Figure 16: high-level essential activity across sectors to 2035



Note: Markers indicate the year milestones will occur rather than the precise point in a given year, while arrows of activity are inclusive of the years in which they start and finish



Note: Markers indicate the year milestones will rather than the precise point in a given year, while arrows of activity are inclusive of the year they run to start and finish

Endnotes

1 BEIS analysis (2021), 'Final UK greenhouse gas emission national statistics: 1990 to 2019', https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-national-statistics-1990-to-2019

2 HM Treasury (2021), 'Net Zero Review: Final Report'.

3 OBR (2021), 'Fiscal Risks Report', https://obr.uk/frr/fiscal-risks-report-july-2021/

4 BEIS (2021), 'Impact Assessment for the sixth carbon budget', https://www.legislation.gov.uk/ukdsi/2021/9780348222616/impacts

5 Production methods include: electrolysis, which splits water into hydrogen and oxygen using electricity; steam methane reformation with CCUS, which uses heat, steam, and catalysts to break methane (from natural gas) into hydrogen and carbon dioxide which is then stored underground; and biomass gasification with CCUS, where heating biomass in special conditions produces a mix of gases including hydrogen and carbon dioxide which is used or permanently stored.

6 BEIS analysis based on 2019 data from the BEIS, *Digest of UK Energy Statistics*, https://www.gov.uk/government/collections/digest-of-uk-energy-statistics-dukes#2021

7 These scenarios have been developed using whole system cost-optimisation modelling (UK TIMES) to produce a feasible range of least-cost solutions and deployment requirements for given emissions targets.

8 Terrawatt-hour is a unit of energy equal to one trillion watts for one hour to indicate energy generation and demand.

9 Emissions from Greenhouse Gas Removals only include engineered removals. Nature-based solutions, such as afforestation, are included in the Agriculture and LULUCF subsector. For further detail see the Natural Resources, Waste & F-Gases and Greenhouse Gas Removals chapters.

10 Estimates of historical UK GHG emissions are revised annually to incorporate methodological improvements, updated data and changes to international guidelines. The percentage reductions implied by CB levels are therefore subject to change.

11 BEIS analysis (2021), 'Final UK greenhouse gas emission national statistics: 1990 to 2019', https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-national-statistics-1990-to-2019

12 Transport emissions include emissions from domestic transport and international aviation and shipping.

13 BEIS (2021), 'UK Hydrogen Strategy', https://www.gov.uk/government/publications/uk-hydrogen-strategy

Reducing Emissions across the Economy

Chapter 3

3i. Power

Delivering a decarbonised power system by 2035

Our Key Commitments

- Take action so that by 2035, all our electricity will come from low carbon sources, subject to security of supply, bringing forward the government's commitment to a fully decarbonised power system by 15 years.
- Accelerate deployment of low-cost renewable generation, such as wind and solar through the Contracts for Difference scheme by undertaking a review of the frequency of the CfD auctions.
- Deliver 40GW of offshore wind, including 1GW of innovative floating offshore wind by 2030.
- Implement the Dispatchable Power Agreement (DPA) to support the deployment of first of a kind power CCUS plant(s).
- Secure a final investment decision on a large-scale nuclear plant by the end of this Parliament whilst taking measures to inform investment decisions during the next Parliament on further nuclear projects as we work towards our net zero target.
- Adopt a new approach to onshore and offshore electricity networks to incorporate new low carbon generation and demand in the most efficient manner, taking account of the environment and local communities.
- Deliver the actions in our recent *Smart Systems and Flexibility Plan and Energy Digitalisation Strategy* to maximise system flexibility.
- Provide £380m for our world-leading offshore wind sector, investing in supply chains, infrastructure and early-coordination of offshore transmission networks, securing jobs and benefitting communities across the UK.
- Reform system governance so that the whole system can achieve our net zero ambitions and meet consumers' needs.
- Drive market-wide rollout of smart meters with a new four-year policy framework that introduces fixed minimum annual installation targets for energy suppliers from 1 January 2022.
- Consider whether broader reforms to our market frameworks are needed to unlock the full potential of low carbon technologies to take us all the way to net zero.
- Ensure that consumers pay a fair, affordable price for their energy, and can engage with a retail energy market that offers the products and services required to make choices that support net zero.

- Ensure the planning system can support the deployment of low carbon energy infrastructure.
- Explore the system need and case for further market intervention for long duration storage and hydrogen in power.

Progress to date

1. The transformation of the power sector over the last 30 years provides a strong basis on which to move forward, on our way to reaching net zero emissions by 2050 across the UK economy. Decarbonising the power sector has led the UK's efforts to reduce GHG emissions overall.

2. In 2019, net UK GHG emissions from the power sector totalled 58 $MtCO_2e$ and accounted for 11% of total net UK GHG emissions.[1] This is a reduction of 72% between 1990 and 2019. In 1990, the power sector accounted for 23% of UK GHG emissions.[2] This has largely been achieved through natural gas generation and renewables displacing coal, and more energy efficient appliances contributing to the reduction of electricity demand. Today, the country gets over half of its power from low carbon technologies.

3. In 2020, we published the *Ten Point Plan for a Green Industrial Revolution* and the *Energy White Paper*, including commitments to put the power sector on an ambitious decarbonisation pathway over the next decade. Since then we have launched a £17.5 million competition to support innovative floating wind ideas for industry and initiated this year's Contract for Difference allocation round, with a £200 million budget for offshore wind and £24 million for floating offshore wind. On delivering new and advanced nuclear power, we have committed to reaching a final investment decision on a large-scale nuclear plant this parliament, subject to value for money and approvals. We are in negotiations with the developer on Sizewell C project in Suffolk. We have since taken further steps: in June, we announced that phasing out of unabated coal generation will be brought forward by one year, to October 2024.[3] In July, we published the Smart Systems and Flexibility plan 2021 and the UK's first Energy Digitalisation Strategy, jointly developed with InnovateUK. Our approach includes measures to facilitate flexibility from consumers, removing barriers to flexibility on the grid including long duration storage, reforming markets to reward flexibility, and digitalising our energy system.

Net zero transition and opportunities for the sector

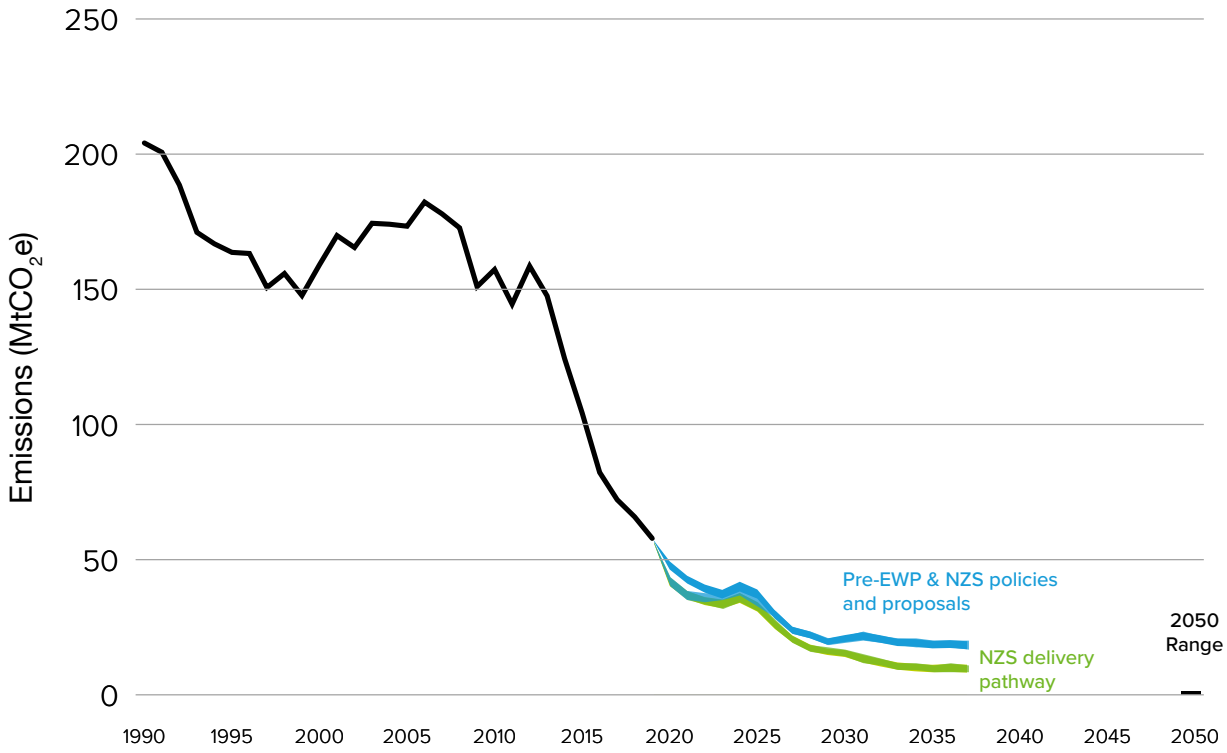
Our 2050 vision and how we get there

4. Reliable and affordable power is a foundation of a modern industrial economy. It is also critical in decarbonising the economy and achieving our net zero goal cost effectively. Although ambitious decarbonisation is required in every sector, deep reductions in emissions from power could offset the need for relatively more expensive decarbonisation efforts elsewhere. Our exposure to volatile gas prices shows the importance of our plan for a strong home-grown renewable power sector to strengthen our energy security into the future.

5. The next 30 years will see a decisive and permanent shift away from the use of unabated oil and gas as the engine of our economy. In the *Energy White Paper*, published in December 2020, we set out what this means for the power sector.[4] Low carbon power is expected to become the predominant form of energy in 2050. It will account for approximately 50% or higher share of final energy consumption, up from 10% in 2019,[5] as it displaces petrol in light vehicles and gas for heat in homes.

6. Based on our whole-system modelling, by 2050, emissions associated with power could need to drop by 95-98% compared to 2019, down to 1-3 $MtCO_2e$. In the interim, to meet our NDC and CB6 targets, we expect emissions could fall by 71-76% by 2030 and 80-85% by 2035, compared to 2019 levels. These figures are based on an indicative power sector pathway contributing to the whole-economy net zero and interim targets (see figure 17 below).

Figure 17: Indicative power emissions pathway to 2037



Source: BEIS analysis

7. Even with major improvements in overall energy efficiency and increased flexibility in the energy system, this could represent a potential doubling of demand. This would require a four-fold increase in low carbon electricity generation and significant expansion of the networks that transport it to where it is needed.

8. We will need to achieve this whilst maintaining a reliable and affordable supply of power. We cannot compromise the essential resilience and reliability of the energy system. It is essential for the critical services we rely on – from hospitals to traffic lights and mobile devices – and its reliability will be fundamental to consumer confidence in adopting new ways of powering their cars or heating their homes.

9. Our understanding of the role of power in 2050, what the system will look like and the level of demand it will need to meet, will evolve over time. This will be informed by the approach to decarbonising other sectors, such as the extent to which hydrogen is used for heat, and what we learn about the cost and achievability of those approaches. It will also be informed by the availability and costs of GHG removal technologies, such as bioenergy with carbon capture and storage (BECCS) and direct air carbon capture and storage (DACCS).

10. The *Energy White Paper* set out our goal of a fully decarbonised, reliable, and low-cost power system by 2050. CB6 represents a very significant increase in the pace of power sector decarbonisation, coupled with increased demand due to the accelerated action in other sectors dependent on low carbon electricity. Although the *Energy White Paper* envisaged achieving an overwhelmingly decarbonised power system during the 2030s, we have since increased our ambition further. By 2035, all our electricity will need to come from low carbon sources, subject to security of supply, bringing forward the government's commitment to a fully decarbonised power system by 15 years, whilst meeting a 40-60% increase in demand.

11. However, the *Energy White Paper's* fundamental approach remains unchanged. A low-cost, net zero consistent electricity system is most likely to be composed predominantly of wind and solar generation, whether in 2035 or 2050. To ensure the system is reliable, intermittent renewables need to be complemented by known technologies such as nuclear and power CCUS, and flexible technologies such as interconnectors, electricity storage, and demand-side response. These flexible technologies can help to minimise the amount of generation and network capacity needed to meet our demand needs, for example, by matching new sources of demand to renewable generation both nationally and locally. To do this, the new critical supply chains for these technologies also need to be resilient to ensure the UK can build the capacity it needs for a reliable system.

12. Our Carbon Budget 6 trajectory suggests that we will need to build all of these technologies at, or close to, their maximum technical limit, to meet the twin challenge of accelerating decarbonisation and servicing increased demand. This represents a considerable delivery challenge. While unabated gas generation currently plays a critical role in keeping the UK electricity system secure and stable, it will be used less frequently in the future, running only when the system most needs it for security of supply.

13. The government is actively taking steps to bring forward low carbon technologies capable of replicating the role of unabated gas in the electricity system, including CCUS-enabled generation, hydrogen-fired generation, BECCS, and flexible storage. We are also bringing forward measures to ensure that any new build combustion power stations, including gas, can convert to clean alternatives in the future. We issued a call for evidence on our plans for *Decarbonisation Readiness* in the summer and subject to feedback on the proposals and parliamentary time, we aim to implement these requirements by 2023.[6]

14. The use of hydrogen to generate electricity can reduce reliance on unabated natural gas. It can also provide additional system flexibility if produced through electrolysis and where there is hydrogen storage. This could contribute to energy security, lowering emissions and system costs. There are trade-offs between the deliverability, optimal fit, and other benefits of emerging technologies versus known technologies. Waiting for emerging technologies before deciding to deploy nuclear and power CCUS at scale could put our CB6 and net zero ambitions at risk. Over the next decade we need to continue to deploy all known low carbon technologies at scale to ensure optionality is maintained, whilst developing new options to mitigate delivery risk and reduce costs.

15. However, a reliable power system is not only about having a balanced mix of generation technologies. We also need to ensure that the networks can transport electricity to where it is required in a cost-effective manner, and to enable crucial system services such as frequency response. Markets should determine the best solution for such a system. We are not targeting a particular solution but will rely on competition to spur investment in technologies which are cheaper and more efficient; and on innovation to reduce the cost of existing options. The government's role is to ensure a market framework which encourages effective competition and delivers an affordable, secure, and reliable system that is, consistent with net zero emissions. We will intervene to address any potential market failures and continue to invest in innovation which helps commercialise new technologies and increase the options available to meet this challenge.

16. The CCC's *Independent Assessment of UK Climate Risk* (June 2021)[7] set out that climate change will likely result in more extreme weather that has the potential to negatively impact GB's power sector. We continue to work closely with industry, regulators, sector bodies, and other stakeholders to ensure that our electricity system is resilient and secure, including to the impacts of climate change.

Seizing new opportunities

17. Transforming the power system offers significant opportunities for UK businesses to exploit technology and know-how in domestic and global markets. Investments in innovation will enable new technologies to deliver benefits to the system and this will be crucial to help us meeting our carbon reduction targets. Innovation will create value by accelerating the commercialisation of low carbon power systems. It can bring costs down, enable us to preserve and develop options and bring forward information to reduce future uncertainty. Renewable energy can also help contribute to our industrial 'SuperPlaces', providing plentiful low carbon electricity to enable the low carbon technologies such as hydrogen, which also offers a renewed era for our industrial heartlands.

18. To fully decarbonise the power sector at the pace we have set out whilst meeting increasing demand, total public and private investment of £280-400 billion is needed in generation capacity and flexible assets – around £150-270 billion of this reflects increased ambition from Carbon Budget 6. The electricity transmission and distribution networks will also both require significant expenditures with an additional £20-30 billion required by 2037 to maintain and reinforce Great Britain's electricity network.

19. The offshore wind sector alone will see over £20 billion in private investment by 2030, and in the last six months around £1.5 billion of investment has already been announced. This includes two purpose-built manufacturing ports and five offshore wind turbine component factories.

20. Decarbonising the power sector will regenerate communities and open up new employment opportunities right around the UK. Based on current estimates, policies and proposals to reduce emissions in the sector could support up to 59,000 jobs in 2024 and up to 120,000 jobs in 2030.

21. For example, the offshore wind sector could support up to 60,000 jobs by 2030, including in the supply chain, with further employment opportunities during construction. Increased deployment of storage and demand side flexibility could support up to 7,000 jobs, levelling up the power sector across Great Britain.

Policies and proposals

Prioritising critical system enablers

22. Crucially, a whole system approach puts more emphasis on addressing critical system enablers. These measures will integrate different low carbon technologies into a coherent, single entity and optimise the system most efficiently and cost-effectively, in the interest of consumers.

23. This means adopting a new approach to developing and delivering electricity networks, both onshore and offshore, to ensure that new low carbon generation can be connected to growing sources of demand. The Offshore Transmission Network Review (OTNR) is transforming how the connections for offshore wind and other offshore transmission infrastructure is planned, designed, and delivered with changes being progressed across the near, medium, and long term. Coordination in how we connect offshore wind can potentially save consumers between £3-6 billion by 2050 and reduce the number of assets and onshore landing points by up to 50%.[8] Ofgem has recently consulted upon regulatory changes to enable offshore coordination for in-flight projects, including potentially allowing anticipatory investment. BEIS is currently consulting on a new long-term policy regime for offshore networks. Onshore, we welcome electricity networks' efforts to invest strategically ahead of need in new capacity, where it is efficient to do so, as well as Ofgem's work to create a price control framework which allows and encourages this. In recognition of the essential role of electricity networks as an enabler of net zero, we will publish, jointly with Ofgem, an Electricity Network Strategy, which will set out how we will facilitate an agile, flexible onshore network that allows the rapid, transformational change required while responding to consumer and energy system needs. This will include our plans to introduce competition in the building, ownership, and operation of onshore network assets, on which we published a consultation in August.

24. We will look to deliver these changes whilst minimising the impacts on citizens and communities. Network companies work closely with local and transport authorities and are incentivised to deliver network upgrades as efficiently as possible both domestically and through the RIIO price control framework, for example by laying larger cables to avoid reopening roads twice. Connection upgrades are becoming increasingly digitalised for domestic customers looking to install a heat pump or electric vehicle chargepoints. In cases where network upgrades require a temporary power disruption, network companies are required to give notice to customers of planned outages. Advice and ongoing information is also provided including support for vulnerable customers, such as providing generators for customers who are medically dependent on electricity.

25. The deployment of smart technologies and flexibility will underpin our energy security and the transition to net zero. Flexibility from technologies such as energy storage, smart and bidirectional charging of electric vehicles, flexible heating systems, and interconnection could save up to £10 billion per year by 2050 by reducing the amount of generation and network needed to decarbonise.[9] These technologies offset the need for more expensive capital investment in traditional infrastructure, as well as help optimise how efficiently the system operates by better integrating intermittent renewables into the system and reducing peak demand.

26. A key enabler for demand side flexibility will be smart meters, which enable innovative products and services such as smart time-of-use tariffs. These tariffs reward consumers financially for using energy outside peak times, when demand is low or when there is excess generation available. Technologies such as electric vehicles and smart appliances can be automatically programmed to take advantage of cheaper rates, cost-effectively integrating them with renewable energy sources and saving consumers money. At the end of June 2021, there were 25.2 million smart and advanced meters in homes and small businesses across Great Britain, representing 46% smart coverage.[10]

27. The *Smart Systems and Flexibility Plan* sets out a vision, analysis, and actions for delivering a smart and flexible energy system. We will facilitate flexibility from consumers and remove barriers to flexibility on the grid, both for small-scale and large-scale long-duration electricity storage, as well as driving policy to increase interconnector capacity. The Plan also sets out actions to improve market design and coordination so that flexibility providers can secure revenues across multiple markets. Data and digitalisation are a core aspect of the future system; we have set out a strategic approach to digitalisation and opening data across the energy sector through the *Energy Digitalisation Strategy*.

28. This transformation of the energy system means our approach to system governance needs to evolve to help the whole energy system achieve our net zero ambitions and meet consumers' needs at the least cost. BEIS and Ofgem have jointly consulted on the future of system operation.[11] We set out proposals for an expert and impartial Future System Operator (FSO) with responsibilities across both the electricity and gas systems, to drive progress towards net zero while maintaining energy security and minimising costs for consumers. These proposals set out how detailed expertise gained from system operation could be used to provide a whole energy system approach to coordination and planning while ensuring that market participants and government has confidence in the impartiality of the FSO's advice and facilitation of markets, competition, and system development. We have also, jointly with Ofgem, consulted on the future governance of energy codes, which set out the detailed technical and commercial rules for the system, building on the government and Ofgem's joint review of code governance and the work of the independent panel on engineering standards.[12]

29. Significant progress towards net zero can happen, and is already happening, within our existing market framework. This combines markets for wholesale power, balancing, and system services with a Contracts for Difference scheme (CfD) for low carbon generation and a capacity market to ensure security of supply. We have recently published a Call for Evidence on actions to better align the capacity market with net zero,[13] including potential actions to encourage the participation of more low carbon capacity. However, it will be necessary to consider whether broader reforms to our market frameworks are needed to unlock the full potential of low carbon technologies to take us to net zero.

30. Throughout the transition, consumers should pay a fair, affordable price for their electricity, and be able to engage with a retail energy market that offers the products and services that allow them to make choices that support net zero. To support these aims, the government is considering what reforms to the retail energy market are needed to support progress to net zero through the 2020s, including the role of suppliers and how they are regulated.[14] In considering these reforms, the government will take account of the lessons of the current market, in which high gas prices have placed financial pressures on suppliers. In the future, the market will need to be resilient and sustainable, and continue to protect consumers as we move to a net zero system. The market will also need to remain competitive, and consumers will need to be engaged with positive choices about their energy supply. To support these choices, consumers should receive accurate information about the carbon content of their energy products, and we will consider the case for reforming the framework which underpins green electricity tariffs and wider environmental carbon accounting schemes.

31. We will also need to address cross-cutting, overarching enablers such as ensuring the planning system has the capacity to support the deployment of low carbon energy infrastructure, while also representing the interests of the environment and of the communities which host this infrastructure. We will do this by updating the energy National Policy Statements to provide greater clarity on the need and urgency for low carbon infrastructure, exploring ways of streamlining processes through the Nationally Significant Infrastructure Projects (NSIP) reform programme and addressing issues at a strategic level, for example through the Offshore Wind Enabling Actions Programme.

32. We will need to consider how low carbon energy infrastructure can be deployed at an unprecedented scale and pace sympathetically alongside the interests of communities and consistent with our obligations to a sustainable environment, both land-based and marine. We will also need to streamline the consenting process to ensure that the deployment needed to stay on track for our 2030 and CB6 targets is delivered.

33. In addition, we will need to grow our supply of skilled workers and further strengthen the UK supply chain to service the demands of energy infrastructure, creating economic opportunity for citizens and communities across the UK. The £160 million announced in the *Ten Point Plan*, has substantially grown our industrial capabilities in the offshore wind sector. To help keep us on track for our Carbon Budget 6 and net zero targets we will need to deploy substantial volumes of floating offshore wind. Our target of 1 GW floating offshore wind by 2030 is a stepping stone to further growth in the UK, which will also develop jobs and opportunities in the associated industrial supply chain putting us at the forefront of this new technology that can utilise our North and Celtic Seas. We will build on this with £380m for our world-leading offshore wind sector, investing in supply chains, infrastructure and early-coordination of offshore transmission networks, securing jobs and benefitting communities across the UK.

Supporting sustained deployment of low carbon generation

34. While our strategic approach to decarbonising power in line with CB6 is predicated on a whole system approach, with a key role for the market in delivering the most efficient solution, part of the CB6 challenge is nonetheless one of deploying low carbon electricity generation infrastructure at an unprecedented scale and pace whilst maintaining optionality for more nascent sources for power generation, such as hydrogen, to help reduce the risk of delivery. In a scenario with higher electricity demand, if there is no hydrogen generation in the power sector, we are likely to need to build all known technologies at or close to their maximum deployment potential by the mid-2030s.

35. In the *Energy White Paper*, we committed to a target of 40 GW of offshore wind by 2030, including 1 GW floating wind, alongside the expansion of other low-cost renewable technologies. We need to continue to drive rapid deployment of renewables, for example offshore wind, so we can reach substantially greater capacity beyond 2030, and accelerate the cost reduction and commercialisation of floating offshore wind. As we decarbonise our electricity system our wholesale prices will become less exposed to fluctuations in global fossil fuel prices, and we would expect wholesale prices to be lower.

36. CB6 also requires a sustained increase to the deployment of land-based renewables such as locally supported onshore wind and solar in the 2020s and beyond. We will seek to ensure a facilitative environment for the deployment of unsubsidised rooftop solar to complement our market-based approach of ensuring exporters receive a fair price through the Smart Export Guarantee. We also have one of the best ocean energy resources in the world and we continue to explore the role of marine technologies in net zero.

37. This step change in renewable deployment will be achieved primarily by providing ongoing support through the CfD scheme, starting with allocation round 4 this December – which will be the biggest-ever round of our flagship renewable energy scheme. The CfD will be key to delivering the levels of generation required by 2030. To support this step change we will undertake a review of the frequency of the CfD auctions. Looking beyond this, ensuring we retain effective means to provide long-term stability will be crucial throughout the 2030s to achieve affordable, scalable deployment.

38. We also need to increase our nuclear capacity, which is why we said in the *Energy White Paper* that we will aim to bring at least one large-scale nuclear project to the point of final investment decision by the end of this Parliament, subject to clear value for money and all relevant approvals. In December 2020 we announced the start of formal negotiations on Sizewell C and those negotiations are ongoing. To facilitate a decision this Parliament, we plan to establish the Regulated Asset Base model to fund new nuclear projects at a low cost of capital, saving consumers money.

39. The government will also take measures to inform investment decisions during the next Parliament on further nuclear projects as we work towards our net zero target. This will include consideration of large-scale and advanced nuclear technologies, including Small Modular Reactors (SMRs) and potentially Advanced Modular Reactors (AMRs). As part of this, we are announcing a new £120 million Future Nuclear Enabling Fund to provide targeted support in relation to barriers to entry. Further details of how this fund will operate will be published in 2022 alongside details of a roadmap for deployment that takes into account value for money.

40. We are also providing funding for a SMR design through our £385m Advanced Nuclear Fund and are progressing plans for an Advanced Modular Reactor demonstrator in the early 2030s. Whether large- or small-scale projects, there remain a number of possible sites available for these options, including Wylfa in North Wales.

41. To help deliver emissions reductions to keep us on track for Carbon Budget 6, we will need significant expansion of power CCUS beyond the *Energy White Paper* commitment of one power plant by 2030. To do this we will implement the Dispatchable Power Agreement (DPA), and seek to bring forward at least one power CCUS plant in the mid 2020's through the CCUS Cluster Sequencing Process, subject to the outcome of that process including value for money and affordability considerations. We will also aim to begin competitive allocation in the 2020's to support a future pipeline of projects and cost reduction via increased deployment and competitive tension. Finally, we will continue to review and evolve the policy framework to stimulate the delivery of future power CCUS projects.

42. Bioenergy has already played a significant role in decarbonising the electricity system, accounting for 12.6% of total renewables generation in 2019.[15] Technological changes mean that biomass usage can now go beyond carbon-neutral and deliver negative emissions by combining it with carbon capture and storage (BECCS). As committed to in the *Energy White Paper*, we will publish a Biomass Strategy in 2022 that will set out how BECCS could be deployed. As is the case with all UK biomass use, any future BECCS projects will need to meet stringent sustainability and air quality requirements for the production and use of biomass, as will be set out in the Biomass Strategy.

Reducing delivery risk

43. Although we need to ensure we can deploy existing low carbon generation technologies at close to their maximum to reach Carbon Budget 6, we also need to de-risk the delivery challenge. We will pursue innovative technology solutions which ease the pressure, including:

- **Exploring the system need and case for market intervention for long duration storage and hydrogen in power –** both technologies have the potential to provide important low carbon peaking capacity during periods of high demand and over extreme events such as long periods of low wind. Long duration storage technologies could provide a range of system stability services such as the provision of inertia. An expansion of hydrogen in power could also reduce the need to build other technologies at the limit of what is technically feasible and could be a form of storage for excess power generated by renewables. We are supporting innovation in longer duration energy storage projects through a £68 million competition for prototypes and demonstrators;[16]
- **Reducing emissions from the energy from waste sector –** emissions from energy from waste plants represent a significant part of the residual emissions in the power sector. We are exploring options to reduce emissions from these plants within the power sector, including whether support for CCUS at Energy from Waste plants could be provided by the Industrial Carbon Capture Business Model. The Government's approach in respect of this is still under consideration and we intend to provide further details later this year;
- **Maximising system flexibility, including through storage technologies, demand side response, and interconnectors –** to integrate renewables, balancing the intermittency of renewables and helping to maintain system operability;
- **Promoting more ambitious and sustained demand reduction and energy efficiency measures to reduce overall power demand –** allowing demand to increase unconstrained as we electrify other parts of the economy could prevent us hitting very low levels of emissions during the 2030s.

Working together across the UK

Examples of policy action by the Scottish Government, Welsh Government, and Northern Ireland Executive

UK Government is working across all levels of government and with Devolved Administrations to ensure consistent action to reduce emissions across the power sector, and across the UK.

Wales

The Welsh Government has supported the development of four regional energy strategies that identify the scale of change needed to reach a low carbon energy system and establish regional priorities for energy. This work models future demand for power, heat and transport, and assesses the economic impact of delivering the proposed ambitions.

In addition, Conwy and Newport local authority areas are piloting local area energy planning. This work will identify the low-regret actions to decarbonise a local energy system and can be used by grid network operators to inform their infrastructure investment.

Scotland

The Scottish Government's £62 million Energy Transition Fund will support Scotland's energy sector and the North East, over the next five years, to make progress on energy transition as Scotland moves toward a net zero society by 2045.

The Emerging Energy Technologies Fund is a £180 million package of funding over five years that will provide capital support to accelerate low carbon infrastructure projects that will be essential to deliver net zero. The Fund will make £100 million available to support hydrogen projects in line with the Scottish Government's Hydrogen Policy Statement.

A further £80 million of this funding will be directed to projects supporting the development of carbon capture, utilisation and storage and negative emission technology projects in Scotland.

The purpose of the hydrogen funding programme is to support the delivery of the Scottish Government's upcoming Hydrogen Action Plan, the development of a hydrogen economy in Scotland, to help overcome challenges to scaling up hydrogen production and to deliver lasting benefits for business and communities.

Northern Ireland

Northern Ireland has already demonstrated its commitment to decarbonisation of the power sector through rolling out renewable electricity generation under the Northern Ireland Renewables Obligation (NIRO) - 45.4% of the electricity consumed in Northern Ireland between 1 July 2020 and 30 June 2021 was generated from renewable sources. Building on this achievement and with a view to meeting the ambition of net zero by 2050, the Minister for the Economy, in considering requirements for the NI Energy Strategy (to be published by end of 2021), has set a renewable electricity target of at least 70% by 2030.

3ii. Fuel Supply and Hydrogen

Transitioning to a low carbon future

Our Key Commitments

- An ambition for 5 GW UK low carbon hydrogen production capacity by 2030.
- We have set up the Industrial Decarbonisation and Hydrogen Revenue Support (IDHRS) scheme to fund our new hydrogen and industrial carbon capture business models. We will be providing up to £140m to establish the scheme, including up to £100m to award contracts of up to 250MW of electrolytic hydrogen production capacity in 2023 with further allocation in 2024.
- Implement the £240 million Net Zero Hydrogen Fund and finalise the Hydrogen Business Model and the Low Carbon Hydrogen Standard in 2022.
- Work with the sector to help develop a low carbon fuel strategy for transport for publication in 2022, as announced in the recent Transport Decarbonisation Plan, and deliver commitments on sustainable aviation fuels.
- Work with stakeholders to address barriers to electrification of oil and gas production by Q4 2022 and continue to drive down routine flaring and venting.
- Regulate the oil and gas sector in a way that minimises GHG emissions, notably through the revised Oil and Gas Authority strategy, which empowers the OGA to assess operators' plans to reduce their emissions levels against effectively a net zero test, and establish a climate compatibility checkpoint for future licensing on the UK Continental Shelf.

Progress to date

1. In 2019 net UK GHG emissions from fuel supply totalled 26 $MtCO_2e$ and accounted for 5% of total net UK GHG emissions. Emissions today mainly derive from fossil fuels and can be attributed to stages of the supply journey.[17] This chapter covers all aspects of fuel supply emissions:

- Extraction ('upstream') – exploration and production of oil and gas including drilling, surfacing resources and onshore processing at gas plants;
- Transportation ('midstream') – transportation and storage of oil and gas including pipelines, pumping stations, trucks, and transcontinental tankers;

- Refinement ('downstream') – refining oil into products including transport fuels, bitumen, lubricating oils, liquid petroleum gasses, heating oils, marine fuels, polymers, solvents, and alcohols. Refining emissions are counted as part of the industry sector but are discussed in this chapter to take a holistic view of supply.

2. Overall, between 1990 and 2019, net UK GHG emissions from fuel supply have decreased by 61%. North Sea production has fallen; older, more polluting installations have been decommissioned whilst cleaner ones have been brought online; regulatory frameworks have supported efficiency gains; coal mines have closed; and iron pipes have been replaced with plastic to reduce methane leakage across the gas network.

3. We have also made progress in low carbon fuel production. An estimated 10-27 TWh of hydrogen production now exists today but is almost all derived from fossil fuels without carbon capture and for use outside of the energy system.[18] In 2019, renewable fuels supplied under the Renewable Transport Fuel Obligation (RFTO) accounted for 5% of total road and non-road mobile machinery fuel. This mainly consisted of biodiesel and bioethanol but also included biomethane and renewable hydrogen.[19]

4. Building on the *Ten Point Plan*, we recently published the *UK Hydrogen Strategy* and associated consultations on a hydrogen business model, the Net Zero Hydrogen Fund (NZHF) and a low carbon hydrogen standard, outlining our approach to kickstarting the production of low carbon hydrogen and developing a robust UK hydrogen economy.

Net zero transition and economic opportunities

Our 2050 vision and how we get there

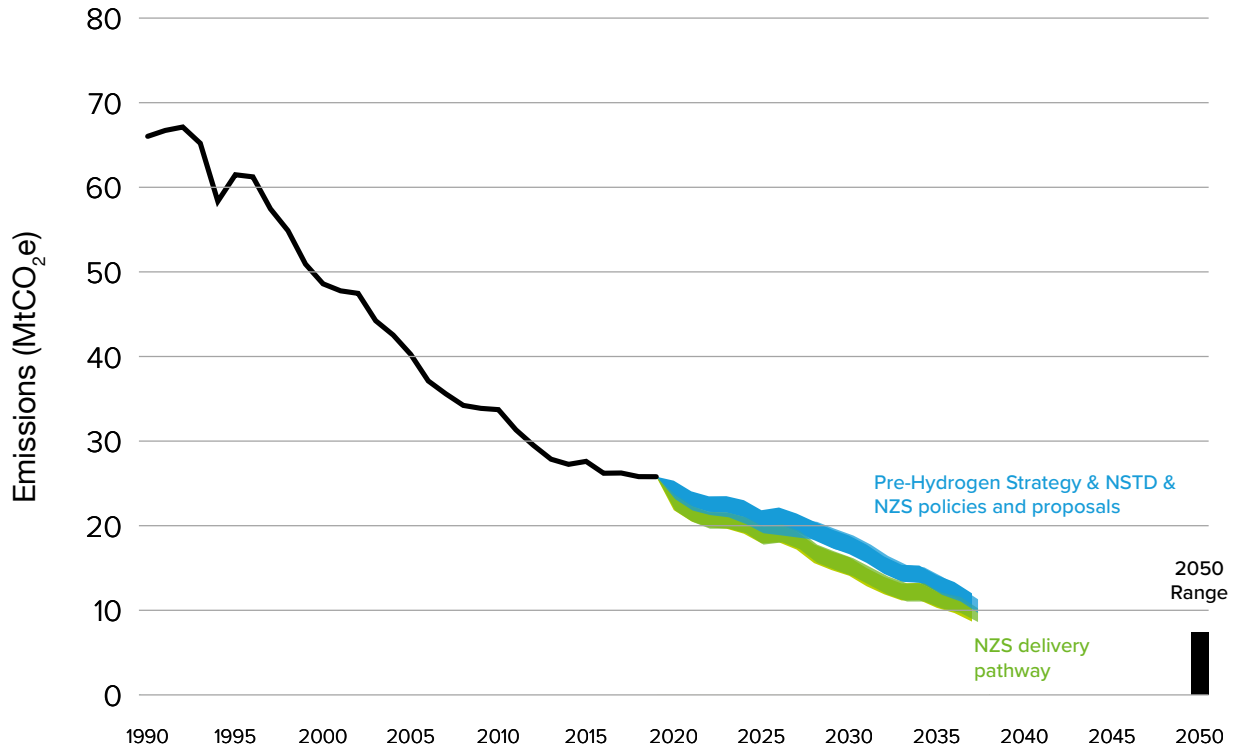
5. There is a need for widespread electrification across the economy, but we cannot rely on electricity alone. Many end use sectors require low carbon energy including those where electrification is not viable or cost-effective, making the supply of cleaner fuels essential to achieving net zero.

6. Our fuel supply will look very different by 2050. Oil and gas production will contract significantly as the UK Continental Shelf matures and investment in the North Sea pivots to new opportunities from CCUS and hydrogen, accelerated by widespread electrification and low carbon fuel switching. This shift away from fossil fuels will protect consumers from volatile gas prices. Remaining oil and gas installations will use low carbon power, with residual emissions minimised. In the *Energy White Paper*, we committed to this, by stating that we will work with the oil and gas sector to transform the UK Continental Shelf into a net zero basin by 2050.

7. Refineries can play an important role in low carbon clusters utilising CCUS and low carbon fuels, and the production of low carbon fuels will increase significantly to meet demand where electrification is not viable. In these areas there will be significant scale up of hydrogen networks and storage, from new and repurposed existing infrastructure.

8. Based on our whole-system modelling, by 2050, emissions associated with fuel supply could need to drop by 71-99% compared to 2019, down to 0-8 $MtCO_2e$. In the interim, to meet our NDC and CB6 targets, we expect emissions could fall by 37-45% by 2030 and 53-60% by 2035, compared to 2019 levels. These figures are based on an indicative fuel supply sector pathway contributing to the whole-economy net zero and interim targets (see figure 18 below).

Figure 18: Indicative fuel supply emissions pathway to 2037



Source: BEIS analysis

9. We have agreed ambitious interim targets for emissions reductions with industry through the *North Sea Transition Deal* (NSTD) including 10% by 2025, 25% by 2027, and 50% by 2030 compared to a 2018 baseline.

10. The *Ten Point Plan* announced our ambition for 5 GW of low carbon hydrogen production capacity by 2030, alongside steps to drive the uptake of sustainable aviation fuels (SAF). Since then we have invested £3 million in kick starting the Tees Valley Hydrogen Transport Hub and announced a £60 million Low Carbon Hydrogen Supply 2 Competition to fund projects to develop innovative low carbon hydrogen solutions. The *UK Hydrogen Strategy* further sets out our comprehensive approach to growing a UK hydrogen economy, indicating that use of low carbon hydrogen enabled by 5 GW of production capacity could deliver total emissions savings of 41 $MtCO_2e$ between 2023 and 2032, the equivalent of the carbon captured by 700 million trees over the same period.

11. Looking across a range of end use scenarios, the *UK Hydrogen Strategy* suggests that we could need 7-20 GW of

production capacity in 2035 and 15-60 GW in 2050, depending on developments across heat, industry, transport, and power.[20] Using more specific end use assumptions, the illustrative pathway in this Strategy suggests production capacity in 2035 would need to be 10 GW if heat is electrified, or 17 GW if hydrogen is used widely for heat.[21]

12. As the production of low carbon fuels replaces fossil fuels, we intend to follow the following principles:

- **Integrating a whole system view**. We will take an economy-wide view, including to balance end-use sector demands with supply side considerations, such as infrastructure and the operation of the electricity and other fuel supply sectors.
- **Taking a portfolio approach**. We will remain flexible to a supply mix of low carbon fuels that could be affected by technologies in early development. As demand grows, we expect innovators, investors and producers will respond with advances delivering further cost or emissions savings. Our hydrogen modelling assumes a combination of electrolysis from renewable electricity, methane reformation with CCUS, and BECCS but we are aware of industry plans involving other production methods and will update our modelling with new technologies as evidence develops.
- **Minimising environmental impacts**. Any impacts from low carbon fuel production on air quality or the environment must be kept under consideration and comply with evolving regulatory standards. We must maintain strict sustainability requirements for fuels to be eligible for government support schemes to achieve genuine emissions savings compared to fossil fuels and minimise environmental impacts.

13. Drawing on the OECD's 'Trade in Embodied CO_2' database, as well as the relative levels of trade openness of UK sectors, our analysis suggests that refineries are currently amongst the areas most at risk of carbon leakage. We are committed to mitigating this risk by engaging with industry to better understand their concerns around carbon leakage. Further analysis and information on the potential mitigations for consideration are set out in HM Treasury's *Net Zero Review*.

Seizing new opportunities

14. To achieve the level of emissions reductions in the fuel supply sector indicated by our delivery pathway to 2037, we will need additional public and private investment of £20-30 billion.

15. Government investment in domestic hydrogen production, to de-risk early projects, could also unlock private sector capital co-investment of over £4 billion by 2030. This could increase to £10-22 billion to meet the 2037 delivery pathway in electrification and hydrogen scenarios for heat respectively.[22]

16. Decarbonising fuel supply and growth of the hydrogen sector will regenerate communities and open up new employment opportunities right around the UK. Based on current estimates, policies and proposals to reduce emissions in fuel supply and growing the hydrogen sector could support up to 10,000 jobs in 2030. We will build on existing commitments in the NSTD to facilitate reskilling and support 40,000 jobs across the supply chain, ensuring everyone employed in the sector can fulfil their potential. Many skills will also be transferable to clean growth industries like offshore wind, CCUS and hydrogen production. Producing low carbon hydrogen at scale will be made possible by carbon capture and storage infrastructure, and we plan to grow both of these new British industries side by side in industrail 'SuperPlaces'.

17. The development of a domestic SAF industry alone could generate support up to 1,000 jobs in 2030, with new jobs as plants are developed as well as opportunities to retain existing fuel expertise across the country. Industry has committed to creating an integrated skills plan to help its transition and diversification with strong support from government, academia, and trade unions.

18. Achieving our 5 GW ambition for hydrogen production capacity could support over 9,000 jobs in 2030, across the full hydrogen value chain. Meeting the delivery pathways set out in the *Journey to Net Zero* chapter could support 13,000-19,000 jobs across the hydrogen economy by 2035.[23]

19. Oil and gas will continue to play an important role as we transform from an economy based on fossil fuels to one based on clean energy. We will manage the transition in a way that protects jobs and investment, uses existing infrastructure, maintains security of supply, and accounts for climate risk.

Case study: The Phillips 66 Humber refinery

The sector can already compete on the world stage and provide domestic resilience by producing products essential for decarbonisation. UK refining includes a global leader and the only European producer of high-grade speciality coke for batteries used in electric vehicles and consumer electronic goods. The Phillips 66 Humber refinery's world scale production capability is equivalent to 1.3 million electric vehicles (EV) per year. . Whilst the majority is currently exported, it has the potential to underpin a domestic UK battery industry and development of a broader EV battery manufacturing base in the UK.

Policies and proposals

Oil and gas supply

20. We have always been clear that as we reduce our dependence on fossil fuels, the North Sea basin has a key role to play. Our approach will ensure that it does contribute to the transition, driving investment in transition technologies and providing the skills needed for net zero. However, we are clear that we do need to reduce our reliance on hydrocarbons as swiftly as possible. The best way to protect British businesses and consumers from volatile international fossil fuel markets is to get our economy off hydrocarbons.

21. Upstream, the North Sea Transition Deal (NSTD) has set us on a transformational path to deliver the long-term skills, innovation, infrastructure, and investment required to decarbonise oil and gas production and industry more widely. The deal will hold the industry to account on commitments it has made to halve its operational emissions by 2030, while supporting up to 40,000 high-quality direct and indirect supply chain jobs in Scotland and our industrial heartlands in the North East, North West and East of England. It also emphasises our shared commitment to achieving 10 $MtCO_2$/year of CCUS capacity, with industry leveraging existing infrastructure to provide key transport and storage capability; and positions the sector to help deliver our 5 GW hydrogen ambition.

22. The Oil and Gas Authority (OGA) published its revised strategy in February, enshrining a range of new net zero obligations for the UK oil and gas industry. This is reflected through the suite of levers available to the OGA, making net zero a key factor in its decisions, including to grant consent for projects. It empowers the OGA to assess operators' plans to reduce their emissions levels against effectively a net zero test, in accordance with its revised strategy, the OFS can now encourage operators to invest in transition technologies such as CCUS and hydrogen – seizing the economic opportunities available to the sector in a net zero future and living up to the commitments of the Transition Deal. The Strategy also introduces full societal carbon cost assessments into the approvals process.

23. Step-change abatement will be delivered by the electrification of existing and new offshore assets, through connections to onshore networks or offshore renewables. We will work with regulators to review supporting infrastructure in the Offshore Transmission Network Review and to address regulatory barriers. We will support removing further barriers through £1 million of additional funding from 2021 to 2022.

24. Beyond power generation, flaring and venting account for most remaining upstream emissions and we will need to be ambitious to allow us to stay on track for our CB6 target. We have endorsed industry's commitment in the NSTD to accelerate reductions beyond the World Bank's 'Zero Routine Flaring by 2030' initiative and new OGA guidance sets out the expectation that all facilities should have zero routine flaring and venting by 2030 or sooner. Industry is taking steps through its Methane Action Plan for continuous emissions reductions with specific methane emissions reduction targets, whilst setting the expectation that assets will have individual action plans by 2022.

25. Further, following the conclusion of our review into the future of offshore oil and gas licensing earlier this year, we will also introduce a formal climate compatibility checkpoint on future licensing rounds for oil and gas exploration. This will ensure future licences are only awarded following a compatibility assessment against the government's broad climate change ambitions, including reaching net zero by 2050. This checkpoint will be designed by the end of 2021. We will be seeking input on the design through a consultation to be published before COP26.

26. This checkpoint builds on the existing checks within our regulatory system, including the OGA Strategy, and the role of the Offshore Petroleum Regulator for Environment and Decommissioning (OPRED). These checks include a full environmental impact assessment and a public consultation.

27. Additional work is being carried out by the government and regulators to review what action can be taken to further reduce emissions. Improved measurement, reporting and verification will play a critical role in this. The government, including the Offshore Petroleum Regulator for Environment and Decommissioning, is working closely with the OGA to collect robust industry data which will enable effective implementation of their strategy. The OGA's tracking of overall emissions reductions and benchmarking of flaring and venting data will also improve performance across industry. Government and regulators will continue to work with industry to drive emissions reductions, including through improved process efficiency, to stay on track for CB6.

28. Midstream, the gas network must be effective at minimising gas leakage and associated emissions by replacing iron pipes with plastic, even with gas demand decreasing leading to 2050. Through network price controls, Ofgem has set gas distribution companies a target to replace 15,500km of iron mains and associated services in 5 years, from April 2021. This will reduce leakage by 17% and emissions by 0.5 $MtCO_2e$. Additional financial incentives will encourage further action through pressure management and gas conditioning. We continue to work with Ofgem and HSE to review how best to continue to reduce methane leakage to 0% in all future decarbonisation scenarios.

29. Blending hydrogen into the gas grid could also support initial steps to decarbonise heating. This will consider the air quality impacts of hydrogen combustion in domestic settings. Government is working closely with key delivery partners to explore options to blend hydrogen up to 20% by volume into the gas distribution network, and up to 2% into the gas transmission network, along with biomethane and natural gas. Subject to both the economic and safety case for blending being demonstrated, we are aiming to make a final decision on blending by the end of 2023.

30. We recognise that industry will need early sight of decisions should blending proceed and propose five principles for delivery:

- **Safety.** Blending must remain within safe limits set by the Health and Safety Executive and changes to gas quality and infrastructure must meet all safety requirements;
- **Operability.** Changes to gas quality and infrastructure must maintain existing system, pipeline, and consumer appliance operability;
- **Security of Supply.** Blending must not prevent consumers' secure gas supply;
- **Affordability.** Costs to consumers should be affordable and value for money; and
- **Temporary.** Blending could support initial development of the hydrogen economy but is not a preferred long-term solution.

31. Acknowledging that the future demand for gas will decline as we decarbonise, means that the gas system will need to change to meet the net zero targets. We will publish a call for evidence this autumn, seeking views from stakeholders on the future of the gas system, with a focus on infrastructure and markets. This will enable us to determine how the gas market will need to evolve to ensure the right market and regulatory signals are in place to offer the necessary level of investment and maintenance throughout the transition. Gathering evidence on the amount of natural gas, biomethane, and hydrogen available and the ongoing role for gas will inform what action we must take.

32. Downstream, UK refineries already underpin major CCUS and hydrogen projects in key industrial clusters. These include Gigastack (Phillips 66), Humber Zero (Phillips 66) and HyNet (Essar Oil UK). The Industrial Energy Transformation Fund recently awarded £7 million and £800,000 to Essar Stanlow and Phillips 66 respectively, in support of hydrogen focussed net zero projects. We are also encouraged to see operators investing in the production of low carbon fuels and will continue to work with the sector to encourage innovation, maximise economic opportunities from net zero, and remove regulatory barriers which hinder the transition away from fossil fuels.

Case study: Fulcrum BioEnergy

Fulcrum BioEnergy has announced plans to develop its first UK residual waste to low carbon SAF plant. The 'Fulcrum NorthPoint' biorefinery will be located at the Essar Oil (UK) Limited refinery at Stanlow, Ellesmere Port in the North West of England.

33. We have also published the draft Downstream Oil Resilience Bill which will give the government the powers it needs to ensure secure fuel supplies are maintained during the transition to net zero.

Low carbon fuel supply

34. The UK has a unique opportunity to be a leader in low carbon fuel production and this will be captured in strategies that we will publish in 2022.

35. A new *Biomass Strategy* will set how sustainable biomass could be best used across the economy to help achieve net zero, including to produce low carbon fuels. It will also assess our existing sustainability standards, already some of the world's most stringent, and set out where and how we can improve them further. When coupled with carbon capture and storage, it is possible that sustainable biomass can not only enable production of low carbon fuels but could also deliver vital negative emissions. Any future BECCS project will need to meet stringent sustainability requirements for the production and use of biomass, as will be set out in the *Biomass Strategy*.

36. This will be complemented by a long-term strategy for low carbon fuels as announced in our recent *Transport Decarbonisation Plan*. The strategy will consider how to maximise emissions savings from low carbon fuels used across different transport modes in the period to 2050.

37. The latter of the two strategies will build on the success of the Renewable Transport Fuel Obligation (RTFO), which has supported the market for low carbon fuel supply since 2008. Fuels supported under the RTFO need to comply with sustainability criteria such as minimum GHG thresholds, and by incentivising fuels produced from wastes, it saved 5.37 $MtCO_2e$ in 2019 alone. Further to sub-targets for so-called development fuels of strategic importance, we have recently widened support to more diverse fuels and announced more ambitious targets for the RTFO to 2032 set at 14.6% of total liquid fuel supply.

38. To accelerate the development of UK plants to produce advanced fuels we have provided grant funding through schemes including the Future Fuels for Flight and Freight Competition (F4C) and Advanced Biofuels Demonstration Competition (ABDC). Delivering on the *Ten Point Plan* we also recently announced the shortlist for the £15 million Green Fuels, Green Skies Competition (GFGS) supporting eight companies pioneering new SAF technologies. To accompany this announcement, we published a consultation on proposals for a new UK SAF blending mandate aiming for introduction in 2025. It included design questions on which feedstocks and technologies should be eligible and welcomed views on what our SAF ambition and targets should be. We are currently reviewing the responses to the SAF mandate consultation, but our ambition is for a comprehensive policy framework, including the mandate, to enable the delivery of 10% SAF by 2030. Further detail can be found in the *Transport* chapter.

Hydrogen production

39. The UK's skills, capabilities, assets, and infrastructure mean that we have the potential to excel in both CCUS-enabled and electrolytic low carbon hydrogen production. Alongside the scale of production that CCUS-enabled methane reformation or 'blue' hydrogen can bring, our renewables can support the growth of electrolytic or 'green' hydrogen, bringing down costs and increasing production capacity whilst new production technologies such as hydrogen from nuclear and biomass are developed. Supporting a variety of different production methods will enable us to develop low carbon hydrogen rapidly at scale during the 2020s and 2030s to deliver what is needed for CB6 and net zero.

40. Our approach to scaling up the UK hydrogen economy in the 2020s is set out in our recent *UK Hydrogen Strategy*, which describes our key policies and proposals to overcome key barriers to development. Alongside the Strategy, we published a package of documents consulting on proposed policy support mechanisms for new hydrogen production. This approach, subject to further policy development following these consultations, and together with the ambition shown by proposed hydrogen projects, provides confidence we can achieve low carbon production sufficient to deliver on our targets under the Climate Change Act. We know there will be more to do and will keep our policy approach under review as the use of hydrogen in the energy system develops and production methods evolve.

41. The UK is already at the forefront of innovation across the hydrogen value chain, reducing technological barriers to production and end use cases. We recently launched a new £60 million Low Carbon Hydrogen Supply 2 Competition, which will develop novel hydrogen supply solutions for a growing hydrogen economy.[24]

42. Low carbon hydrogen is not yet competitive with traditional fuels as production projects face additional costs compared to existing energy sources. Investors cannot currently justify upfront capital investments without visibility or predictability of revenue and returns. Lessons learnt from the success of UK offshore wind deployment suggests government intervention to address this cost difference is a key requirement to bring forward hydrogen supply at scale.

43. In August this year we published our consultation on our preferred hydrogen business model[25] to provide revenue support to hydrogen producers and help overcome the cost challenge to bring through investment in new low carbon hydrogen projects. As set out in the *Industry* chapter, and Hydrogen Revenue Support (IDHRS) scheme to fund our new hydrogen and industrial carbon capture business models. We will be providing up to £140 million to establish the scheme, including up to £100 million to award contracts of up to 250 MW of electrolytic hydrogen production capacity in 2023 with further allocation in 2024. The IDHRS will fund the allocation of the hydrogen business model contracts to both electrolytic and CCUS-enabled projects from 2023, resulting in up to 1.5 GW of low carbon hydrogen contracts awarded to projects.

44. As set out in the August consultation,[26] our Net Zero Hydrogen Fund (NZHF) will provide up to £240 million for government co-investment to support new low carbon hydrogen production out to 2025. The aim of the Fund is to support commercial deployment of new low carbon hydrogen production projects during the early 2020s, by helping to address barriers related to commercial risk and high upfront costs relative to fossil fuel alternatives, unlocking private sector investment in projects. We intend to launch the NZHF in early 2022.

45. In August we also published a consultation[27] on the proposed UK low carbon hydrogen standard which will define what is meant by low carbon hydrogen, allowing us to incentivise and support the right production for supply across the energy system. It will establish a threshold for greenhouse gas emissions allowed in the production process for hydrogen to be considered low carbon and be eligible for support.

46. The RTFO has supported the supply of renewable hydrogen into transport since 2018 and has been successful in launching small-scale renewable hydrogen supply. In July, the Department for Transport announced changes to the RTFO which could further encourage the uptake of renewable hydrogen in transport, including in rail and shipping. The original consultation, published in March, also proposed to make evidencing the provision of renewable electricity for hydrogen production easier through power purchase agreements and recognising the importance of regional grids. The final decision on these changes will be published shortly.

47. *The UK Hydrogen Strategy* sets out the initial steps being undertaken to develop the hydrogen economy over the 2020s, to deliver our 2030 5 GW production capacity ambition and position the hydrogen economy for further ramp up needed to support CB6 and net zero. But we know there will be more to do beyond this. That is why we committed in the strategy to say more on the mix of production technologies and supporting network and storage infrastructure that could help meet future hydrogen demand following conclusion of our consultations and further work. Similarly, we set out our plans to develop appropriate regulatory and market frameworks to support an expanding hydrogen economy throughout the 2020s and beyond. We will publish a Hydrogen Sector Development Action plan in early 2022.

Working together across the UK

Examples of policy action by the Scottish Government, Welsh Government and Northern Ireland Executive

UK Government is working across all levels of government and with Devolved Administrations to ensure consistent action to reduce emissions across the fuel supply and hydrogen sectors, and across the UK.

Wales

In December 2020 the Welsh Government commissioned a report on hydrogen that included baseline reporting on related activities and expertise, and a pathway for developing the sector.[28] The proposed pathway contains ten objectives covering both supply and use of hydrogen, including the establishment of at least one 10+ MW renewable production site and the deployment of 200 fuel cell buses. The Welsh Government consulted on the pathway earlier this year and following analysis of the responses it will finalise a pathway for hydrogen development over the second Welsh carbon budget period (2021-25).

Scotland

In December 2020, the Scottish Government published a Hydrogen Policy Statement which sets a vision for Scotland to become a leading Hydrogen Nation with an ambition to generate 5 GW of renewable and low-carbon hydrogen by 2030, committing to £100 million funding to accelerate the hydrogen economy in Scotland over the next five years.

The Hydrogen Policy Statement has provided the framework for the development of a Hydrogen Action Plan in 2021 which will provide further detail on the planned approach and necessary actions to implement the policy positions outlined in the Policy Statement. The Hydrogen Action Plan will be published later this year.

The Scottish Government has led the way in supporting world-leading hydrogen demonstration projects in Scotland that are helping to determine the role of hydrogen in Scotland's future energy system. This includes the provision of £7 million funded support towards the cost of a world first £28 million demonstration of an end-to-end 100% hydrogen energy system. The project will construct and operate a hydrogen heat network system in Fife able to service around 300 houses and will be of UK-wide significance to evidence the role that hydrogen can play in decarbonising heat, using the gas network.

Northern Ireland

A new Northern Ireland Energy Strategy is expected to be published by the end of 2021, with proposals on phasing out coal, solid fuels and heating oil alongside decarbonising our gas network, including the future injection of biomethane and potential hydrogen blending.

Northern Ireland is uniquely positioned to become a leader in the hydrogen economy and secure these benefits locally. This is already gathering momentum, with NI Water trialling an innovative new hydrogen electrolyser at its wastewater treatment works – the first such project of its kind across the UK. Translink, the public transport service provider in Northern Ireland, is also introducing three new hydrogen buses to its fleet and is procuring a new hydrogen fuelling station for these and an anticipated 20 more under a new contract. The GenComm project, led by Belfast Metropolitan College, will trial hydrogen production via electrolysis for hydrogen buses. They are also engaged with a range of potential complementary projects to build on this momentum and contribute to the growth of an indigenous hydrogen economy in Northern Ireland.

3iii. Industry

Stretching our ambition for net zero

Our Key Commitments

- Ambition to deliver 6 $MtCO_2$ per year of industrial CCUS by 2030, and 9 $MtCO_2$ per year by 2035.
- Set up the Industrial Decarbonisation and Hydrogen Revenue Support (IDHRS) scheme to fund our new industrial carbon capture and hydrogen business models.
- Support the deployment of CCUS through the £1 billion CCS Infrastructure Fund.
- Following Phase 1 of the Cluster Sequencing process, the Hynet and East Coast Clusters have been confirmed as Track 1 clusters.
- Support the installation of energy efficiency and on-site decarbonisation measures through the £315 million Industrial Energy Transformation Fund (IETF) (£289 million for England, Wales and Northern Ireland, £26 million for Scotland).
- Support the increased requirement for fuel switching to low carbon alternatives, with an ambition to replace around 50 TWh of fossil fuels per year by 2035.
- In collaboration with the Steel Council we will consider the implications of the recommendation of the Climate Change Committee to set targets for ore-based steelmaking to reach near-zero emissions by 2035, and the business environment necessary to support the transition.
- Develop several Resource and Energy Efficiency (REEE) measures with ambition of achieving the anticipated requirement of 11 $MtCO_2e$ worth of savings by 2035, including up to 3 $MtCO_2e$ of potential abatement in the Iron and Steel sector.
- Incentivise cost-effective abatement in industry at the pace and scale required to deliver net zero, through the UK ETS by consulting (in partnership with the Devolved Administrations) on a net zero consistent cap.
- Explore opportunities for faster decarbonisation of dispersed sites in the 2020s.

Progress to date

1. The UK's manufacturing and refining sector plays an essential role in society. It contributes £180 billion to the overall economy,[29] directly accounting for 8% of GDP[30] and provides 2.5 million direct jobs across the country[31] as well as over 5 million across the value chain.[32]

2. However, industry[33] is also a major source of CO_2 emissions, producing 15% (78 $MtCO_2e$)[34] of the UK's current total. Around half of industrial emissions are concentrated in specific clusters – geographical areas with large concentrations of industry.

3. Industry emissions have more than halved since 1990, due mainly to the changing structure of the UK's manufacturing sector, improved energy efficiency, and a shift to low carbon fuels. Despite this progress, the overall pace of reductions is slowing, and more action is needed to achieve our net zero commitments.

4. The *Industrial Decarbonisation Strategy* (IDS), published in March 2021, was the first of its kind in a major economy. It sets out how industry can decarbonise in line with net zero while transforming industrial regions by attracting inward investment, future-proofing businesses, and securing the long-term viability of jobs.

5. This followed previous work including the landmark *Industrial Decarbonisation and Energy Efficiency Roadmaps to 2050*, published in 2015, which set out a series of pathways for emissions reductions for energy-intensive sectors.

6. We plan to have the world's first net zero industrial cluster by 2040, awarded grants from the £315 million Industrial Energy Transformation Fund (IETF), announced a £1 billion Carbon Capture and Storage Infrastructure Fund, and a £240 million Net Zero Hydrogen Fund. Additionally, as part of the Industrial Decarbonisation Challenge (IDC), we recently announced £171 million of funding, matched by over £200 million industry investment, for nine projects within five clusters.

7. Growing new industries in low carbon hydrogen alongside CCUS and renewable energy will put our industrial 'SuperPlaces' at the forefront of technological development. Together this will develop resilient supply chains, support jobs, and position UK companies at the forefront of an exciting growing global market, as well supporting industrial processes, industrial heat, power, shipping and trucking to make the shift to net zero.

8. Energy intensive industry in the UK has been covered by a cap-and-trade policy since 2005. The UK government and Devolved Administrations successfully launched the UK Emissions Trading Scheme (UK ETS) on 1 January 2021. The UK ETS cap, which sets the limit on emissions for sectors covered by it, will be aligned with a net zero consistent trajectory by January 2023, or January 2024 at the latest. In the coming months, we will be publishing a consultation on the level of the cap and other elements of UK ETS evolution.

9. We recognise the importance of addressing the risk of carbon leakage so policy interventions do not lead to increased emissions elsewhere, and to ensure that UK industry has the confidence needed to fully decarbonise. The IDS and the *Net Zero Review* set out the potential options available to address this, including regulatory standards and Carbon Border Adjustment Mechanisms (CBAMs), as well as the ongoing review of our current carbon leakage mitigation policy of free allowances under the UK ETS. Government will continue to explore options to mitigate carbon leakage, with emphasis on an international, multilateral effort to tackle carbon leakage at source through global action on industrial decarbonisation and climate regulation, with continued monitoring of related global policy developments.

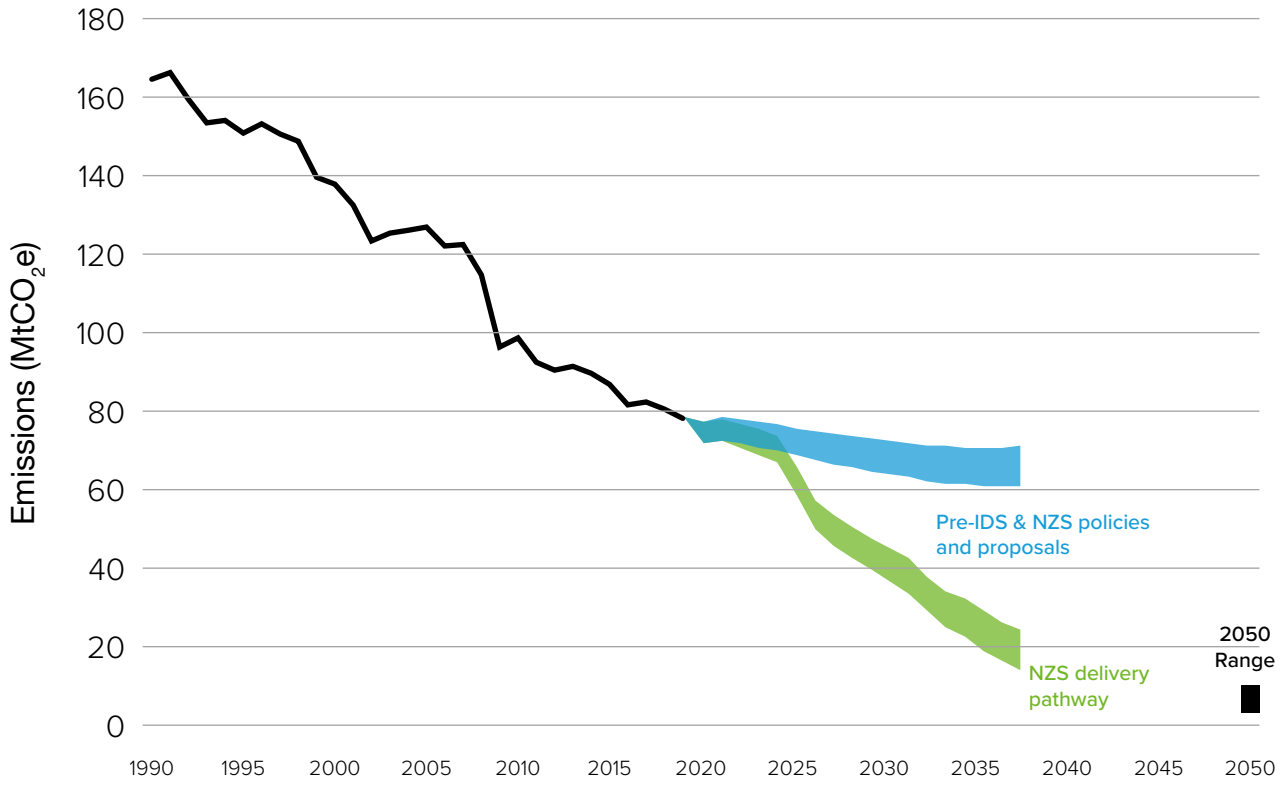
Net zero transition and economic opportunities

Our 2050 vision and how we get there

10. To stay on track for net zero, industrial emissions will need to fall significantly, with residual emissions being compensated for by Greenhouse Gas Removal methods. All industrial sectors will need to act to meet this challenge and to ensure they are resilient to climate changes that are already inevitable. To do this, we need to transform how industry uses energy and makes products and rethink the type of industrial products consumers buy.

11. Based on our whole system modelling, by 2050, emissions associated with industry could need to drop by 87-96% compared to 2019, down to 3-10 $MtCO_2e$. In the interim, to meet our NDC and Carbon Budget 6 targets, we expect emissions could fall by 43-53% by 2030 and 63-76% by 2035, compared to 2019 levels. These figures are based on an indicative industry pathway contributing to the whole-economy net zero and interim targets (see figure 19 below).

Figure 19: Indicative industry emissions pathway to 2037



Source: BEIS analysis

12. The IDS sets out the policy foundations to deliver net zero for industry, including immediate actions in the 2020s. The initial reduction target of around two thirds (67%) of industrial emissions by 2035 was informed by sector-specific modelling developed in conjunction with the CCC. Our new ambition of 63-76% is consistent with, and builds on, the pathways we set out in the IDS, but with, amongst other things, increased levels of fuel switching and iron and steel decarbonising in the 2020s and early 2030s.

13. Our Carbon Budget 6 delivery pathway aims to give long-term clarity to industry, going further than the IDS in several areas:

- **Going further and faster on fuel switching and carbon capture, utilisation and storage (CCUS).** These are critical for our overall pathway, requiring both infrastructure decisions and revenue support, via the IDHRS scheme. Modelling suggests fuel switching to low carbon alternatives could reach 50 Twh per year by 2035, along with an increase in capturing and storing industrial emissions, from 3 $MtCO_2$ per year to 6 $MtCO_2$ by 2030, and 9 $MtCO_2$ per year by 2035.

- **Working towards more resource and energy efficiency savings.** We anticipate the need for regulatory, fiscal, and wider measures targeted at industrial products and supply chains to achieve 11 $MtCO_2e$ worth of savings by 2035, including up to 3 $MtCO_2e$ of potential abatement in the iron and steel sector, as estimated by the Climate Change Committee.
- **Realising the benefits of demand-side measures and carbon pricing.** An increasing carbon price will help to incentivise action on decarbonisation by industry, whilst demand side measures, such as product labelling, regulatory standards, and changes to public and private procurement approaches, can play a key role in helping the development of the market, and mitigating the risk of carbon leakage.

Seizing new opportunities

14. To achieve the level of emissions reductions in the industry sector indicated by our delivery pathway to 2037, we will need additional public and private investment of at least £14 billion and significant operating expenditure from the expected increase in CCUS, hydrogen use and other fuel switching technology. Energy and resource efficiency will also play a key role in offsetting some of these costs.

15. Due to challenges faced by industry, such as the level of capital investment required to commercially scale essential low carbon technologies, it will be important to drive the decarbonisation of industry at a pace that allows technology to develop and companies, large and small, to adapt their working practices, and retrain their workforces.

16. Many industrial sectors also have low profit margins, so their ability to invest in some decarbonisation technologies is limited and has been exacerbated by the pandemic. Short-to-medium term capital funding and revenue support will therefore be required to overcome these investment hurdles, reduce the risk of carbon leakage, and stimulate long term private investment.

17. Decarbonising the industry sector will regenerate communities and open up new employment opportunities right around the UK. Based on current estimates, policies and proposals to reduce emissions in the industry sector could support up to 54,000 jobs in 2030. This figure is driven by CCUS, which could support up to 50,000 jobs in 2030[35], split across industry, power, and the transport and storage network.[36] In addition, the manufacture and installation of on-site energy efficiency and fuel switching measures to achieve a net zero pathway for industry could support up to 4,000 jobs in 2030.

18. We have the opportunity to future-proof industrial sectors and take advantage of future low carbon markets. This will include creating resilient supply chains that ensure we exploit our strengths and have diverse supply sources for critical goods, as well as supporting those areas that could be vulnerable to global shocks. The UK is already a world leader in new clean technology, as seen in our growing hydrogen and CCUS sectors, and we can develop new markets for low carbon goods and support further innovation. As highlighted in the IDS, wider environmental and air quality impacts will be kept under consideration, in line with evolving regulatory standards.

19. CCUS will be critical to achieving net zero, alongside low carbon alternatives such as low carbon hydrogen and electricity. These technologies offer a renewed era for our industrial heartlands. Connecting locally, for instance positioning hydrogen train trials near blue hydrogen clusters means we can start to bring higher skilled, higher paid jobs and expertise to cluster in these area. The engineers, fabricators, and geologists currently working in industrial clusters and the oil and gas sector will be able to make use of local skills programmes such as Skills Bootcamps or Free Courses for Jobs to support new emerging industries in renewables, CCUS, and low carbon hydrogen to help build SuperPlaces. As the demand pulls through these lower carbon technologies, the costs fall. And these industrial clusters, our potential 'SuperPlaces', will foster and lead internationally on the development and roll out of these technologies.

Policies and proposals

Fuel switching and carbon capture

Low carbon hydrogen

20. Fuel switching to hydrogen is likely to be technically feasible for most industrial processes and our modelling indicates it is the least-cost option to decarbonise harder to electrify sites, processes, and sectors.

21. The IDS sets out that a low regret level of deep decarbonisation infrastructure should be installed in industrial clusters this decade. This will give industry the confidence to invest in switching to low carbon fuels, such as hydrogen. Industrial users located in clusters are therefore expected to provide the most significant new demand for hydrogen by 2030, with the greatest potential from chemicals and iron and steel sectors. A significant proportion of this demand could arise from a small number of sites acting as 'pathfinders', proving the viability of hydrogen at a commercial scale and fostering the initial market for low carbon hydrogen.

22. The *UK Hydrogen Strategy* indicated that in 2030 consumption of low carbon hydrogen as an industry fuel could range from around 10 TWh per year if supply is limited to clusters, and up to around 20 TWh per year if pipelines are connected to some dispersed sites. While supply is likely to come mostly from large scale cluster-based CCUS-enabled hydrogen production sites, there could also be industrial demand for low carbon hydrogen from electrolysis, which can be produced at a smaller scale on a more localised level. To stay on track for our Carbon Budget 6 delivery pathway, hydrogen demand from industry may need to increase up to 50 TWh by 2035. This increase would be driven by a growing number of sites having access to low carbon hydrogen, further technology development to enable an expanding range of processes to switch to hydrogen, and a shift in the associated costs, such as the price of carbon, to make hydrogen an increasingly competitive fuel option.

23. The *UK Hydrogen Strategy* also set out the actions we are taking to support industry to realise the potential of this new technology. It is critical that we demonstrate fuel switching to low carbon hydrogen on industrial sites during the 2020s so we will provide further support for research and innovation through the Net Zero Innovation Portfolio and initiatives led by the Industrial Decarbonisation Research and Innovation Centre (IDRIC).

24. Demand-side measures and carbon pricing could help to drive demand for hydrogen and will be supported by grant funding, such as the £55 million Industrial Fuel Switching Competition under our Net Zero Innovation Portfolio and the Phase 2 of the IETF, to support on-site fuel switches. Regulatory measures can also support industry to switch to low carbon hydrogen, with the *Hydrogen Strategy* announcing calls for evidence on hydrogen-ready industrial equipment and decarbonising existing high carbon hydrogen production. Alongside this, hydrogen production measures in the *fuel supply* chapter of this strategy will bring forward low carbon hydrogen supply for use across the economy and help make hydrogen a price competitive decarbonisation option to encourage end users to switch.

Carbon capture, usage and storage (CCUS)

25. Carbon Capture, Usage & Storage (CCUS) will be an exciting new industry to capture the carbon we continue to emit and revitalise the birthplaces of the first Industrial Revolution. The Prime Minister's *Ten Point Plan* established a commitment to deploy CCUS in a minimum of two industrial clusters by the mid-2020s, and four by 2030 at the latest. Our aim is to use CCUS technology to capture and store 20-30MtCO2 per year by 2030, forming the foundations for future investment and potential export opportunities. Developed alongside hydrogen, we can create these transformative 'SuperPlaces' in areas such as the Humber, North East, North West and southern England, as well as in Scotland and Wales.

26. Developed alongside hydrogen, CCUS will be part of creating transformative "SuperPlaces" in areas such The Humber and North East, North West, and Southern England as well as in Scotland and Wales. Our £1 billion CCS Infrastructure Fund will provide industry with the certainty required to deploy CCUS at pace and at scale and will form part of a package of government support, which will also include the Industrial Decarbonisation and Hydrogen Revenue Support (IDHRS) scheme and the £240 million Net Zero Hydrogen Fund supporting both CCS-enabled 'blue' and electrolytic 'green' hydrogen.

27. Following the completion of Phase 1 of the Cluster Sequencing process, the Hynet and East Coast Clusters have been confirmed as track 1 clusters for the mid-2020s and will be taken forward into Track-1 negotiations. If the clusters represent value for money for the consumer and the taxpayer then subject to final decisions of Ministers, they will receive support under the government's CCUS Programme. We are also announcing the Scottish Cluster as a reserve cluster if a back-up is needed; we will continue to engage with this cluster as well as the track 1 clusters, throughout the next stage of the process. This puts these places - Teesside, the Humber, Merseyside, North Wales and the North East of Scotland - among the potential early SuperPlaces which will be transformed over the next decade.

28. We remain committed to helping all industrial clusters to decarbonise as we work to reach net zero emissions by 2050, and we are clear that CCUS will continue to play a key role in this process. Consequently, the government continues to be committed to Track-2 contributing capacity of 10Mt per year to help achieve our 2030 ambition. Deploying CCUS will be a significant undertaking, these are new major infrastructure projects for a new sector of the economy and carry with them significant risks to deliver by the mid-2020s.

Government will need to play a role in providing long-term certainty to these projects to manage these risks and bring forward the UK's first CCUS clusters.

29. CCUS will be critical to achieving net zero, alongside low carbon alternatives such as low carbon hydrogen and electricity. These technologies offer a renewed era for our industrial heartlands. Connecting locally, for instance positioning hydrogen train trials near blue hydrogen clusters means we start to bring higher skilled, higher paid jobs and expertise to cluster in these areas. The engineers, fabricators and geologists currently working in industrial clusters and the oil and gas sector will be able to make use of skills programmes such as Skills Bootcamps and Free Courses for Jobs to support new emerging industries in renewables, CCUS and low carbon hydrogen to help build SuperPlaces. As the demand pulls through these lower carbon technologies, the costs fall. And these industrial clusters, our potential SuperPlaces, foster and lead internationally on the development and roll out of these technologies.

30. Industrial CCUS is fundamental to decarbonising of industries such as chemicals, oil refining, and cement. This is because options for decarbonising industry are limited and fuel switching is sometimes only a partial solution. CCUS is not currently investable for most industrial sectors as deployment costs are higher than the current carbon price can support, and businesses are unable to pass these through to consumers. Additionally, businesses may face challenges raising capital finance to invest in CCUS until it has been more widely deployed in the UK. Therefore, an investable business model is needed, alongside clear commitments to provide certainty to industry.

31. The IDS set out the ambition to capture 3 $MtCO_2$ per year by 2030. Our delivery pathway for Carbon Budget 6 requires an increased ambition of 6 $MtCO_2$ per year by 2030 and 9 $MtCO_2$ per year by 2035. We envisage these emissions to be captured from industries in clusters as well as from more dispersed sites, where non-pipeline transport solutions such as the shipping of CO_2 may be required.

Revenue support for industrial carbon capture and hydrogen production

32. CCUS and hydrogen deployment will play a central role in our green industrial revolution and ensuring that the UK's businesses are competitive in a net zero future. We have been working with industry to develop business models for industrial carbon capture and hydrogen production to give investors the long-term revenue certainty they require. We are now setting up the Industrial Decarbonisation and Hydrogen Revenue Support (IDHRS) scheme to fund these business models and enable the first commercial scale deployment of low carbon hydrogen and industrial carbon capture. This will unlock by 2030 up to £6bn private sector capital, create thousands of jobs in key levelling up regions, grow the UK supply chain and achieve cost reductions, and deliver carbon savings to allow us to stay on track for our carbon budgets.

33. The IDHRS scheme will initially commit to providing up to £100 million to support initial electrolytic hydrogen projects, as set out in the Fuel Supply chapter. We will also be announcing a funding envelope in 2022 that will enable us to award the first contacts to industrial carbon capture facilities and CCUS-enabled hydrogen production projects from 2023 through the Cluster Sequencing process, to deliver up to 3 MtCO2/yr of industrial carbon capture and up to 1GW of CCUS-enabled hydrogen by the mid-2020s.

34. Subject to costs falling, we are also committing to further allocation rounds for all types of eligible low carbon hydrogen production and industrial carbon capture from 2025. We will announce further allocation rounds in due course which will enable us to meet our 2030 deployment ambitions of 6MtCO2/year of industrial carbon capture, 5 GW hydrogen production capacity, and four CCUS clusters, while continuing to grow the UK supply chain and achieve cost reductions. Once established, this framework could also be used in the future for other critical decarbonisation technologies.

35. From 2025 at the latest, all revenue support for hydrogen production will be levy funded, subject to consultation and legislation being in place. Further details on this will be set out in 2022 through the Government's response to the ongoing Hydrogen Business Model consultation. This will include parallel work to ensure fairness and affordability, such as exemptions for energy intensive industries at risk of carbon leakage.

Electrification

36. Electrification has the potential to abate between 5 $MtCO_2e$ and 12 $MtCO_2e$ of industry emissions per year by 2050. Electrification will play a more significant role (12 $MtCO_2e$) if hydrogen is unavailable in dispersed sites. This equates to an increase demand of electricity by 15-44 TWh. Additional electricity demand is consistent under our delivery pathway for Carbon Budget 6, albeit the demand comes at a faster pace due to the possible adoption of electrification in the iron and steel sector.

37. Electrification technologies for low temperature processes are technologically mature and could be applied to less energy intensive sites today. However, industry faces barriers to adoption such as high electricity costs. We have seen the impact of overreliance on gas pushing up prices for hardworking people but our plan to expand our domestic renewables will push down electricity wholesale prices. Applications for higher temperature processes are currently limited due to the low maturity of technologies. We are currently assessing these barriers and will set out initial steps that we will take to support the uptake of electrification by the end of 2021. Some initial grant funding support will be available via Phase 2 of the IETF from Autumn 2021. We are also working with Ofgem, network operators, and stakeholders on the approach to delivering low carbon electricity networks with the capacity to meet increased demand from industry.

Biomass

38. Initial support for sustainable use of biomass fuel switching and BECCS is available via Phase 2 of IETF. As set out in the IDS, current evidence strongly suggests that given limited sustainable biomass supply, we may need to prioritise the use of biomass where it can be combined with carbon capture and storage (BECCS), resulting in negative emissions. The Biomass Strategy, due to be published in 2022 will review the amount of sustainable biomass available to the UK, how this could be best used across the economy, and establish a role for BECCS in reducing carbon emissions across the economy.

Industrial non-road mobile machinery (NRMM)

39. NRMM covers a wide variety of machinery across the economy (e.g. diggers, combine harvesters, generators, cranes), with total emissions of around 12 $MtCO_2e$ per year. Industrial NRMM accounts for around 6 $MtCO_2e$,[37] coming from construction, mining, and manufacturing, with the remaining emissions largely attributed to agriculture (see *Natural Resources* chapter), and some to buildings and transport. New technologies have begun to penetrate markets for some NRMM uses, for example electrification technologies, particularly for small, light duty equipment. Government intervention is

likely to be necessary to ensure low carbon technologies continue to be developed and ensure uptake at the level needed to reach carbon budgets and net zero.

40. The first stage in government support will involve innovation funding to prepare key low carbon technologies for commercialisation. The £40 million Red Diesel Replacement competition will provide grant funding to develop and demonstrate low carbon alternatives to red diesel for the construction and mining and quarrying sectors, to help these sectors to decarbonise.

41. Further cross government work is required to develop policies to support the deployment of technological solutions and required infrastructure in specific sectors, including agriculture, transport and buildings. Relevant government departments will work together to ensure a coherent approach.

Steel

42. UK steel plays a critical role in the economy as a foundation industry supporting local economic growth and our levelling-up agenda. Steel employs around 32,500 people and supports up to a further 40,000 jobs through its supply chains, providing high value employment in economically deprived areas.[38] The IDS contains commitments to work with the newly constituted Steel Council to consider the implications of the recommendation of the Climate Change Committee to 'set targets for ore-based steelmaking to reach near-zero emissions by 2035'. Hydrogen-based steelmaking, CCUS and electrification are some of the technological approaches being considered as part of this process.

43. The Steel Council offers the forum for government, industry, and trade unions to work in partnership on the shared objective of creating an achievable, long-term plan to support the sector's transition to a competitive, sustainable, and low carbon future.

44. Steel accounts for 14% of industry emissions,[39] with 95% of this coming from two blast furnace sites, Scunthorpe, and Port Talbot.[40] Decarbonising these sites and the wider steel sector through switching to Electric Arc Furnace applying industrial carbon capture technology to existing blast furnaces or in the future using hydrogen-based DRI.

45. The UK recognises the importance of coordinating international activity on steel sector decarbonisation, to reduce the costs and risks of unilateral action. This includes working with international partners to collaborate on measures to mitigate carbon leakage, increase the effectiveness of R&D spending, and create larger, international markets for low emission steel products. The UK is taking a leading role in driving forward this activity, championing a number of key initiatives in this area at COP26, and beyond. This includes the Clean Energy Ministerial's Industrial Deep Decarbonisation Initiative, which the UK co-leads with India. This focuses on aligning approaches to data measurement, standards and procurement, to ensure there is a coordinated approach to market creation across borders. We are also supporting the Net Zero Industry Mission, under Mission Innovation, which aims to foster deeper collaboration on industry decarbonisation.

Resource efficiency and energy efficiency (REEE)

46. The Climate Change Committee estimate that REEE measures could contribute 11 $MtCO_2e$ of annual emissions reductions by 2035.[41] Various policies exist to incentivise and regulate action on REEE, but we need to ensure the right frameworks are in place to end clear investment signals and drive rapid action.

Resource efficiency

47. Resource efficiency and material substitution measures could save 9 $MtCO_2e$ per annum in industry within the UK by 2050.[42] Resource efficiency measures reduce emissions from industrial processes by keeping products and materials in circulation for longer by way of reuse, repair, remanufacture and recycling as well as reducing material usage. These activities enable the retention of value, and in some cases the creation of new value for both the producer and customer, at a much-reduced environmental impact.

48. The approach in driving the transition to a more resource efficient economy is set out for England in the Government's 2018 *Resources and Waste Strategy*, to be supplemented by a new Waste Prevention Programme, which outlines how we will maximise the value of our resources and minimise waste to increase the circularity of our economy. We will formalise joint working arrangements across government departments to promote collaboration on resource efficiency approaches, ensuring we are using all the policy tools available in working towards shared emissions and environmental targets.

49. The Climate Change Committee (CCC) balanced pathway estimates that 3 $MtCO_2e$ of potential savings per year could be driven by consumer-side measures by 2035. Government aims to support this shift in the 2020s through policy measures that inform consumers of the embodied carbon of industrial goods and empower them to make choices that support more efficient use of resources. Measures across different sectors will be explored, but opportunities have been identified in the construction, automotive and electronics sectors.

50. Government aims to support action in the construction sector by improving reporting on embodied carbon in buildings and infrastructure with a view to exploring a maximum level for new builds in the future. We recognise there is potential to reduce embodied carbon by way of material substitution where appropriate, such as in timber usage (see *Natural Resources, Waste and F-gases* chapter) and resource efficiency approaches, amongst others. We have also supported the Green Construction Board to produce a *Routemap to Zero Avoidable Waste*, published in July 2021.

51. Government is identifying opportunities to reduce the substantial embodied carbon footprint of the automotive sector, beyond the reduction and then elimination of emissions at the tailpipe.

52. We are building on the successful introduction this year of the first wave of right to repair measures for certain appliances and equipment. Alongside the review of Waste from Electrical and Electronic Equipment (WEEE), we will explore the use of labels that inform consumers of durability, repairability and recyclability. Other options under consideration include enhancing and extending producer responsibility schemes to incentivise sharing and renting.

53. To realise the wider emissions saving potential of resource efficiency measures will require establishing frameworks which minimise virgin resource use and maximise recycled, reused, or remanufactured content. We will continue to assess all, fiscal and non-fiscal, policy options to meet these objectives.

54. Knowledge can be a barrier preventing the value in waste resources from being realised, including the sharing of secondary resources across different industrial processes. We will support companies to identify these Industrial Symbiosis opportunities through facilitation of a cross sector network to boost take-up of circular economy initiatives. We will

support inter-disciplinary approaches and strengthen the evidence base on resource efficiency initiatives by collaborating with the UKRI funded National Interdisciplinary Circular Economy Research (NICER) programme, and through the development of data systems to connect energy, waste, and water flows from industrial sites.

Energy efficiency

55. Energy efficiency measures in industry range from simple, bill-saving measures to complex retrofits of industrial equipment with long payback periods and replacement cycles. We intend to explore regulatory measures to drive greater, earlier uptake of energy efficiency measures in line with Carbon Budget targets, supported by a wider package of policies to enable a smooth industry transition. We intend to consult on the development of a package of measures.

56. The heterogeneity of manufacturing industry means that processes are very varied, so codifying them for regulation across the whole sector may be challenging. We are currently exploring potential new regulatory options to address this challenge. This includes consideration of whether Energy Management Systems can provide a tailored, technology-neutral approach, and we would seek to minimise burdens imposed by regulation, possibly by using digital tools.

57. Energy intensive industry (EII) firms are already covered by energy efficiency regulations and many have adopted efficiency measures. We are examining how existing schemes can be enhanced (e.g. reforming Climate Change Agreements) and/or expanded (e.g. to non-EIIs and SMEs). For non-EIIs and SMEs, we are reviewing existing policies to ensure financial support is accessible and minimum standards are clear.

58. For smaller businesses, behaviours (awareness, prioritisation, maintenance) are often a further barrier to improving energy efficiency and we are considering new policies to respond to these barriers. Building on behavioural insights approaches in other areas of government policy, we are keen to explore how local networks – such as growth hubs, Local Enterprise Partnerships (LEPs), the local net zero hubs, and chambers of commerce – can be used to drive energy-efficient behaviours amongst businesses. We will consider which levers could work best to support, interconnect and scale-up these networks.

59. Funding for complex industrial retrofits with high payback periods will remain available via the IETF Phase 2 from Autumn 2021. These would be further supported by any future extension to the IETF, reflecting the government's manifesto commitment to increase funding to £500 million to 2028. Work will be undertaken to ensure sustainable financing measures are available long-term.

Demand-side measures

60. The IDS sets out our ambition to create demand for low carbon products, growing the associated market and supporting industry to share the costs of decarbonisation with consumers.

61. The IDS committed to exploring a range of policy options that can support this ambition including improved transparency of embodied emissions data, product labelling, regulatory standards, and agreeing public and private procurement approaches. The government has committed to developing detailed policy proposals in this area, beginning with a call for evidence on demand-side policy by Spring 2022. The call for evidence will investigate how we can define low carbon products and the emissions reporting that will be required to support those definitions. It will also explore the design of demand-side policy levers, with a view to the potential introduction of voluntary standards and labelling as early as 2025, and regulatory standards being introduced in the late 2020s.

62. Across these approaches, the IDS recognises the significant benefits which can be achieved through international cooperation, and the UK is leading the new Clean Energy Ministerial Industrial Deep Decarbonisation Initiative (IDDI), which aims to develop shared approaches to embodied emissions reporting and definitions for green steel and cement to drive public and private procurement.

Dispersed sites

63. Dispersed sites[43] account for approximately half of the UK's industrial emissions[44], and therefore form a major part of industry's pathway to net zero. These sites are highly diverse in terms of location, sectors, and industrial processes, ranging from energy-intensive processes such as clinker production in cement to less energy-intensive processes like pasteurisation in food and drink manufacturing.

64. The IDS indicated that emissions reductions in the early 2020s would focus on energy efficiency. Deeper decarbonisation potential is expected to be reached in the 2030s onwards, when uptake of low carbon technologies in dispersed sites is expected to be rapid.

65. Whilst the broad trajectory on decarbonising dispersed sites remains valid, the more ambitious Carbon Budget 6 targets mean we will explore opportunities for faster decarbonisation in dispersed sites in the 2020s. Going further on dispersed sites in the 2020s could help industry avoid technological lock-in through offering decarbonisation opportunities to align with investment cycles; and spread the benefits of green technologies beyond the clusters, supporting the levelling up agenda.

66. To achieve this, we intend to advance work in the following main areas:

- **Accelerated decarbonisation across dispersed sites:** We will investigate the potential for securing earlier emissions savings from segments of emissions where the technological pathway is more straightforward, or where economies of scale can be developed. This could include areas such as heat pumps for low temperature processes, and electrification of off-gas grid sites.
- **Preparing sites for key infrastructure decisions in the mid-2020s:** For most sites, more clarity on optimal decarbonisation options depends on key infrastructure decisions, such as the future of hydrogen in the gas grid by 2026. We will work with stakeholders to ensure that these sites understand their decarbonisation options once these decisions have been made. This would include funding for Mini-Cluster Industrial Decarbonisation Plans in the early 2020s, to develop shared infrastructure and intergrated decarbonisation solutions in local areas. This would be supplemented by continued funding via Phase 2 of the IETF for site-level studies and deployment.[45]

Working together across the UK

Examples of policy action by the Scottish Government, Welsh Government, and Northern Ireland Executive

Wales

A collaboration between researchers at Swansea University and cement producer Hanson UK has seen the installation of a new demonstration unit at the company's Regen Ground Granulated Blast Furnace Slag (GGBS) plant in Port Talbot. The demonstration unit replaces some of the natural gas in the Regen process with green hydrogen. The carbon footprint of Regen GGBS is about one tenth of Portland cement and it is used as a replacement for up to 80% of the cement in concrete. The project is part of the £9.2 million Reducing Industrial Carbon Emissions (RICE) project which has been part-funded by the European Regional Development Fund through the Welsh Government.

Scotland

The Scottish Government has announced a major fund to decarbonise industry and manufacturing opening opportunities to develop negative emissions technologies (NETs). The Scottish Industrial Energy Transformation Fund commits £34 million for projects at industrial sites for energy efficiency or deeper decarbonisation, including on feasibility and conceptual studies into the role of NETs.This is supported by a £180 million Emerging Energy Technologies fund to support Hydrogen, CCS and NETs projects.

The Scottish Government has also launched the Grangemouth Future Industry Board in recognition of the continued commitment to Scotland's largest industrial manufacturing cluster, now and in our net zero future. Supporting a just transition to net zero is at the heart of the Board's work, designing the collaborative approach to planning for the transition of this core manufacturing region and harnessing the significant assets, technical and engineering,, skills, and significant opportunities presented by the cluster.

Northern Ireland

Invest Northern Ireland delivers a suite of support, including specialist advice and investment capital to enable Northern Irish businesses to become more efficient and resilient through green efficiencies. Support includes:

- Technical Consultancy: Available to all businesses with an annual energy and resource spend above £30,000, this support includes fully funded technical audits, feasibility studies and advice to help businesses identify cost and carbon savings.
- Resource Matching through Industrial Symbiosis: fully funded support that offers opportunities to convert redundant materials of one business into a resource for another business, utilising a circular economy approach to add value and to reduce costs and carbon for all parties.
- Resource Efficiency Capital Grant: Available to eligible businesses, grants of up to £50,000 to help with the purchase of new resource efficient technologies that reduce the consumption of water, raw materials and waste produced leading to reduced carbon emissions.
- COVID-19 Energy Efficiency Capital Grant: Available to eligible businesses to build resilience through green efficiency, grants of up to £80,000 are available for the installation of energy efficiency equipment that offers cost and carbon savings through the reduction of energy consumption.

3iv. Heat & Buildings

Decarbonising the way we heat and power our buildings

Our Key Commitments

- Levelling up through supporting 175,000 green skilled jobs by 2030 and 240,000 by 2035 – resulting in £6 billion additional GVA by 2030 and with a focus on the areas that need investment most.
- Making the transition to low carbon buildings affordable and achievable for all by:
    - Aiming to phase out the installation of new and replacement natural gas boilers by 2035 in line with the natural replacement cycle, and once costs of low carbon alternatives have come down, including any hydrogen-ready boilers in areas not converting to hydrogen, to ensure that all heating systems used in 2050 are compatible with net zero.
    - Making heat pumps as cheap to buy and run as a gas boiler by growing the heat pump market to support 600,000 installations per year by 2028 and expanding UK manufacturing – with the ambition of working with industry to reduce costs by at least 25-50% by 2025 and to parity with gas boilers by 2030 at the latest.
    - Supporting households in making this transition with a new £450 million Boiler Upgrade Scheme providing £5,000 capital grants and a new market-based incentive for heating system manufacturers, whilst investing £60 million in heat pump innovation – making them beautiful, smaller, easier to install.
    - Consulting on phasing out the dirtiest and most expensive fossil fuels first - new oil, coal and liquefied petroleum gas heating - and replace with low carbon alternatives in non-domestic buildings from 2024 and homes from 2026, following natural appliance replacement cycles.
    - Committing to action on addressing distortions in fuel prices to ensure that low carbon technologies are no more expensive to run than fossil fuel boilers.
- Helping households and businesses reduce their energy bills while making buildings healthier and more comfortable benefiting from warmer, comfier, more valuable buildings through:
    - Upgrading fuel poor homes to EPC Band C by 2030 where reasonably practicable and providing additional funding to the Home Upgrade Grant and the Social Housing Decarbonisation Fund – investing £1.75 billion.

- Consulting on phasing in higher minimum performance standards to ensure all homes meet EPC Band C by 2035, where cost-effective, practical and affordable.
- Setting long-term regulatory standards to upgrade Privately Rented Homes to EPC C by 2028 and considering setting a long-term regulatory standard for Social Housing, subject to consultation.
- Reducing the energy consumption in commercial and industrial buildings in England and Wales by 2030, using measures including regulations and a performance-based measurement scheme.
- Investing a further £1.425 billion in the Public Sector Decarbonisation Scheme, with the aim of reducing direct emissions from public sector buildings by 75% by 2037.
- Setting a minimum energy efficiency standard of EPC Band B by 2030 for privately rented commercial buildings in England and Wales.

- Establishing large scale trials of hydrogen for heating to take decisions in 2026 on the role of hydrogen in decarbonising heating, and consult on the case for enabling or requiring hydrogen-ready boilers and broader heating system efficiencies.
- Continuing to grow and decarbonise the UK Heat Network market through the £338 million Heat Network Transformation Programme of which at least £270m will go towards the Green Heat Network Fund, introducing sector regulation and new heat network zones by 2025.
- Launching a new world-class policy framework for energy-related products to ensure products use less energy, reducing emissions and household bills.

Progress to date

1. The UK has around 30 million buildings[46] and includes some of the oldest building stock in Europe.[47] In total, buildings are responsible for around 17% of our national emissions.[48] Currently, 1.7 million fossil fuel heating systems are installed per year (gas, oil, and coal).[49] The vast majority of emissions from buildings result from heating. Including indirect emissions (e.g. from electricity generation) emissions from heating buildings make up around 78% of all buildings emissions and about 21% of all UK emissions.[50] Overall, between 1990 and 2019, net UK greenhouse gas emissions from heat and buildings decreased by 17%.

2. The package of measures presented here, and in our *Heat and Buildings Strategy* (HBS) and associated consultations, delivers on commitments made in the *Ten Point Plan* for a *Green Industrial Revolution* and the *Energy White Paper*. In the *Ten Point Plan*, we committed to deliver greener buildings. Since then, we have announced £60 million to support decarbonisation of Social Housing and have allocated over £1 billion from the Public Sector Decarbonisation Scheme, in doing so, supporting up to 30,000 jobs.

3. Homes: The UK already has a strong track record improving energy performance, with 40% of our homes now above Energy Performance (EPC) Band C, up from just 9% in 2008. There are approximately 28 million households in the UK,[51] and 86% of homes in England use natural gas boilers.[52] Across the UK, 9% of the energy consumed to heat homes is provided by other fossil fuels, such as oil and coal, generally in homes that do not have access to the gas grid.[53] In 2019, approximately 15 million (60%) of homes in England had a lower energy performance, with ratings of EPC band D and below.[54] The largest proportion of homes in England are owner-occupied (64% in 2019), with a much smaller proportion being socially rented (17% in 2019), or privately rented (19% in 2019).[55] Owner-occupied homes are now the worst performing tenure, with the greatest proportion of homes below EPC band D.[56] Improving the energy performance of all homes and taking a 'fabric first' approach, by improving the energy efficiency will be key to ensuring the transition to low carbon heating is cost effective.[57]

4. Non-domestic buildings: There are approximately 1.7 million non-domestic (commercial, industrial and public) properties in England and Wales.[58] Non-domestic buildings account for around a quarter of UK building emissions.[59] Commercial and industrial buildings over 1,000 m^2 are responsible for over half of the energy used by commercial and industrial buildings (excluding process heat) but account for only 5% of the stock.[60] Public sector buildings account for about 9% of building emissions.[61]

Net zero transition and economic opportunities

5. By 2050, buildings will need to be almost completely decarbonised, by making use of a combination of technologies to minimise their carbon emissions and maximise their energy performance. The scale of this challenge is significant, but we will take an approach that goes with the grain of consumer behaviour and maximises consumer choice, to ensure a smooth and gradual transition for households and businesses. Much like the move to electric vehicles, the move to low carbon options such as electric heat pumps will be a gradual transition from niche product to mainstream consumer option. To ensure that we all benefit from cleaner, warmer and comfier buildings, will need to improve the energy efficiency of our buildings and products, end the use of fossil fuel heating systems and switch to low carbon sources, and integrate the use of smart technologies that give more control to consumers.

Seizing new opportunities

6. The decarbonisation trajectory of the sector presents significant potential for investment and export opportunities for goods and services. Deployment of energy efficiency measures and low carbon heating in domestic and non-domestic buildings, in line with the ambitions and outcomes in the Heat and Buildings Strategy, will drive up to £6 billion gross value added (GVA) per year by 2030.[62]

7. This will be investment not just in the buildings themselves, but in the infrastructure that supplies them. Government support will stimulate this investment and will need to be focussed on growing key markets for low carbon heat and supporting vulnerable and low-income households, the social housing sector, and the public sector.

8. Decarbonising the heat and buildings sector will regenerate communities and open up new employment opportunities right around the UK. Based on current estimates, policies and proposals to reduce emissions from buildings could support up to 100,000 jobs by the middle of the 2020s and up to 175,000 in 2030. Jobs will be supported across a range of areas – from manufacturing to services, and from installation to research and development.

9. Decarbonising buildings will deliver a range of benefits:

- **Levelling up**. Decarbonisation will support clean, local growth in every region of the UK, while investing in equality of living standards and job creation. Reducing heat and buildings emissions will require installing energy efficiency measures and new heating systems, which rely on local supply chains and businesses.
- **Reducing energy bills and business operating costs**. Inefficient homes are more expensive to run. The Energy Efficiency Infrastructure Group estimate that upgrading all UK homes to EPC band C could provide annual energy cost savings of £7.5 billion.[63]
- **Tackling fuel poverty**. In 2014, the Government introduced a statutory fuel poverty target for England, to improve as many fuel-poor homes as is reasonably practicable to a minimum EPC rating of band C by the end of 2030. Tangible, targeted support for more deprived areas can be achieved through action to upgrade poor-performing buildings, leading to warmer, healthier homes and lower energy bills. We recently published an updated fuel poverty strategy for England.[64]
- **Improving health**. COVID-19 has highlighted the importance of good ventilation in buildings. Improving the energy performance of our buildings, whilst ensuring good ventilation, will ensure they are efficient and healthy environments. This can help avoid many physical illnesses, including heart and lung conditions[65]. Reducing the number of fossil fuel boilers will also significantly reduce the various pollutants emitted, including nitrous oxides, which negatively impact human health. Improved thermal comfort also leads to better health and wellbeing as well as reducing the likelihood of condensation and mould.
- **Increasing property value**. Studies indicate that more energy efficient properties typically have a higher value than less efficient ones. Evidence from a study commissioned by BEIS indicated that properties with an EPC C rating were worth around 5% more than those currently at EPC D rating, after controlling for other factors such as property size and archetype.[66]

Our 2050 vision and how we get there

10. Our approach to this transition must be affordable and achievable for all and, following successes in power and electric vehicles, we will utilise long-term signals alongside early investments to bring down costs and improve consumer offers:

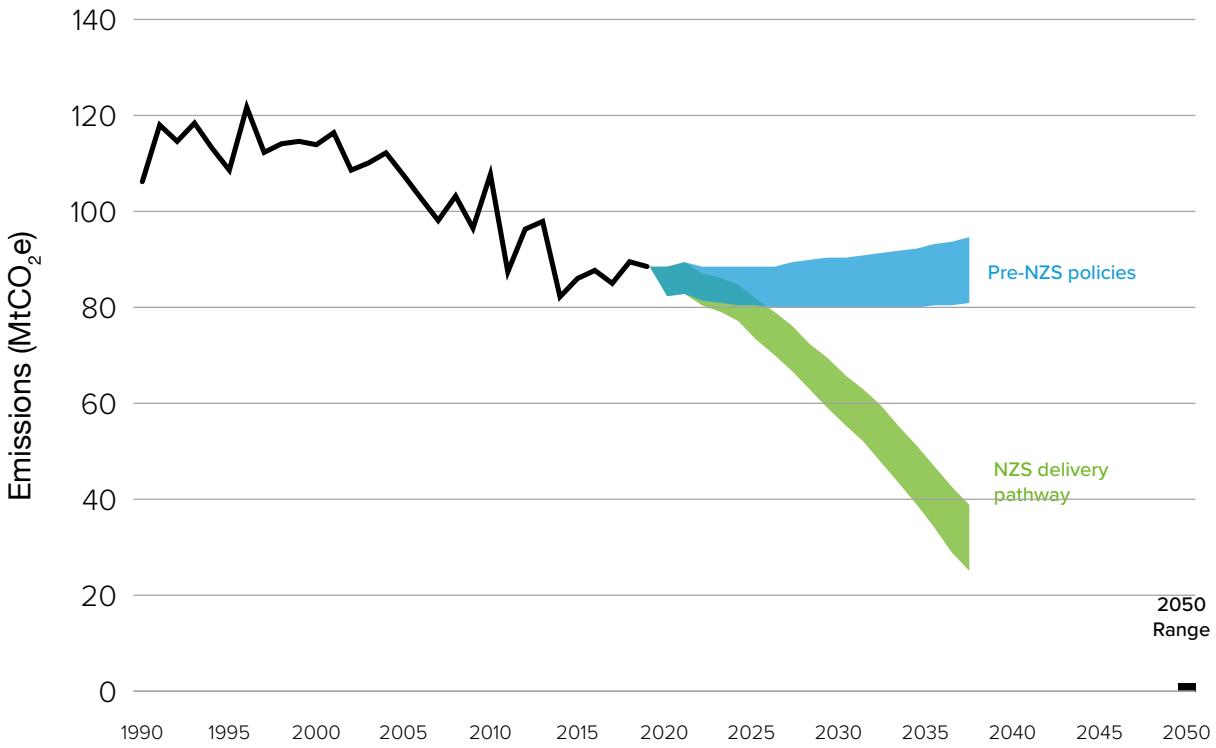
- **Investing in innovation**. Continuing to work with industry to refine processes and technologies to deliver value-for-money and value for the UK economy – with an emphasis on making technology cheaper, easier to install and designed to appeal to consumers. We are investing in technology now, in trialling hydrogen ahead of strategic decisions on the role of hydrogen for heating in 2026; and £60 million in heat pump innovation – making them beautiful, smaller and easier to install.

- **Prioritising no or low regrets actions**. Reducing bills through a fabric-first approach to improving building thermal efficiency through, for example, insulation, draught-proofing and increasing the energy performance and capability of products and appliances.[67]
- **Growing supply chains and bringing down costs**: Making heat pumps as cheap to buy and run as a gas boiler by growing the heat pump market to support 600,000 installations per year by 2028 and expanding UK manufacturing – reducing costs by at least 25-50% by 2025 and to parity with gas boilers by 2030. To help achieve this we are announcing a new £450 million Boiler Upgrade Scheme – offering households £5,000 grants when they install an air source heat pump.
- **Continuing to support those most in need**. Supporting the vulnerable through the transition to low carbon buildings and meeting our statutory fuel poverty target. We will continue to ensure financial support is available for those who need it most. We are investing a further £1.75 billion in funding for our Home Upgrade Grant and Social Housing Decarbonisation Fund schemes, which provide support for low-income households in installing energy efficiency and low carbon heating.
- **Balancing certainty and flexibility**. Providing stability for investment through clear long-term signals that work with the grain of the market and minimise impact on consumers. For example, aiming to phase out the installation of new and replacement natural gas boilers by 2035, in line with the natural replacement cycle and only once costs of low carbon alternatives have come down.
- **Ensuring buildings are resilient to the impacts of climate change**. Implementing measures to ensure homes and buildings are well ventilated and protected against rising temperatures.
- **Taking a whole-sector and whole-system approach**. Considering the heating system in the context of what is most appropriate for the whole building to minimise costs, as well as accounting for local suitability, environmental impacts, and air quality.

11. The benefits of more efficient, low carbon buildings for consumers are clear: smarter, better performing buildings, reduced energy bills and healthier, more comfortable environments. Households and businesses will need to play their part in decarbonising their buildings, but we need to ensure that the costs of doing so fall fairly across society.

12. Based on our whole-system modelling, by 2050, emissions associated with heat and buildings could need to drop by 98-100% compared to 2019, down to 0-2 space between digit and unit $MtCO_2e$. In the interim, to meet our NDC and CB6 targets, we expect emissions could fall by 25-37% by 2030 and 47-62% by 2035, compared to 2019 levels. These figures are based on an indicative heat and buildings pathway contributing to the whole-economy net zero and interim targets (see figure 20 below).

Figure 20: Indicative heat and buildings emissions pathway to 2037



Source: BEIS analysis

13. We have developed **three high-level illustrative scenarios to reflect different technology mixes** that would allow us to decarbonise heating of buildings, contributing towards meeting our Carbon Budget 6 target. We are committed to taking strategic decisions on the role of hydrogen for heating in 2026, following trials, which will further inform out pathway to 2050. Realising these scenarios would be consistent with our trajectory to net zero in 2050. These are: a high hydrogen scenario, a high electrification scenario and a dual energy system scenario.

14. In all scenarios the following will be important:

- Improving the energy performance of buildings to keep buildings warm and comfortable, keep bills down, minimise the impacts of transition on the energy system, and make switching to low carbon heating easier.
- Phase out of heating appliances that are only capable of burning fossil fuels, consistent with our ambition to phase out the installation of new and replacement natural gas boilers by 2035, and phase out the installation of high-carbon fossil fuel boilers in properties not connected to the gas grid by 2026 (and 2024 for non-domestic buildings).

- Heat pumps: these will be the best low carbon heating option for some types of buildings, for example, if they are new buildings or off the gas grid. We have set a target of 600,000 heat pump installations per year by 2028, from roughly 35,000 currently. We expect this to be the minimum number of heat pumps that need to be deployed each year after 2028 across any scenario, and all scenarios other than high hydrogen will require much higher deployment. Of the 600,000 heat pumps per year, we expect about 200,000 to be in new build properties.
- Heat networks: they use hot water in pipes to deliver heating (and in some cases cold water for cooling) to many consumers from a centralised heat source. Heat networks could supply up to 20% of UK heat demand by 2050, up from 3% of UK heat supply today.[68]

15. To achieve the level of emissions reductions in the heat and buildings sector indicated by our delivery pathway to 2037, we will need additional public and private investment of approximately £200 billion.

High electrification scenario

16. In this scenario, we assume there is no significant use of hydrogen for heating in buildings. This may be because hydrogen is not proven to be feasible, cost-effective, or preferable as a solution for low carbon heating, or because its deployment has been significantly delayed. In this scenario, we would need to continue the rapid growth of the heat pump market beyond 600,000 per year in 2028 to up to 1.9 million per year from 2035, resulting in roughly 13 million homes using low carbon heating systems by 2035 – around 11 million with heat pumps and around 2 million using heat networks.

17. To ensure we drive this level of heat pump deployment, further policy would be required to phase out installation of new fossil fuel heating faster. We could grow the heat pump market and transition consumers in stages, while continuing to follow natural replacement cycles to work with the grain of consumer behaviour. For homes, we could focus initially on key segments of the domestic building stock, for example based on tenure, property age or fabric efficiency.

18. The increased deployment of heat pumps will be accompanied by investment in the infrastructure we need to meet increased electricity demand, including the generation of low carbon electricity and additional grid capacity.

High hydrogen scenario

19. In this scenario, hydrogen has proven feasible and preferable as a solution for heating most UK buildings, and decisions taken in 2026 set the UK on a path to converting most of the national gas grid to hydrogen. We would expect to begin the transition by converting a pilot hydrogen town by the end of the decade and then accelerate rollout. The conversion would likely start by building out from existing hydrogen production and use in industrial clusters, and roll-out would involve switchover on an area-by-area basis in different locations.

20. Due to the infrastructure and supply chain requirements of a hydrogen conversion we estimate that in this scenario, we would convert around 4 million homes to using low carbon hydrogen by 2035. New heating system installations should be low carbon or hydrogen-ready, meaning ready for a planned future conversion, from 2035. We estimate that by 2035 roughly 13 million homes will have low carbon heating, comprising around 7 million with heat pumps, 4 million using hydrogen, and around 2 million homes using heat networks.

Dual energy system scenarios

21. In this scenario, both hydrogen and electrification prove feasible and preferable as heating solutions to large numbers of consumers. This could arise in several forms:

- All or most of the gas grid is converted to low carbon hydrogen, but the costs and benefits of switching to hydrogen versus installing a heat pump are viewed differently by different consumers. This could result in a high switchover to both hydrogen and heat pumps on the gas grid.
- There is partial but still extensive conversion of the gas grid to hydrogen, based on differing geographical or built environment factors. This would require careful consideration of which parts of the grid would be converted and where responsibility for decisions about the costs and benefits of converting different areas should lie.
- There is widespread consumer demand for hybrid systems that utilise a mix of energy sources.

22. It is too early to determine the policy framework that might support this mixed transition. Any scenario in which hydrogen is an available option for consumers will require public policy decisions to enable cost-effective and co-ordinated investment in infrastructure and supply chains, and ensure consumer choice and other public interests are protected. If the case for converting the network to hydrogen differs strongly from area to area, more of the preparation may need to take place at a regional or local level.

Future scenarios - what factors we are going to consider in making decisions for mass decarbonisation of heating

Over the 2020s, we will need to start taking more decisive steps about which technologies and infrastructure should be rolled out, where and when, and accordingly, where we need to target investment, skills, and other enabling actions. We aim to make decisions about the role of hydrogen in heating by 2026, and commit to reviewing existing institutional arrangements, as stated in our Heat and Buildings Strategy, helping ensure that we have an appropriate framework in place to facilitate decision making at all levels.

Upfront costs

The cost of installing a heat pump is currently significantly more expensive than gas boilers and installation often requires additional ancillary works, such as upgrading radiators. This can result in total installed costs of around £10,000 for the average home. However, the cost of installing heat pumps should fall significantly as the market scales up, and the Heat and Buildings Strategy has set ambitions on reducing the installed cost of heat pumps over this decade. We are also providing subsidy for first movers: through the Boiler Upgrade Scheme, which will provide grants of £5,000 towards the cost of installing an air source heat pump and £6,000 for Ground Source Heat Pumps. We will look to help the market drive down the upfront costs, which leading market participants believe can make heat pumps as cheap to buy and run as a gas boiler by 2030. This ambition reflects the opportunity for innovation and economies of scale across the value chain and has been seen in other technologies such as solar PV, wind and electric vehicles. Conversely, it is likely hydrogen appliances will cost approximately the same as natural gas appliances (around £3k).

Running costs

Heat pumps are significantly (2.5 – 3x) more efficient than gas boilers and may get even more efficient, therefore requiring much less energy to run. Currently, on average heating a home with a heat pump costs more than with a gas boiler. This is, in part, due to policy and social costs charged on electricity bills. However, by addressing existing distortions between electricity and gas prices, we will ensure heat pumps will be no more expensive to run than gas boilers.

It is too early to properly estimate the running costs of hydrogen heating. The cost of producing hydrogen is currently higher than fossil fuels. Though the future production costs of hydrogen will not be the same as the ultimate cost to consumers, using hydrogen for heating could cost more than natural gas heating. There remains uncertainty on other issues that will impact on hydrogen costs, such as, new and innovative means of production, the cost to store it, new and innovative business models, and the cost of any changes to the gas grid that may be required.

Consumer journey

Heat pumps, unlike most traditional fossil fuel boilers, tend to work by providing an ambient temperature, rather than short blasts through very hot radiators. Evaluation and research have shown that the majority of consumers are happy with the performance of their systems, and smart controls help consumers with this change. Installing heat pumps at the same time as carrying out building energy efficiency and heating system improvements allows for a single intervention and could prove more efficient for many households or businesses.

Hydrogen boilers will likely work in a similar way to gas boilers. Some adaptive measures might be needed to enable hydrogen, but requirements for this and associated costs are still uncertain and could vary significantly between different types of buildings. When switching over to hydrogen, the initial grid conversion process is likely to require streets or areas to be converted at the same time. It is expected that an engineer will need to have access to homes to do the changeover in a particular timeframe, and building residents are unlikely to have control over when this happens.

Policies and proposals

Decarbonising heat

23. Much like the move to electric vehicles, the move to heat pumps will be a gradual transition from niche product to mainstream consumer option. Our core commitment is that we will aim to phase out the installation of new and replacement natural gas boilers in homes and buildings by 2035 at the latest, once costs have come down. This would be in line with the natural replacement cycle, and include hydrogen ready boilers in any areas not converting to hydrogen, to ensure all heating systems used in 2050 are compatible with net zero.

24. Accelerating heat pump deployment. We will grow the UK heat pump market to support 600,000 installations per year by 2028. As part of this, and working with industry to do so, we will aim for cost parity between heat pumps and gas boilers by 2030 with significant cost reductions of at least 25-50% by 2025. To achieve this, we will introduce a range of new policies to support heat pump deployment, including a new £450 million Boiler Upgrade Scheme over 2022/23 to 2024/25 with grants of £5,000 for an air source heat pump. In addition, we will consult on phasing out the installation of new oil, coal, and LPG heating, and replace with low carbon alternatives such as heat pumps in off gas grid non-domestic buildings from 2024 and homes from 2026, and we will launch a new market-based incentive for heating system manufacturers, similar to that for CO_2 in cars. Subject to strategic decisions on the pathways and market conditions, we would look to grow the heat pump market beyond 600,000 per year in 2028 and potentially up to 1.7 million a year by 2035, and we will consult on our proposed approach to doing this.

25. We are investing £60 million in a 'Heat Pump Ready' Programme which will support the development of innovative solutions to improve deployment, tools and technologies across the heat pump sector. These new opportunities will build on our previous Energy Innovation Programme activities, such as the Electrification of Heat Demonstration Project.

26. Heat networks. Under the £338 million Heat Network Transformation Programme, we will launch the £270 million Green Heat Network Fund to grow the market for low carbon heat networks. We will also pass new legislation to regulate the sector for consumers, give heat networks the statutory powers they need to build, and regulate the carbon emissions of projects from the early 2030s. We will also deliver new heat networks zones in England by 2025 where heat networks are the default solution for decarbonising heating. Finally, we will work with industry to increase the capacity and capability of the UK supply chain to support the sector to reach its growth potential and look to improve performance of legacy networks through the Heat Network Efficiency Scheme.

27. Hydrogen heating. We will work in partnership with industry and other key stakeholders to thoroughly assess the feasibility, safety, consumer experience and other costs and benefits, of hydrogen as an option for heating our homes and workplaces. We will support industry to develop and deliver large scale trials of hydrogen for heating, including a neighbourhood trial by 2023 and a village scale trial by 2025, and develop proposals for a possible 'hydrogen town' before the end of the decade. We will develop the evidence base and frameworks necessary to take strategic decisions on the role of hydrogen in decarbonising heat in 2026. In the shorter-term, we will work with the Health and Safety Executive and industry partners to enable up to 20% hydrogen blending in suitable areas of the GB gas networks subject to the success of testing and trials, and value for money assessment.

28. Hydrogen-ready boilers and boiler standards. We are aiming to consult shortly on the case for enabling or requiring new gas boilers to be readily convertible to use hydrogen ('hydrogen-ready') by 2026. We will also use this consultation to test proposals on the future of broader boiler and heating system efficiency and explore the best ways to reduce carbon emissions from our gas heating systems over the next decade.

29. Biomethane in the gas grid. We will deliver a new Green Gas Support Scheme (GGSS) to support the injection of biomethane from anaerobic digestion (expected to deliver 2.8TWh of renewable heat per year in 2030/31), and we will explore the development of commercial-scale gasification and the replacement of the GGSS with a long-term biomethane support scheme.

Improving buildings

30. Our core commitment is to reduce bills, whilst improving comfort, health and home value, through ensuring as many homes as possible to achieve EPC Band C by 2035 at the latest, where cost-effective, practical, and affordable.

31. New Buildings. We will introduce regulations from 2025 through the Future Homes Standard to ensure all new homes in England are ready for net zero by having a high standard of energy efficiency and low carbon heating installed as standard. This should mean that all new homes will be fitted with a low carbon heat source such as a heat pump or connected to a low carbon heat network. To reinforce this, we will consult on whether it is appropriate to end new gas grid connections, or whether to remove the duty to connect from the Gas Distribution Networks. As an interim measure to the Future Homes Standard, we plan to introduce an uplift in standards, effective from June 2022, for England that would result in a 31% reduction in carbon emissions from new homes compared to current standards. We will also respond to our consultation for the Future Buildings Standard for new non-domestic buildings.

32. Domestic private rented sector. We will build on our 2020 consultation on strengthening the Minimum Energy Efficiency Standards to EPC band C by 2028 to set long term minimum regulatory standards consistent with our net zero commitment for private rental sector. We are aiming to publish a response to this consultation by the end of the year We have provided significant additional support to local authorities to ensure compliance and enforcement of these regulations, building on earlier compliance and enforcement pilots. This includes providing £4.3m to 57 local authorities to support activity in these areas. We plan to scale up activity further in the coming years. We have also set out proposals to strengthen the compliance and enforcement framework under our recent EPC Band C consultation. This includes the introduction of a compliance and exemption database to support local authority enforcement of the Regulation.

33. Owner occupied homes. We are also exploring opportunities to improve the energy performance of owner-occupier homes. We have conducted a series of stakeholder workshops on the case for action, with over 50 representatives from the housing sector, landlord representatives, retrofit supply chain, NGOs, and consumer organisations. We plan to consult on options to upgrade homes in the owner occupier sector. We will work with owner-occupiers to help them improve the liveability of their homes. The provision of green finance will be an important step in making this easier and more accessible.

34. Social housing. We will provide £800 million additional funding to the Social Housing Decarbonisation Fund (SHDF) over 2022/23 to 2024/25, which will deliver energy performance improvements to social housing. We will also consider setting a long-term regulatory standard to improve social housing to EPC Band C and consider levers required to decarbonise the stock in line with net zero. We will consult the sector before setting any regulatory standard.

35. Low Income/Fuel Poor Consumers. We will ensure as many fuel-poor homes as reasonably practicable achieve a minimum energy efficiency rating of C by the end of 2030. To help achieve this, we will provide £950 million additional funding over 2022/23 to 2024/25 for off-gas-grid properties through the Home Upgrade Grant (HUG) to provide ongoing support for low-income households living off the mains gas grid with energy efficiency and low carbon heating upgrades. We will also expand and extend the Energy Company Obligation Scheme and the Warm Homes Discount Scheme until 2026.

36. Net zero backstop for homes. We will consider on an ultimate backstop date to ensure that all homes meet a net zero minimum energy performance standard before 2050, where cost effective, practical, and affordable.

37. Public Sector. We have committed to halve direct emissions from public sector buildings by 2032, against 2017 levels, and we aim to further reduce emissions from public sector buildings by 75% by 2037. To help achieve this, we will provide £1.425 billion additional funding for the Public Sector Decarbonisation Scheme (PSDS) over 2022/23 to 2024/25, and through our Greening Government Commitments (GGCs) which sets targets to reduce emissions from central government departments and arms-length bodies. We have also initiated the Public Sector Low Carbon Skills Fund which provides complementary funding alongside the PSDS to enable public sector organisations to acquire expert skills in order to unlock decarbonisation projects.

38. Non-domestic buildings. The *Energy White Paper* set a minimum energy efficiency standard of EPC Band B by 2030 for privately rented commercial buildings in England and Wales. Later this year we plan to consult on regulating the non-domestic owner-occupied building stock, and we are considering whether this should align with the private rented sector minimum energy efficiency standards. We will also respond to the 2021 consultation on introducing a performance-based policy framework in large commercial and industrial buildings and pilot the scheme in 2022.

39. We will look to consult stakeholders on the Small Business Energy Efficiency Scheme (SBEES) later this year. The scheme will aim to remove barriers for SMEs in accessing energy efficiency measures, drive forward better buildings performance and aid SMEs in meeting regulatory standards. Finally, we have consulted on strengthening the Energy Savings Opportunity Scheme (ESOS), which is a mandatory energy assessment scheme for large businesses' energy use and opportunities to improve energy efficiency.

- **Energy-related products.** We have published a policy framework setting out illustrative proposals for raising minimum energy performance standards and improving consumer information for a range of high potential products, including but not limited to space heating, cooking, taps and showers and lighting. We plan to consult on more concrete proposals between 2022 and 2023 ahead of implementing measures from 2025.

Enabling actions

40. There are a range of barriers to home energy performance improvements, which we will also need to address to help people act:

- **Advice & information**. Our existing Simple Energy Advice service has received over 1.5m users to date. We will enhance our digitally led service, and are considering options to support tailored retrofit advice in local areas. The aim is to create a Government-led home energy advice journey, supported by tailored local advice. This includes moving our Simple Energy Advice service to GOV.UK, which will improve user experience, and supporting local advice provision. This will help households to improve the energy performance of their homes, and move towards net zero.
- **Green finance**. Catalysing the market for Green Finance is a priority. We are working with mortgage lenders to support homeowners to improve the energy performance of their properties and will publish our response to our lenders consultation in due course. Government is also exploring the case for a further green home finance innovation programme, focussed on supporting lenders to develop green finance products targeted at consumer types who will be impacted by future regulation, and which the market is unlikely to develop on its own in the short term. BEIS has invited the UK Infrastructure Bank (UKIB) to help steer this work, and we will work further with the UKIB to explore whether they can play a wider role in scaling up green home finance.

41. Rebalancing energy prices: Clean, cheap electricity is an everyday essential. We have seen the impact of overreliance on gas pushing up prices for hardworking people but our plan to expand our domestic renewables will push down electricity wholesale prices. However, current pricing of electricity and gas does not incentivise consumers to make green choices, such as switching from gas boilers to electric heat pumps. We want to reduce electricity costs so we will also look at options to shift or rebalance energy levies (such as RO and FiTs) and obligations (such as ECO) away from electricity bills over this decade. This will include looking at options to expand carbon pricing and remove costs from electricity bills while ensuring that we continue to limit any impact on bills overall. We know that in the long run, green products are more efficient and cheaper, and we are putting fairness and affordability at the heart of our approach. We will launch a Fairness and Affordability Call for Evidence on these options for energy levies and obligations to help rebalance electricity and gas prices and to support green choices, with a view to taking decisions in 2022.

42. Developing a workforce pipeline with the skills to meet the requirements of net zero transition:

- The increase in deployment of low carbon heating systems over the coming decade will require a significant escalation in the number of trained, high-quality installers. With this in mind, we have launched the independent Green Jobs Taskforce with key industry bodies to advise on how we can have the skilled workforce to deliver net zero and support people in high carbon sectors with the transition.
- We will encourage current gas engineers, electricians, and those with transferrable skills in complementary sectors, to retrain and specialise in smarter, greener, and cleaner technologies. There are over 140,000 plumbers and heating and ventilation engineers in the UK. Approximately 90% of builders stated they would be willing to retrain to meet the demand for new roles and skills' changes in the future.[69] Attracting new entrants to the sector also provides a great opportunity to diversify the workforce. We will work with industry to support training and new routes of entry to help boost heat pump installer numbers and other areas of skills shortage to support the decarbonisation of homes. We will also work with industry and the low carbon projects supported through the Green Heat Network Fund to increase opportunities to gain skills in the heat networks sector.
- We will also continue to work with Ofgem, distribution network operators, and other local actors on the approach to planning the network in Great Britain and delivering smart, secure, cost-effective solutions. This will include considering the potential for storage and hybrid technologies in combination with flexible tariffs.

Working together across the UK

Examples of policy action by the Scottish Government, Welsh Government and Northern Ireland Executive

UK Government is working across all levels of government and with Devolved Administrations to ensure consistent action to reduce emissions across the heat and buildings sector, and across the UK.

Wales

The Optimised Retrofit Programme is testing a new approach to decarbonising homes, based on the recommendations of the Jofeh Report.[70] The programme is delivering fabric improvements, heating technology and intelligent use of energy supplies to more than 1,500 homes across Wales. Significant Welsh Government investment is supporting social landlords to decarbonise 230,000 social homes over the next decade, and the learning from the programme will be used to help decarbonise Wales's 1.2 million private-rented and owner-occupier homes.

Scotland

The Scottish Government published its Heat in Buildings Strategy on 7 October 2021. This sets out a vision and actions for the decarbonisation of heat in homes and buildings in line with Scotland's statutory climate targets. The Scottish Government will allocate at least £1.8 billion over the next five years to support the accelerated deployment of heat and energy efficiency measures in homes and buildings. This investment will help to cut emissions, create jobs, strengthen supply chains, and tackle fuel poverty. The Scottish Government offers cashback grants to all homeowners as part of the Home Energy Scotland (HES) Loan Scheme, up to £6,000 for energy efficiency improvements and up to £7,500 for new renewable heating. It is also bringing forward the requirement for all homes to be upgraded to meet at least EPC C standards or equivalent by 2033 with the majority meeting this standard by 2030.

Subject to devolved competence, the Scottish Government has committed to phasing out the need to install new or replacement fossil fuel boilers, in off gas areas from 2025 and in on gas areas from 2030, subject to technological developments and decisions by the UK Government in reserved areas. It is currently developing regulations which will require new buildings receiving a warrant from 2024 to use zero emissions heating and cooling.

Northern Ireland

A phased programme is planned to uplift Northern Ireland's building regulations, taking developments in other administrations into account, to provide ultra-high energy efficient building fabric and services with low carbon heating standards for new buildings as soon as is practicable and no later than 2026/27. Consideration may be given to earlier uptake of requirements for low carbon heating solutions from 2022/23, if deemed feasible following consultation with industry.

There are several schemes currently available to support energy efficiency improvements and the installation of lower carbon heating, including the Boiler Replacement Scheme, Affordable Warmth, and the Northern Ireland Sustainable Energy Programme (NISEP). A new Northern Ireland Energy Strategy is expected to be published by the end of 2021, which will provide further information on proposals to phase out coal and solid fuels, along with fossil fuel home heating oil. The Energy Strategy will also provide further information on proposals to decarbonise the natural gas network, including through future injection of biomethane and potential hydrogen blending. Further detail will also be provided on the transition to low carbon heating options, such as heat pumps, and future proposed support schemes, including energy efficiency and low carbon heating pilot schemes, which are intended to be launched in 2022/23.

3v. Transport

Setting the pace for greener, better transport

Our Key Commitments

- End the sale of new petrol and diesel cars and vans from 2030; from 2035, all new cars and vans must be zero emission at the tailpipe.
- Introduce a zero emission vehicle mandate setting targets for a percentage of manufacturers' new car and van sales to be zero emission each year from 2024.
- Take forward our pledge to end the sale of all new, non-zero emission road vehicles by 2040, from motorcycles to buses and HGVs, subject to consultation.
- Ensure the UK's charging infrastructure network is reliable, accessible, and meets the demands of all motorists. Later this year, we will publish an EV infrastructure strategy, setting out our vision for infrastructure rollout, and roles for the public and private sectors in achieving it.
- Building on the £1.9 billion from Spending Review 2020, the Government has committed an additional £620 million to support the transition to electric vehicles. The funding will support the rollout of charging infrastructure, with a particular focus on local on-street residential charging, and targeted plug-in vehicle grants.
- Build a globally competitive zero emission vehicle supply chain and ensure our automotive sector is at the forefront of the transition to net zero.
- Lead by example with 25% of the government car fleet ultra low emission by December 2022 and all the government car and van fleet zero emission by 2027.
- Take action to increase average road vehicle occupancy by 2030 and reduce the barriers to data sharing across the transport sector.
- Maximise carbon savings from the use of low carbon fuels, including by increasing the main Renewable Transport Fuel Obligation (RTFO) target.
- Increase the share of journeys taken by public transport, cycling and walking.
- Support decarbonisation by investing more than £12 billion in local transport systems over the current Parliament.
- Invest £2 billion in cycling and walking, building first hundreds, then thousands of miles of segregated cycle lane and more low-traffic neighbourhoods with the aim that half of all journeys in towns and cities will be cycled or walked by 2030. As announced in the *Transport Decarbonisation Plan*, we will create at least one zero emission transport city.

- Invest £3 billion in the National Bus Strategy, creating integrated networks, more frequent services, and bus lanes to speed journeys, and support delivery of 4,000 new zero emission buses and the infrastructure needed to support them.
- Electrify more railway lines as part of plans to deliver a net zero rail network by 2050, with the ambition to remove all diesel-only trains by 2040.
- Plot a course to net zero for the UK domestic maritime sector, phase out the sale of new non-zero emission domestic shipping vessels and accelerate the development of zero emission technology and infrastructure in the UK. We will engage with industry to explore establishing a UK Shipping Office for Reducing Emissions (UK-SHORE) to transform the UK into a global leader in the design and manufacturing of clean maritime technology.
- Become a leader in zero-emission flight, kick-starting commercialisation of UK sustainable aviation fuels (SAF), and developing a UK SAF mandate, to enable the delivery of 10% SAF by 2030, and we will be supporting UK industry with a £180m funding to support the development of SAF plants.

Progress to date

1. Domestic transport has the largest share of UK greenhouse gas emissions of any sector across the economy, at 23% in 2019. The majority (55%) of these emissions are from passenger cars, contributing 68 $MtCO_2e$. This is followed by heavy goods vehicles and light goods vehicles contributing 19 $MtCO_2e$ (16%) and 19 $MtCO_2e$ (16%) respectively. The remaining emissions in domestic shipping, road transport, rail, and domestic aviation contribute a combined further 16 $MtCO_2e$ (13%).[71]

2. We must deliver a step change in the breadth and scale of our ambitions and, to this end, in July 2021 we published our world leading *Transport Decarbonisation Plan.* This covered all areas of transport and set out an ambitious but deliverable pathway to reaching net zero and delivering against carbon budgets along the way. The pathway we have set out is not about stopping people from doing things. Rather, it's about doing the same things differently. We want to be a world leader in green technologies, and encourage more sustainable travel choices.

3. Removing tailpipe emissions from road transport is a clear priority and we must continue the progress we have made to date. We have expanded our commitments in this area and will set ambitious but achievable phase out dates for every type of road vehicle. Alongside the *Transport Decarbonisation Plan*, we published the *2035 Delivery Plan* outlining the key timelines, milestones, and progress towards the *Ten Point Plan* commitment to accelerate the shift to zero emission vehicles.

4. There are now over 600,000 plug-in electric vehicles in the UK. In September 2021, more than one in five new cars sold had a plug. Additionally, more than 300 walking and cycling schemes have been delivered since 2020. For public transport, our *National Bus Strategy for England*, published in March, sets out a vision of a transformed bus industry and a green bus revolution. Rail is already the greenest form of motorised transport, with almost 38% of the network electrified and significantly more to come as set out in the *Great British Railways White Paper* in May.

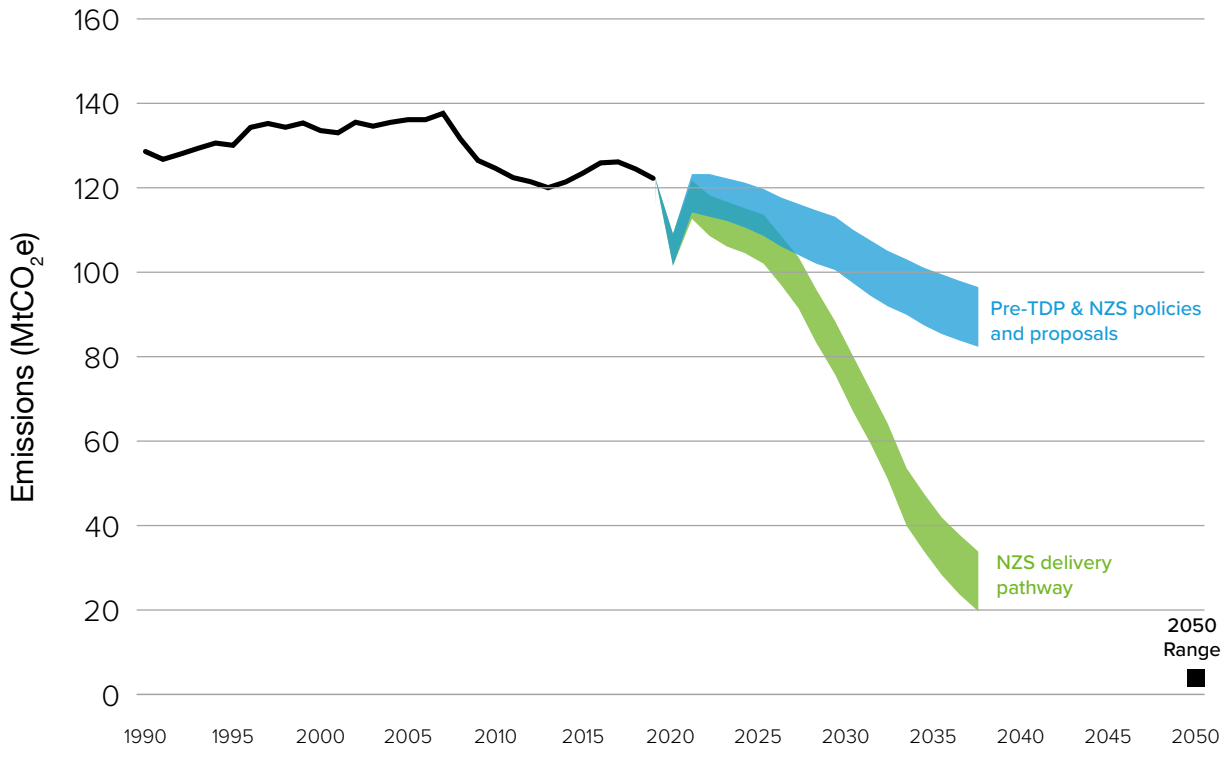
Net zero transition and economic opportunities

Our 2050 vision and how we get there

5. Every place in the UK will have its own net zero emission transport network before 2050, serving the unique needs of its communities. Sustainability will be at the heart of levelling up. People everywhere will feel the benefits – villages, towns, cities, and countryside will be cleaner, greener, healthier, and more prosperous and pleasant environments in which to live, work and enjoy.

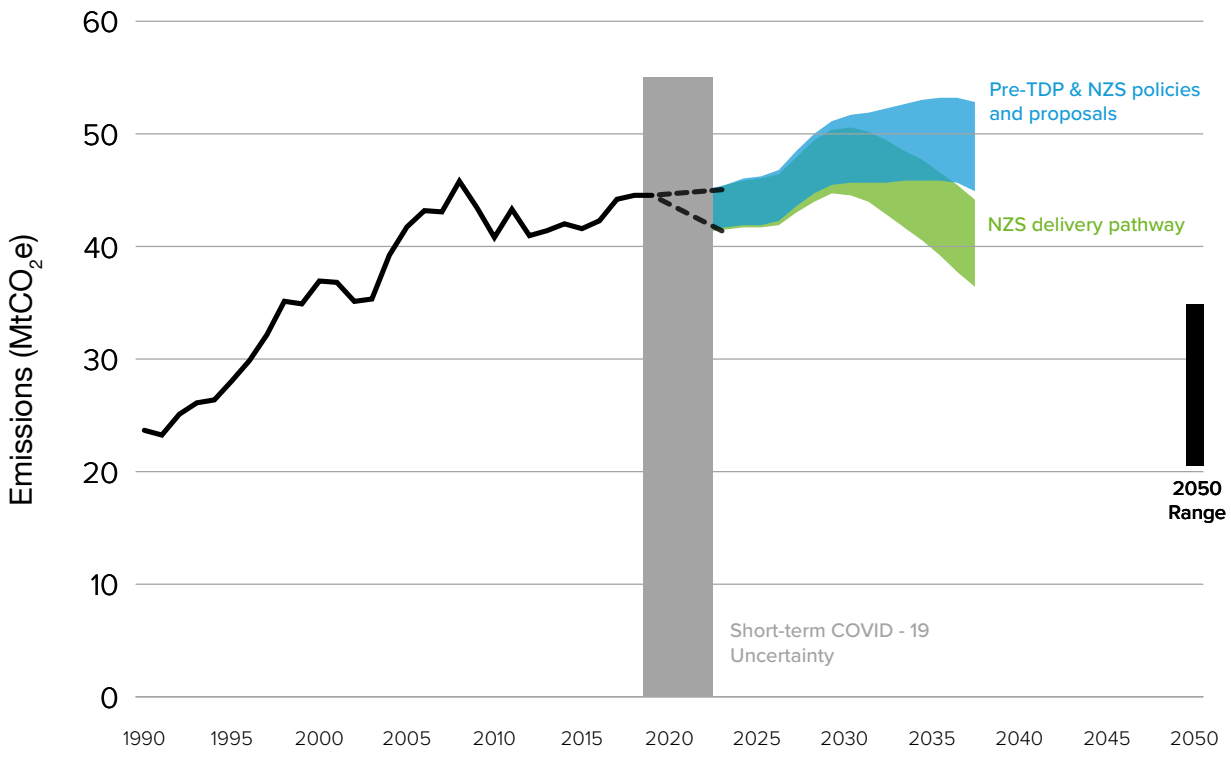
6. Based on our whole system modelling, by 2050, total transport emissions, including international aviation and shipping, could need to drop by 76-86% compared to 2019, down to 23-40MtCO_2e. In the interim, to meet our NDC and CB6 targets,[72] we expect they could fall by 22-33% by 2030 and 46-59% by 2035, compared to 2019 levels. These figures are based on an indicative transport sector pathway contributing to the whole-economy net zero and interim targets. Our potential pathway also indicates residual emissions from domestic transport could need to fall by around 34-45% by 2030 and 65-76% by 2035, relative to 2019 levels (see figure 21). We anticipate that international aviation and shipping emissions could need to fall by up to 12% by 2035, relative to 2019 levels (see figure 22).

Figure 21: Indicative domestic transport emissions pathway to 2037



Source: BEIS analysis

Figure 22: Indicative international aviation and shipping emissions pathway to 2037



Source: BEIS analysis

7. Much of the change needed to deliver net zero for the transport sector is already underway and makes sense even without the global imperative of climate change. Decarbonisation will deliver fundamentally better transport, for everyone, every day. It will make it faster and more efficient, as well as cleaner, and provide benefits including increased reliability and better connectivity. This is also a huge industrial opportunity, a once in a generation chance to increase economic growth and future prosperity – using electricity, low carbon hydrogen, sustainable low carbon fuels and pedal power – to invest in new jobs across our country.

8. Our *Transport Decarbonisation Plan* sets out this 'green print' in detail.

- The technology transformation started in cars and vans will spread to all road transport, from motorcycles to buses, coaches and HGVs. Over time, the use of zero emission vehicles will become even cleaner, as the use of renewable energy in the UK's electricity mix continues to increase. An extensive network of charging and refuelling infrastructure for all vehicles will enable the transition and meet growing demand.

- Low carbon fuels will continue to play a crucial role in maximising carbon savings from road vehicles during the transition, whilst increasingly being required in other transport modes such as aviation and maritime. This includes low carbon hydrogen, which is likely to be fundamental to achieving net zero in heavy transport applications and represents a major industrial opportunity.
- We cannot simply rely on the electrification of road transport, or believe that zero emission cars and lorries will solve all our problems. As we build back better from the pandemic, it will be essential to avoid a car-led recovery. Alongside road vehicle decarbonisation, we must increase the share of trips taken by public transport, cycling and walking. We want to make these modes the natural first choice for all who can take them. As more journeys are cycled or walked, and taken by public transport, the carbon, air quality, noise and congestion benefits will be complemented by significant improvements in public health and wellbeing.
- We will support and encourage modal shift of freight from road to more sustainable alternatives, such as rail, cargo bikes and inland waterways. We will transform last mile deliveries, with zero emission HGVs and decarbonised deliveries made possible through the adoption of new delivery models, supported by accurate data and digital innovations which drive greater efficiencies.
- The rail network will be net zero emissions by 2050 through a sustained, long-term programme of investment in rail electrification, supported by deployment of battery and hydrogen-powered trains.
- UK aviation and shipping will achieve net zero emissions by 2050. Ahead of that, our domestic lead will act as a showcase to the world and bolster our call to action internationally, where cooperation and collaboration through the International Civil Aviation Organization (ICAO) and the International Maritime Organization (IMO), will continue to be vital to decarbonise these industries.
- The Government has set CB6 to formally include the UK's share of international aviation and shipping emissions, as recommended by the CCC, which allows these emissions to be accounted for within CB6.
- We will address aviation emissions through new technology such as electric and hydrogen aircraft, the commercialisation of sustainable aviation fuels, increasing operational efficiencies, developing and implementing market-based measures and GHG removal methods, while influencing consumers to make more sustainable choices when flying.
- The UK will play an important role in developing zero emission maritime technology, such as alternative fuel powered vessels using ammonia or methanol produced from low carbon hydrogen, or highly efficient batteries, particularly where we can build on domestic expertise to capture early market share.
- As we have stated in the Ten Point Plan and the Transport Decarbonisation Plan, we need to ensure that the taxation of motoring keeps pace with the change to electric vehicles to ensure that we can continue to fund the first-class public services and infrastructure that people and families across the UK expect.

Zero emission vehicles (ZEVs)

The transition to zero emission cars and vans is leading the way in our effort to decarbonise transport. The car and van sector is easier to decarbonise compared to other sections of the economy, through the combination of a proven low carbon technology that has significant advantages over the existing high carbon technology it replaces, reducing costs and growing consumer demand. Strong progress is already being made towards our 2030/2035 phase out commitments:

- **Demand is rising:** Industry figures show over 650,000 new plug-in cars registered in the UK since 2010, and over 1 in 7 cars sold so far in 2021 had a plug.
- **Range is increasing as costs are falling:** There are 20 EV models that come with a range of over 200 miles compared to the early Nissan Leaf models that delivered 60 miles, and battery prices are little more than a tenth of what they were in 2010.
- **The charging infrastructure market is growing:** There are now over 25,000 public chargepoints in the UK, which includes over 4,700 rapid devices according to industry sources. This is one of the largest networks of rapid chargers in Europe.

Seizing new opportunities

9. Across every form of transport, decarbonisation and growth will go hand in hand. The UK will play a leading role in this modern-day industrial revolution, consolidating our position as a world leader in green technology, science, and research. The imperative to decarbonise brings with it a host of other benefits, including new business models, new modes, increasing levels of autonomy, far better integration, and a blurring of the distinction between traditional forms of transport, as well as public and private travel coming together to offer greater choice and flexibility. We will use research and development to build on the expertise of business and academia, maximising opportunities for growth, exports and hundreds of thousands of new high-quality jobs.

10. To achieve the level of emissions reductions in the transport sector indicated by our delivery pathway to 2037, we will need additional public and private investment of around £220 billion.

11. Decarbonising the transport sector will regenerate communities and open up new employment opportunities right around the UK. Based on current estimates, policies and proposals to reduce emissions in the sector could support up to 22,000 jobs in 2024 and up to 74,000 jobs in 2030. Development of road transport sector technologies as the economy transitions to net zero could support up to 71,000 jobs in 2050.

12. We need a skilled workforce capable of developing, implementing and operating mobility solutions in a way that maximises the huge potential benefits they offer. The government launched the Green Jobs Taskforce, to advise the government, industry and the skills sector on the action required to deliver the jobs and skills required for the net zero transition. Our approach on green jobs and skills is set out in the *Green Jobs, Skills and Industries* chapter of the Net Zero Strategy.

13. Decarbonising transport will also help achieve other benefits:

- It will improve health by removing a source of air pollution. There will still be particulate emissions associated with road, rail, tyre, and brake wear, and we are working to tackle those too, but the toxic by-products of burning hydrocarbon fuels will be eliminated from the roadside and rail;
- Physical inactivity costs the NHS up to £1 billion per annum, with further indirect costs of £8.2 billion – active travel can reduce that; and
- Over half the UK population is exposed to daytime noise levels above recommended limits. Zero emission vehicles – extremely quiet at low, urban speeds – will help address this. This will support levelling-up and help reinvent high streets as enjoyable places to live, work, visit and spend leisure time.

Policies and proposals

14. As the *Transport Decarbonisation Plan* and this Strategy are implemented, we will continue to consider the views of stakeholders from across the UK. We will engage closely with Devolved Administrations, respecting areas of devolved competency, as we work towards our shared goal of achieving net zero. We will also continue to collaborate with local authorities and other regional bodies to identify and support local solutions.

15. Depending on progress in the sector, at some points additional targeted action maybe be required, such as steps to reduce use of the most polluting cars and tackle urban congestion, to enable these targets to be met. We will regularly review progress against our targets – publishing the next transport decarbonisation plan within five years – and continue to adapt and take further action if needed to decarbonise transport.

Cycling and walking

16. Cycling and walking can help us tackle some of the most challenging issues we face as a society, not just climate change, but improving air quality, health and wellbeing, addressing inequalities, and tackling congestion and noise pollution on our roads. Increased levels of active travel can improve everyday life for us all.

17. We will deliver the Prime Minister's bold vision for cycling and walking, investing £2 billion over five years with the vision that half of all journeys in towns and cities will be cycled or walked by 2030. We will also deliver thousands of miles of safe, continuous, direct routes for cycling in towns and cities, physically separated from pedestrians and volume motor traffic along with more low traffic neighbourhoods and school streets.

18. We will deliver a world class cycling and walking network in England by 2040. This will include comprehensive cycling and walking networks in all large towns and cities, with measures to enable cycling and walking, such as cycle training for all children and adults that want it. We will enable behaviour change through targeted personal incentives, such as GP prescribing of active travel, existing tax reliefs, and rewards programmes.

Buses and coaches

19. We will deliver the *National Bus Strategy*'s vision of a transformed bus industry and a green bus revolution. We will make buses more frequent, more reliable, more comprehensive, easier to understand and use, better co-ordinated and cheaper – to dramatically increase passenger numbers and reduce congestion and carbon emissions.

20. We will support delivery of 4,000 new zero emission buses, either battery electric or hydrogen, and the infrastructure needed to support them. This will be the single largest investment ever made in zero emission buses, representing the replacement of nearly 12% of England's local operator bus fleet.

21. We will deliver the first All-Electric Bus City. This will demonstrate what can be achieved when there is a real commitment to move all buses in a place to electric zero emission. Coventry has now been announced as the UK's first all-electric bus city, with £50 million to fund up to 300 electric buses and charging infrastructure.

22. We are consulting on a phase out date for the sale of new non-zero emission buses and coaches. We have already begun consulting on an appropriate date to end the sale of new non-zero emission buses and on the appropriate supporting policy and regulatory framework. We will also consult on a phase out date for the sale or purchase of new non-zero emission coaches.

Railways

23. We will deliver a net zero rail network by 2050, with sustained carbon reductions in rail along the way. Our ambition is to remove all diesel-only trains (passenger and freight) from the network by 2040. We will deploy new low-carbon technologies on the network such as hydrogen and battery trains, where they make operational and economic sense. We will incentivise the early take up of low carbon traction by the rail freight industry.

24. We will build extra capacity on our rail network to meet growing passenger and freight demand and support significant shifts from road and air to rail. This includes new high-speed lines, reopening lines closed under the Beeching cuts and significant improvement to regional city public transport networks with the aim of making them as good as London's.

25. We are working with industry to modernise fares ticketing and retail and encourage a shift to rail and cleaner and greener transport journeys. *Great British Railways* set out a transformation in how people will pay for their journeys, to encourage a shift to rail and cleaner, greener journeys. Greater provision of walking and cycling routes to and from stations, and supporting infrastructure, will be introduced to support healthier greener journeys. *Great British Railways* will encourage more rail freight by providing the right conditions for industry growth, with better coordination, modern contracts, and new safeguards.

Cars, vans, motorcycles, and scooters

26. We will end the sale of new petrol and diesel cars and vans by 2030. From 2035 all new cars and vans must be fully zero emission at the tailpipe. Between 2030 and 2035, new cars and vans will only be able to be sold if they offer significant zero emission capability.

27. To provide certainty to consumers, energy providers, the chargepoint industry, vehicle manufacturers and supply chains during this transition, we will introduce a zero emission vehicle mandate setting targets requiring a percentage of manufacturers' new car and van sales to be zero emission each year from 2024.

28. We will continue to regulate the tailpipe CO2 emissions of new non-zero emission cars and vans to limit their emissions until 100% of new sales are zero emission. This framework could subsequently be applied to all forms of new road vehicles sold in the UK.

29. Between 2030 and 2035, new cars and vans will only be able to be sold if they offer significant zero emission capability and we will provide further detail on the outcome of our recent consultation on this shortly. We will then publish a further consultation in early 2022 on:

- The design of the ZEV mandate (including uptake trajectories) and CO2 emissions regulation (as a backstop to ensure standards in the remainder of the fleet are maintained); and
- How and when targets will be set and enforced.

30. We are building a globally competitive UK zero emission vehicle supply chain to ensure our automotive sector is at the forefront of the transition to net zero. Since 2020, the government has been actively supporting the transformation of the automotive supply chain to electrification through the Automotive Transformation Fund (ATF). We are allocating a further £350 million of our up to £1 billion ATF commitment to support the electrification of UK vehicles and their supply chains. We will also continue to invest in R&D through the Advanced Propulsion Centre (APC) competition to ensure the UK remains at the forefront of the development and industrialisation of zero emission vehicle technologies.

31. We will consult this year on a phase out date of 2035, or earlier if a faster transition appears feasible, for the sale of new non-zero emission powered two and three wheelers (and other L category vehicles).

32. We will lead by example with 25% of the government car fleet ultra low emission by December 2022 and all the government car and van fleet zero emission by 2027.

33. We will ensure the UK's charging infrastructure network meets the demands of its users. We have already announced £1.3 billion of investment to accelerate the rollout of charging infrastructure on motorways, on streets, in homes and workplaces. The Government has committed an additional £620 million of funding to support the transition to electric vehicles. Further details will be published in due course. Later this year, we will publish an EV infrastructure strategy, setting out our vision for infrastructure rollout, and roles for the public and private sectors in achieving it.

Smart Charging

Amir is self-employed and uses a van for work. His work involves a lot of journeys locally, totalling around 250-300 miles per week. He usually plugs into charge every few evenings, with his vehicle fully charged by the morning. He has a chargepoint installed on his driveway so he can charge on his domestic energy tariff. The chargepoint is smart, which means it shifts charging to off-peak times, which saves Amir money. He has also signed up to a vehicle-to-grid scheme with his electricity supplier. By keeping his van plugged in during the week when he doesn't need to use it, he's able to sell energy back to the grid when demand is high.

Maritime

34. We will plot a course to net zero for the UK domestic maritime sector, with indicative targets from 2030 and net zero as early as is feasible. We will establish, after public consultation in 2022, an ambitious 'Course to Zero'. Following consultation, we will establish ambitious indicative targets and embed this course in our Clean Maritime Plan.

35. We will consult on a potential phase-out date for the sale of new non-zero emission domestic vessels. Following the conclusion of the current Clean Maritime Demonstration Competition and the Course to Zero consultation, we will consult in mid-2022 on the potential for accelerated decarbonisation through carefully designed, well signposted measures to phase out the sale of new, non-zero emission domestic vessels.

36. We are assessing how economic instruments could be used to accelerate the decarbonisation of the domestic maritime sector. Building on Maritime 2050, the Clean Maritime Plan and our published research, we will further investigate the use of economic instruments to drive decarbonisation.

37. We will extend the Renewable Transport Fuel Obligation to the maritime sector. Following consultation earlier this year, we will make renewable fuels of non-biological origin used in shipping eligible for incentives under the RTFO.

38. This year we will be consulting on the appropriate steps to support and, if needed, mandate the uptake of shore power in the UK. We will consult in winter 2021 on how government can support wider deployment of shore power, including potential regulatory interventions, for both vessels and ports.

39. We are accelerating the development of zero emission technology and infrastructure in the UK. We have launched the £20 million Clean Maritime Demonstration Competition (CMDC) to fund feasibility studies and technology trials. We will engage with industry to explore establishing a UK Shipping Office for Reducing Emissions (UK-SHORE) in cooperation with UKRI and Innovative UK. UK-SHORE aims to transform the UK into a global leader in the design and manufacturing of clean maritime technology.

Aviation

40. Earlier this year we consulted on our Jet Zero Strategy, which will set out the steps we will take to reach net zero aviation emissions by 2050. We have also consulted on a target for UK domestic aviation to reach net zero by 2040.

41. We are supporting the development of new and zero carbon UK aircraft technology through the Aerospace Technology Institute (ATI) programme and fund zero emission flight infrastructure R&D at UK airports. As part of the Jet Zero ambition, the Aerospace Technology Institute (ATI) provides R&D funding, matched by industry, to support the design and development of new aerospace technologies, with particular focus on zero carbon technologies, that are most likely to grow the UK's share in the global market. We are also investing £3 million in 2021/22 through the Zero Emission Flight Infrastructure competition to accelerate R&D into infrastructure requirements at airports and airfields to handle new forms of zero emission aircraft.

42. We will accelerate the commercialisation of UK sustainable aviation fuels (SAF). Our ambition is to enable delivery of 10% SAF by 2030 and we will be supporting UK industry with a £180 million funding to support the development of SAF plants. This builds on our recently launched £15 million Green Fuels, Green Skies competition. We will also establish a SAF clearing house, the first of its kind announced in Europe, to enable the UK to certify new fuels.

43. We are currently reviewing the responses to the SAF mandate consultation. Ahead of a second consultation in 2022, we will continue to engage with industry to ensure our policy can support the delivery of any future mandate ambitions.

Freight and logistics

44. We recently consulted on phase out dates for the sale of all new non-zero emission HGVs - that is, on ending the sale of new non-zero emission HGVs by 2035, for vehicles 26 tonnes and under, and 2040, for vehicles over 26 tonnes, with the government's response due to be published in due course.

45. We will support and encourage modal shift of freight from road to more sustainable alternatives, such as rail, cargo bike and inland waterways. This will be supported by a package of policies including:

- Investing in the capacity and capability of the rail network for freight, including infill electrification schemes;
- The Mode Shift Revenue Support and Waterborne Freight Grant Schemes;
- Introducing a rail freight growth target; and
- 'Last mile' measures to support more sustainable freight in urban areas.

Delivering decarbonisation through places

46. We will support transport decarbonisation by investing more than £12 billion in local transport systems over the current Parliament. We will deliver this through existing funding streams where decarbonisation sits alongside other core government objectives.

47. We are driving decarbonisation and transport improvements at a local level by making quantifiable carbon reductions a fundamental part of local transport planning and funding. Local Transport Plans (LTPs) – statutory requirements that set out holistic place-based strategies for improving transport networks and proposed projects for investment – will need to set out how local areas will deliver ambitious carbon reductions in line with carbon budgets and net zero.

48. We will embed transport decarbonisation principles in spatial planning and across transport policy making. Last year, the government set out proposals for a new and improved planning system, central to our most important national challenges, including combating climate change and supporting sustainable growth. The *National Model Design Code*, published in July this year, guides local planning authorities on measures they can include within their own design codes to create environmentally responsive and sustainable places. The *National Model Design Code* provides tools and guidance for local planning authorities to help ensure developments respond to the impacts of climate change, are energy efficient, embed circular economy principles and reduce carbon emissions.

Maximising the benefits of sustainable low carbon fuels

49. As announced in July 2021, and subject to parliamentary approval, the RTFO main obligation will increase from 9.6% in 2021 to 14.6% in 2032. This is estimated to achieve additional carbon savings of up to 20.8 $MtCO_2e$ over this period. The 'development fuels' sub-target, which incentivises specific fuels of strategic importance, is already set to increase from 0.5% in 2021 to 2.8% by 2032, and by 2023 we will review whether there is scope to be more ambitious. We also committed to additional measures to promote the uptake of low carbon fuels in the freight, maritime and aviation sectors and we will work with stakeholders to develop a longer-term low carbon fuel strategy for the deployment of low carbon fuels across different transport modes to 2050.

Hydrogen in a decarbonised transport system

50. We expanded the RTFO to incentivise the use of renewable hydrogen in maritime and rail in 2018. As set out clearly in the recent *Hydrogen Strategy* and *Transport Decarbonisation Plan*, hydrogen is likely to play a significant role in transport applications, particularly where energy density requirements or refuelling times make it the most suitable low carbon energy source. Our dedicated hydrogen R&D funding and support is focussed on heavier applications, such as rail, maritime, aviation and heavy road freight, where hydrogen offers in-use advantages and the largest global market potential. The government remains technology neutral and acknowledges that there will be other transport applications where hydrogen may be well suited, including the potential for hydrogen to be utilised within combustion engines, where it can be shown to produce zero harmful emissions at the tailpipe.

51. We are investing £3 million in 2021 to establish the UK's first multi-modal hydrogen transport hub in Tees Valley. The funding is kick-starting activity across the region, supporting collaborative R&D pilot projects and pop-up trials that demonstrate hydrogen technology solutions across transport modes and forge new industry and academic partnerships.

Future transport – more choice, better efficiency

52. We will take action to increase average road vehicle occupancy by 2030. Increasing car occupancy from 1.55 to 1.7 could save nearly 3 Mt of carbon a year by 2030. We are building our evidence base to understand the barriers and potential policies to increase the uptake of shared mobility and will work with industry and local authorities to understand where further action can be taken.

53. We will reduce the barriers to data sharing across the transport sector. Better data can provide new policy and operational insights, drive new products and services and 'nudge' people towards lower emission journeys. We recently published a new annual statistical release, drawing together various data sources on transport's environmental impact. Data consumers can use these data, without restrictions on use or disclosure, for journey planning applications, products and services enabling users to plan green end-to-end journeys.

Working together across the UK

Examples of policy action by the Scottish Government, Welsh Government and Northern Ireland Executive

UK Government is working across all levels of government and with Devolved Administrations to ensure consistent action to reduce emissions across the transport sector, and across the UK.

Wales

The Welsh Government's vision is that by 2025 all users of electric cars and vans are confident that they can access electric vehicle charging infrastructure when and where they need it.[73] Its *Electric Vehicle Charging Strategy* identified a need for 30,000-55,000 fast chargers and up to 4,000 rapid chargers by 2030. The forthcoming EV Charging Action Plan will include further details on the specific support for the roll out of a comprehensive network.

Scotland

The transport measures in the updated 2018 *Climate Change Plan* contain action across all modes. The Scottish Government will phase out the need for new petrol and diesel cars and vans by 2030, and will work with public bodies to lead the way to do this by 2025. It will also work with the freight industry to remove the need for new petrol and diesel heavy vehicles by 2035, supported by its work with Scottish Enterprise to establish a Zero Emission Heavy Duty Vehicle programme to remove the majority of fossil fuel buses in public transport by 2023.

The commitment set out in the Climate Change Plan to reduce car kilometres by 20% by 2030 demonstrates the level of ambition in meeting Scotland's statutory targets. To encourage modal shift to public transport the Scottish Government is investing over £500 million in bus priority infrastructure and extending nationwide free bus travel to all young people resident in Scotland under 22 years old from 31 January 2022. On active travel, the Scottish Government will support transformational active travel projects with over £500 million of investment over 5 years and has committed to ensuring that at least £320 million or 10% of all the transport capital budget is spent on supporting walking, cycling and wheeling by 2024-25.

On public transport, Scotland's rail services will be decarbonised by 2035, and the Scottish Government is working with its Bus Decarbonisation Taskforce to create a pathway to zero emission buses. This is supported by its long-term investment of over £500 million in bus priority infrastructure.

Northern Ireland

In Northern Ireland, £74 million has been invested in the purchase of zero and low emission vehicles (hydrogen and electric) and associated infrastructure in the public transport sector. A £20 million Blue/Green infrastructure investment fund was launched in 2020/21 and has continued in 2021/22, which has supported a range of initiatives including active travel schemes across Northern Ireland. An Executive Energy Strategy is currently being developed which will include measures focusing on informing transport choices and behaviours, and establishing a sustainable transport hierarchy that will support changes in how we travel, reduce the distances travelled in private vehicles, and decarbonise transport.

3vi. Natural Resources, Waste & F-Gases

Harnessing nature for net zero

Our Key Commitments

- 75% of farmers in England will be engaged in low carbon practices by 2030, rising to 85% by 2035. Government is introducing farming schemes, including the new environmental land management schemes, which will provide a powerful vehicle for achieving net zero, and goals of the *25 Year Environment Plan*.
- Increase investment in industry-led research and development into solutions to help deliver net zero in agriculture and horticulture, including through the Farming Innovation Programme.
- Treble woodland creation rates by the end of this Parliament, reflecting England's contribution to meeting the UK's overall target of increasing planting rates to 30,000 hectares per year by the end of this Parliament and maintain new planting at least at this level from 2025 onwards. We will explore a long-term statutory tree target in England within the public consultation on Environment Bill targets.
- We will boost the existing £640 million Nature for Climate Fund with a further £124 million of new money, ensuring total spend of more than £750 million by 2025 on peat restoration, woodland creation and management. This will enable more opportunities for farmers and landowners to support net zero through land use change.
- Restore at least 35,000 hectares of peatlands in Englad by 2025, through the Nature for Climate Fund. Restore approximately 280,000 hectares of peat in England by 2050, including via funding from the new environmental land management schemes.
- Mobilise private investment into tree planting, including through the Woodland Carbon Code, with the support of government's Woodland Carbon Guarantee, and into peat restoration through implementing a package of reforms to the Peatland Code.
- We will work with key stakeholders to develop a policy roadmap to increase the use of timber in construction in England, and will create a cross-government and industry working group tasked with identifying key actions to safely increase timber use and reduce embodied carbon.

- To support our commitment to explore options for the near elimination of biodegradable municipal waste to landfill from 2028, we are bringing forward £295 million of capital funding which will allow local authorities in England to prepare to implement free separate food waste collections for all households from 2025.
- Complete a review of the F-gas Regulation and assess whether we can go further than the current requirements and international commitments, including by looking at what additional reductions in F-gas use can be made to help the UK meet net zero by 2050.
- Through the Environment Bill we will legislate for Local Nature Recovery Strategies – a new system of spatial strategies that will map proposals for improving or creating habitat for nature and wider environmental benefits, helping to deliver net zero objectives.
- Biodiversity co-benefits and other environmental objectives are maximised alongside decarbonisation.

Progress to date

1. This chapter covers natural resources including agriculture, forestry, and other land use (AFOLU), (inclusive of peatlands and soils), as well as resources, waste, wastewater, and fluorinated gases (F-gases). In 2019, net UK greenhouse gas (GHG) emissions from these sectors, referred to as NRWF (natural resources, waste, and F-gases), reflected 103 $MtCO_2e$ or 20% of the UK total, having decreased by 45% between 1990 and 2019.[74]

2. In the *Ten Point Plan*, we committed to protecting our natural environment. Since then we have launched the floods investment programme to better protect 336,000 properties from flooding. We also awarded 90 projects grants under round 2 of the £80 million Green Recovery Challenge Fund (GRCF). In total, the GRCF is set to plant almost over 1 million trees.

Agriculture, forestry, and other land use (AFOLU)

3. AFOLU were responsible for 63 $MtCO_2e$ (12%) of UK net GHG emissions in 2019, having risen slightly in the last 2 years but reduced by 24% since 1990.

4. Emissions from agriculture, mainly stemming from livestock, agricultural soils, and farm machinery, added up to 55 $MtCO_2e$ (11%) of UK emissions in 2019. Although rising by 1% from 2018 to 2019, agricultural emissions have fallen by 13% since 1990. The *Agriculture Transition Plan* (2020) sets out how we will move away from the EU's Common Agricultural Policy to use public money to reward farmers and land managers for delivering environmentally sustainable outcomes in England.[75]

5. Forestry and woodlands currently act as carbon sinks and, in 2019, captured about 4% of our emissions.[76] Since 2010, 123,000 hectares of new woodland has been planted across the UK, an area equivalent to Bedfordshire. The *England Tree Action Plan* (2021) committed to increasing tree planting rates from 13,410 hectares across the UK in 2020/21, to 30,000 hectares each year by the end of this Parliament. The plan is supported by £500 million of the Nature for Climate Fund. In 2020-21 we funded new partnerships with Northumberland County Council, Trees 4 Cornwall, and England's network of ten Community Forests. Two new

community forests were launched, Plymouth and South Devon in June 2021 and North-East, in July 2021.

6. Although peatlands are the UK's largest terrestrial carbon store, in a degraded condition they represent a net source of emissions. In 2019, peatlands emitted 4% of UK net GHG emissions, having become degraded due to drainage for agricultural use, overgrazing and burning. We have rewetted around 100,000 hectares of peatland across the UK and set out further plans for peatland restoration and responsible management in the *England Peat Action Plan* (May 2021).

Resources, waste, and F-gases

7. Waste management emissions consist of waste disposed to landfill sites, waste incineration without energy recovery, and the treatment of wastewater. In 2019, waste management accounted for 25 $MtCO_2e$ (5%) of UK emissions, a significant decrease of 71% since 1990, largely driven by a reduction in biodegradable waste to landfill. The *Resources and Waste Strategy* (RWS), (2018) set out how we will transition to a more circular economy, and included key reforms to enable us to manage our waste more efficiently, reduce the amount of waste we create as a society, and ensure we use resources more efficiently.[77]

8. F-gases (GHGs which can be used in systems such as heat pumps and air conditioning units) accounted for 15 $MtCO_2e$ (3%) of UK emissions in 2019, with 93% of these coming from hydrofluorocarbons (HFCs). F-gas emissions have fallen by 10% since 1990.[78] In 2017, the UK was one of the first countries to commit to cutting HFC consumption by 85% by 2036, ratifying the Kigali Amendment to the UN Montreal Protocol.[79] We have cut HFC consumption even faster than that, reducing levels placed on the market by 55% since 2015, through quota limits.[80]

Net zero transition and economic opportunities

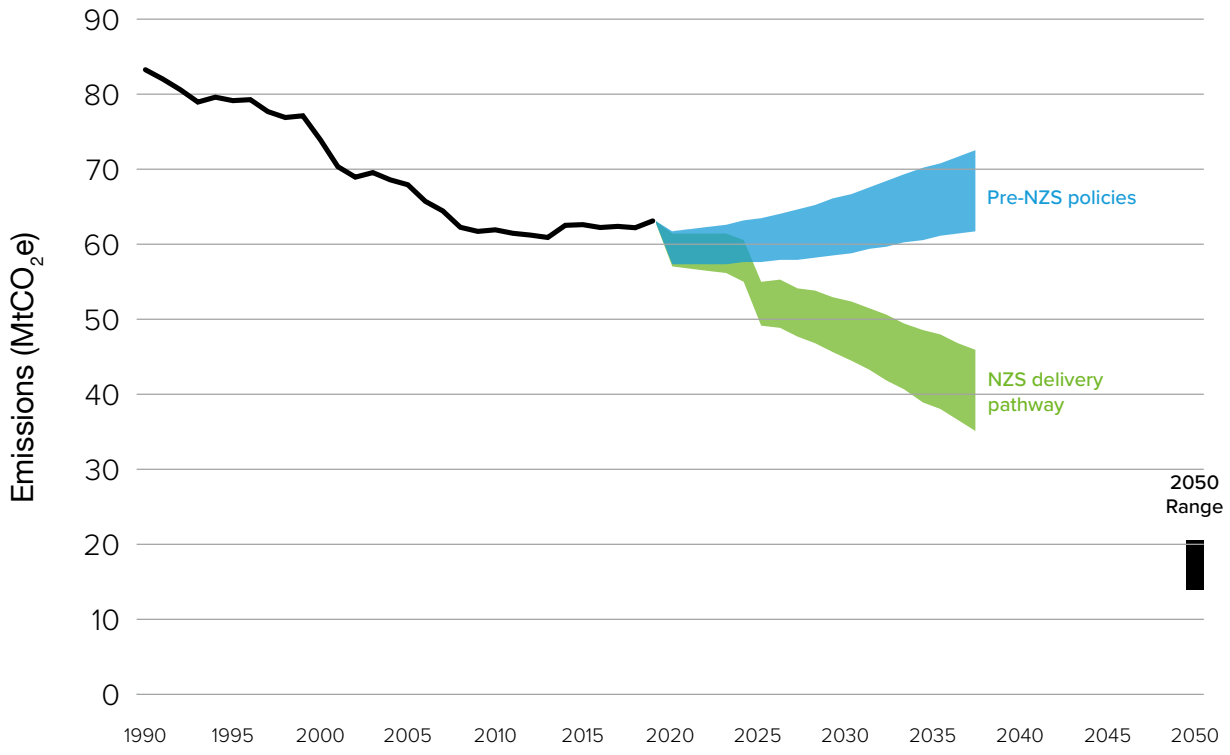
Our 2050 vision and how we get there

9. A systemic transformation across the UK economy, including NRWF sectors, is required to achieve net zero by 2050. While we will significantly reduce emissions across the NRWF sectors, some residual emissions from agriculture, waste, and F-gases will remain. These will need to be compensated for by both nature-based and engineered greenhouse gas removals (GGRs) as a last resort. On our journey to net zero, we will maximise opportunities to adapt to climate change and the extreme weather it brings, and to maximise the co-benefits for other environmental objectives.

10. By 2050, emissions associated with the NRWF sectors could need to drop by 67-75% compared to 2019, down to 26-34 $MtCO_2e$. In the interim, to meet our NDC and Carbon Budget 6 targets, they are expected to fall by 30-40% by 2030 and 39-51% by 2035, compared to 2019 levels. These figures are based on the indicative NWRF sectoral pathway to help us reach net zero and interim targets. Our potential pathway also indicates residual emissions in AFOLU sectors could need to fall by 17-30% by 2030 and 24-40% by 2035, relative to 2019 levels; waste and F-gas emissions could need to fall by 50-57% by 2030 and by 62-69% by 2035, relative to 2019 levels.

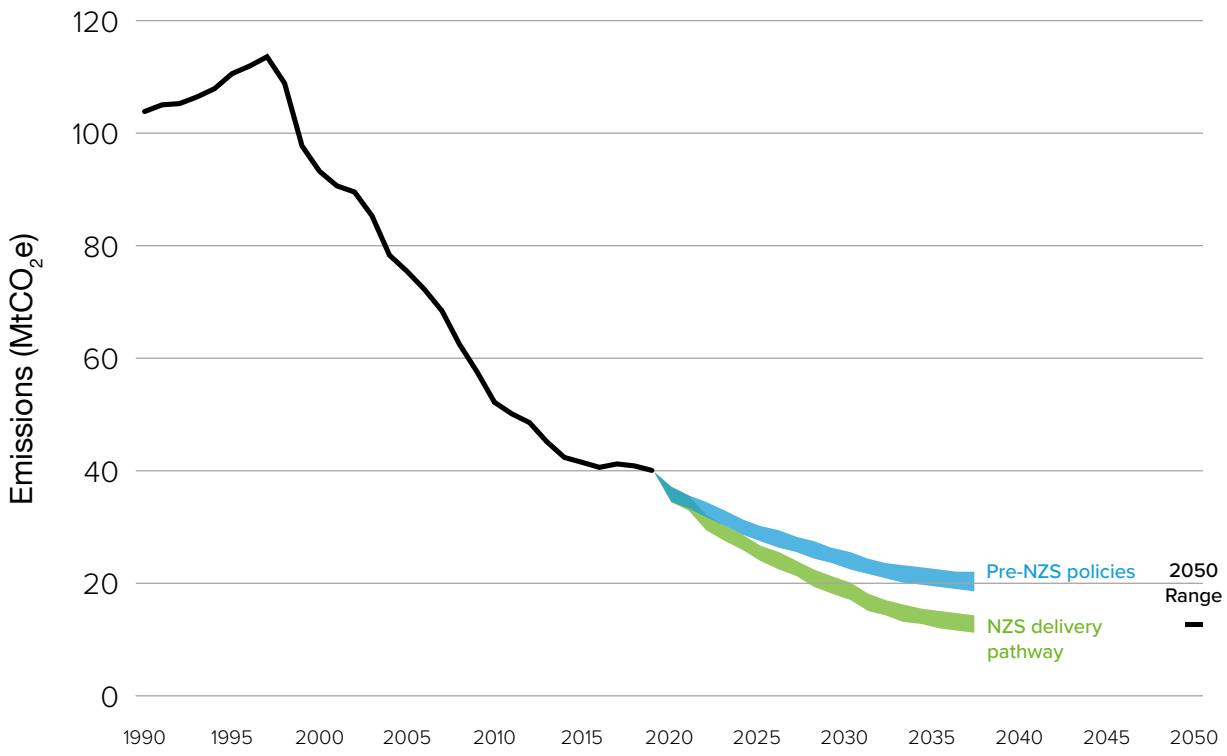
11. We are working closely with Devolved Administrations to deliver this ambition. This includes frequent engagement at Ministerial and official levels through existing and new forums, and allows us to think practically about how we deliver across the UK. We will also consider the interdependencies between land use sectors and other goals.

Figure 23: Indicative agriculture, forestry and other land use emissions pathway to 2037



Source: BEIS analysis

Figure 24 Indicative waste and F-gas emissions pathway to 2037



Source: BEIS analysis

Agriculture, forestry, and other land use (AFOLU)

12. By 2050, we will have a resilient and prosperous countryside, where farmers and land managers are supported to reduce emissions and deliver a range of environmental outcomes. 75% of farmers in England will be engaged in low carbon practices by 2030, rising to 85% by 2035. Emissions mitigation in agriculture is complex and diverse, with no silver bullets. It is difficult to establish a single metric to track progress, but government monitors engagement with low carbon farming practices through our Farm Practice Survey. We will continue to improve this metric in future years to address what we consider to be key limitations in the current approach.

13. We will support farmers to adopt low carbon farming practices, and increase the carbon stored on their farms, helping to improve business productivity and profitability gains. Schemes that support environmental land management will help drive this change and will also help compensate for residual emissions that are harder to reduce, such as from livestock. The Farming Investment Fund will offer funding for equipment, technology, and infrastructure that improves farm productivity and benefits the environment. We are also providing funding to help farmers produce healthier animals, reduce GHG emissions and enhance welfare through the Animal Health and Welfare Pathway. Additionally, Defra will develop a Farming for Net Zero resource, providing advice to farmers on good practice techniques to understand, manage and abate GHG emissions.

14. We also recognise the importance of other policy levers with potential climate benefits, for example Environmental Permitting for dairy and intensive beef herds which is planned under the *Clean Air Strategy*. There is also an important role for emerging markets in nature-based solutions. For example, the Woodland Carbon Code, which incorporates robust standards and accreditation processes. We will seek to establish a robust market framework, with arrangements to ensure additionality, transparency, and traceability of carbon credits, so that regulators and the public can be confident that carbon savings are verified and also guaranteed against future issues such as forest fires or disease. Additionally, we continue to consider the impact that climate change will have on the suitability of our land for different uses, such as the impact of hotter, drier summers and warmer, wetter winters on agriculture, habitat creation and restoration, and forestry.

15. Biomass will also be an important component of our pathway to net zero. It is likely that the UK will be producing more domestic perennial energy crops (such as miscanthus and short rotation coppice) and short rotation forestry than today, but the exact role is yet to be determined. The *Biomass Strategy*, due in 2022, will look to address this. The sustainability, and wider environmental impact of growing and using biomass, including on air quality, will be key factors in establishing its role.

Resources and waste, and F-gases

16. By 2050, we will have met the *25 Year Environment Plan* (25YEP) commitments to eliminate all avoidable waste, including plastic, and to double resource productivity.[81] A circular economy will be part of everyday life: reusing, repairing, and remanufacturing goods will be standard practice. Goods will be designed to last for longer and be more efficient. At end of life, the vast majority of products will be sent for recycling, with food, garden, and dry materials collected separately and used as lower carbon inputs for new products. Producer responsibility schemes will be embedded across the economy. Any non-recyclable residual waste will be treated to enable the processing of waste into valuable outputs, such as energy. Where possible, these processes would include carbon capture and storage. (See the *Power* chapter for more on energy from waste.) Only where no such treatment is possible may landfill be permitted.

17. By 2050, current F-gas use will have been predominantly replaced by alternative gases or technologies. HFC importers, equipment manufacturers and servicing technicians will have taken steps to reduce their use in favour of alternatives, not only in line with the current phasedown, but also with further measures implemented following the F-gas Regulation review and future international changes.

Other sectors

18. Protecting, restoring, and sustainably managing other natural resources such as soils or blue carbon habitats like saltmarsh and seagrass, can provide benefits for biodiversity and climate adaptation, as well as for carbon sequestration. We do not currently have the required data to include these habitats in the UK GHG Inventory or to accurately quantify their potential contribution to net zero but are doing further work to close these evidence gaps.

Reducing emissions while balancing other climate and environmental objectives

While reducing emissions, we must also adapt to the inevitable changes in our climate, ensuring that policies supporting net zero are resilient to current and future climate risks, and preventing locking in future vulnerabilities or maladaptation. The second *National Adaptation Programme* sets out how we are addressing, and will address, climate risks between 2018 and 2023 and further detail on adaptation is included in the Climate Science Annex of this strategy.

Delivering net zero creates opportunities to benefit other environmental objectives too. For example, climate change and biodiversity loss are closely related, and policies to tackle climate change can help to improve biodiversity. Likewise, net zero policies can support further environmental goals, such as water quality, natural beauty, and the delivery of the 25YEP. For example, we will ensure afforestation across England and that the right species of tree is planted in the right place, benefitting flood management, soil health and biodiversity, while also sequestering carbon. In some cases, however, we know it will be important to manage potential misalignments: for example, ammonia emissions from digestate, a by-product from the process of anaerobic digestion, can negatively impact human health and cause biodiversity loss. We are working to mitigate ammonia emissions through the Green Gas Support Scheme, which will require participants to take additional steps to mitigate ammonia emissions, and by researching technologies that can help reduce the negative environmental impacts of digestate. The relationship between net zero and wider environmental objectives, including air quality, is set out in more detail in the *Technical Annex*.

The UK has a limited amount of land and delivering net zero will require changes to the way this land is used, for example, for afforestation, biomass production, and peat restoration. Opportunities for land to be used for multiple purposes, such as agroforestry will help to make sure land use for decarbonisation purposes is balanced with other demands, such as housing development and food production. These changes are likely to have varying effects on wider environmental outcomes and may completely alter the character of some landscapes and rural livelihoods (see section below). Land use change must be designed in a systemic, geographically targeted way with appropriate local governance and delivery structures which consider the complex range of interacting social, economic, and demographic factors. To support this, government is developing a Net Zero Systems Tool which aims to allow key decision makers to gain new insights and understanding, by highlighting dependencies and trade-offs within the land use system, as well as by demonstrating the knock-on effects of proposed policies. In addition, through the Environment Bill, the Government is introducing Local Nature Recovery Strategies (LNRS), a spatial planning tool for nature, allowing local government and communities to identify priorities and opportunities for nature recovery and nature-based solutions across England. The Bill includes a specific duty on all public authorities to "have regard" to relevant LNRSs and the spatial information they provide will support the development of local plans and other land use change incentives. Delivery of priorities and opportunities identified in LNRS will be supported by a range of delivery mechanisms including our environmental land management schemes, and in particular, the Local Nature Recovery scheme. By 2028, Defra's current plans are for total spend to be evenly split between farm-level, locally tailored, and landscape-scale investment within ELM

Seizing new opportunities

19. Reducing emissions will create growth and employment opportunities across NRWF sectors, and it is important that these opportunities are evenly felt and realised by all. Achieving net zero will require innovation from businesses and landowners, investment from government and the private sector, and changes in our choices as consumers. We want to create domestic and international demand for our low carbon, high welfare and world-renowned produce, whilst supporting international markets for sustainably produced commodities.

20. To achieve the level of emissions reductions in the NRWF sector indicated by our delivery pathway to 2037, we will need additional public and private investment of approximately £30 billion. Given the importance of R&D to deliver our pathway, we are committing to spend £75 million on net zero related R&D across the NRWF sectors over the next three years.

21. Decarbonising the NRWF sectors will regenerate communities and open up new employment opportunities right around the UK. For example, an increase in afforestation across England could support up to 1,900 jobs in 2024 and up to 2,000 jobs in 2030. By investing in rural infrastructure and skills development we will seek to ensure rural communities and rural businesses, including the most disadvantaged, benefit from net zero. There will be significant opportunities for upskilling, reskilling, and starting new career paths, alongside expanding current sectors. For example, nature-based solutions create entry-level opportunities for people just starting out, as well as requiring specialist skills such as hydrology, ecology and forest management. By delivering long-term policy certainty, we will unlock the private investment necessary to deliver these green jobs.

22. Innovation will also be vital to delivering net zero and maximising benefits for the UK. In agriculture, farmers will be able to adopt new emission saving technologies, produce lower carbon foods and steward the land in new ways, such as through vertical farming. This will allow them to diversify income streams and produce high quality, low carbon produce for domestic and international markets, boosting the rural economy. Investment in agricultural innovation, through schemes like the Farming Innovation Programme, will drive development of new precision technologies, explore the potential of robotics and artificial intelligence, and take advantage of developments in breeding technologies, including the potential of gene editing. This can also make our agricultural sector more resilient to the impacts of climate change and safeguard our food security. We also know other technological solutions, such as those to reduce emissions from non-road mobile machinery in the agricultural sector require further development. Cross government work is required to develop non-road mobile machinery policies to support the deployment of technological solutions and required infrastructure in specific sectors, including industry, transport, and buildings. Relevant government departments will work together to ensure a coherent approach (see the *Industry* chapter). A significant market share for innovations such as alternative proteins will take time to materialise, but will align with consumer dietary trends, and the UK already has a lively and growing domestic market that could grow to become another great British food export that competes internationally. These and other novel methods of food production could create significant opportunities to further promote high quality British food internationally.

23. Innovation is key to other NRWF sectors too. Industry is responding to the HFC phasedown by switching to alternative gases and technologies in areas such as refrigeration, air conditioning, and heat pumps, and will continue to innovate in this area. The UK Research and Innovation's National Interdisciplinary Circular Economy Research programme is looking at how to transition to a more circular economy. Producers will need to move to more sustainable product design, and consumers, with support from the public and private sectors, will need to shift to more sustainable product choices and towards reusing, repairing, remanufacturing, and recycling products.

Policies and proposals

Agriculture, forestry, and other land use (AFOLU)

24. We have begun the Agricultural Transition Period and have moved away from the CAP. We are reducing and then stopping untargeted Direct Payments in England and moving to a system where public money rewards farmers and land managers for environmentally sustainable actions, including reducing emissions and expanding the carbon sequestration potential of our land. We will introduce three environmental land management schemes: the Sustainable Farming Incentive (SFI), Local Nature Recovery (LNR) and Landscape Recovery (LR). The SFI will be open to all farmers and will incentivise low carbon practices, for example, soil and nutrient management. LNR will fund actions that support local nature recovery and deliver local environmental priorities. The LR scheme will fund long-term land use change projects such as large-scale tree planting, and peatland restoration projects. Net zero will be a key priority across the delivery of our environmental land management schemes.

25. Take up of these schemes will be voluntary and will require a shift in the practices of landowners and farmers. We are working to ensure the schemes encourage participation, including through appropriate payment rates, in line with the Payment Principles.[82] Participants will still be able to benefit from private sector funding, for delivering additional benefits. Advice and guidance will also be provided to support participants to adopt new practices. Tests and trials for the schemes began in 2020. The scheme will be rolled out in full by 2024.[83] Government has committed to maintain current levels of spending on the sector in England, based on 2019 levels, until 2024/5, amounting to an average of £2.4 billion a year.

26. We are also supporting the acceleration of private investment in nature through initiatives such as the Natural Environment Investment Readiness Fund. These will test new models and build pipelines of investable nature projects by providing technical assistance and capacity building support to create opportunities for private investment. Projects will capture the value of the carbon and other benefits provided by natural assets such as woodlands, peatlands wetlands and river catchments. They will create multi-functional landscapes that deliver diverse benefits, providing a return on investment and improving our understanding of how to attract private investment.

27. We will boost the existing £640 million Nature for Climate Fund with a further £124 million of new money, ensuring total spend of more than £750 million by 2025 on peat restoration, woodland creation and management. This will enable more opportunities for farmers and landowners to support net zero through land use change.

Agriculture

28. Government will support a range of measures to decarbonise the agriculture sector specifically, including by providing further funding to support farmers to take up low carbon practices and technologies. We will introduce a targeted set of financial incentives to improve animal health and welfare and reduce emissions from animals, including action to identify and eliminate bovine viral diarrhoea, with pilots starting in late 2022 or early 2023. The Farming Investment Fund will provide further grants to farmers, enabling them to invest in equipment, technology and infrastructure that will improve their profitability and benefit the environment. The scheme will be launched in 2021. From 2022, Government will also provide grants for new slurry stores, equipment, and other interventions. The primary goal will be delivering reductions in nitrate and ammonia pollutants from slurry, a key cause of pollution on farms, but the grants will also reduce methane emissions and protect and restore habitats.

29. We will increase investment in industry-led research and development into productivity challenges, delivering net zero and testing new technologies and methods. The Farming Innovation Programme will open for applications in October 2021 with further competitions planned for 2022 and beyond. These will bring together interested farmers, scientists, and researchers to tackle productivity and environmental challenges. We will invest in supporting knowledge exchange so more farmers and growers have access to the latest findings from cutting-edge research that they can apply on their farms.

30. We will encourage and support increased agroforestry (trees and agriculture coexisting on the same land) through our environmental land management schemes from the early 2020s, enabling agricultural land to sequester emissions while delivering other environmental benefits, such as air quality and biodiversity, and providing alternative income streams for farmers from trees.

31. Government is working, and will continue to work, in partnership with the sector to develop a new outcome-focused approach to regulation and enforcement which supports net zero. For example, ruminant livestock are the leading cause of farm emissions, but feed additives with methane inhibiting properties have the potential to reduce emissions, especially from housed cattle. Whilst this is an emerging technology, government is actively investigating the promising role these products may have in delivering emissions savings in the mid-term, including by assessing whether regulation could ensure maximised take up of such products.

32. We will also consider how best to reduce and better target the use of manufactured fertiliser, including exploring the potential of regulation in this area. In addition, we are considering whether we need new legislative powers to improve soil management and nutrient management. We will consider the recommendations of the Nutrient Management Expert Group, due to report in spring 2022, on the optimal policy approaches to minimise emissions from fertiliser use.

33. The Government's upcoming Food Strategy will support the delivery of net zero, nature recovery, and biodiversity commitments and will help to create a food system that incentivises farmers to produce high quality, high welfare food in the most sustainable way. Government is exploring options to reduce carbon emissions from food production, support innovation in the food sector, incentivise land use change to sequester more carbon, and preserve natural resources.

34. Government is also committed to exploring the monitoring, reporting, and verification of emissions in the agriculture sector. This will enable us to understand where the greatest decarbonisation opportunities could be across the sector, considering all options. We will continue to review potential carbon pricing strategies for land use sectors, including the potential role for voluntary or compliance carbon markets to support cost effective decarbonisation for the sector.

Peat

35. The *England Peat Action Plan* (EPAP) sets out the government's long-term vision for managing, protecting, and restoring peatlands so that they provide a wide range of benefits to wildlife, people and the planet.

36. Tackling the drivers of peatland degradation is essential. The EPAP commits to ending the horticultural use of peat in the amateur sector by the end of this parliament and a consultation will be launched on potential legislative measures (e.g. a sales ban) in 2021. Legislation to end managed burning on protected blanket bog that is 40 cm deep or more, unless covered by a license, has already been laid, protecting 40% of England's blanket bog, and government is committed to reviewing the economic and environmental case for extending protections.

37. At least 35,000 ha of peatlands in England will be restored, by 2025, via the Nature for Climate Fund. From 2024, public funding for peatland restoration will be available in England through the new environmental land management schemes. To further support peatland restoration, government is implementing a range of policies that will mobilise private investment. The Natural Environment Investment Readiness Fund has been launched and a package of reforms to the Peatland Code, including expanding it to cover more peatland types, will be implemented in 2022. We will aim to restore approximately 280,000 ha of peatland in England by 2050.

38. Degraded lowland peat is responsible for 86% of England's peatland emissions. Full restoration may not always be desirable, due to the lowlands' agricultural value and interactions with landscape scale water level management regimes. Where it is not possible to restore peatlands, we will support new responsible management measures for lowland peatlands.The Lowland Agriculture Peat Taskforce will provide recommendations in summer 2022 on how to improve the condition of lowland farmed peatlands, both to reduce emissions and support continued profitable agriculture. From 2024, our Local Nature Recovery scheme will provide a key funding stream for wetter modes of farming, including paludiculture. To prevent delay, our Farming Innovation Programme will be open to supporting applications for R&D in paludiculture from the 20 October 2021, with more competitions to follow in 2022 and beyond.

Forestry and woodlands

39. We will treble woodland creation rates by the end of this Parliament, reflecting England's contribution to meeting the UK's overall target of increasing planting rates to 30,000 hectares per year by the end of this Parliament, and maintain new planting at least at this level from 2025 onwards. We will explore a long-term statutory tree target in England within the public consultation on Environment Bill targets. We intent to spend over £500 million of the Nature for Climate Fund on funding woodland creation and management in England until 2025, beyond which the new environmental land management schemes will provide the main source of public funding. Whilst this rate of planting will lead to a relatively small emission savings in the short-medium term, it will play an increasingly important role as time goes on, while also providing other environmental benefits.

40. Private finance for tree planting and management is being generated via the Woodland Carbon Code with the support of government's Woodland Carbon Guarantee. Government has also launched a new England Woodland Creation Offer to fund woodland creation in England and will establish new Woodland Creation Partnerships in key areas, bringing together government, NGOs, and the private sector to develop bespoke offers to encourage woodland creation.

41. The government will review guidance on the tax treatment of trees and woodlands, to provide greater clarity to landowners on how new and existing trees on their land affect tax liabilities. Further, government will regulate to improve protections for existing woodlands and increase the number of woodlands under active management, improving resilience to natural hazards.

42. Felled trees store carbon within them and timber has the lowest embodied carbon of any mainstream building materials. Guided by market analysis, fire safety and structural considerations, key opportunities for the safe growth of timber use will be in low-rise buildings using traditional and certain modern methods of construction, and in a wide range of commercial and non-residential settings. We will promote the safe use of timber in construction through several measures, including by:

- Providing financial support to develop innovative timber products through the Forestry Innovation Fund;
- Working with key construction stakeholders, including the Green Construction Board, Construction Leadership Council, Home Builders Federation, and Federation of Master Builders to develop a policy roadmap on use of timber;
- Driving an increase in the use of certain modern methods of construction, some forms of which can encourage use of sustainable materials such as timber;
- Working with Homes England and delivery partners to explore ways to increase timber use in the delivery of housing programmes;
- Increasing public demand for sustainably sourced timber through procurement policies; and
- Encouraging research into barriers to uptake of timber, including looking at timber strength grades and the fire resistance of engineered timber structures.

Biomass

43. Government will publish a *Biomass Strategy* in 2022 which we will set out the results of a review of the amount of sustainable biomass available to the UK (including domestically grown perennial energy crops and short-rotation forestry), and how this resource could be best utilised across the economy to help achieve net zero. The strategy will set out the role which Bioenergy with Carbon Capture & Storage (BECCS) can play in reducing carbon emissions and how the technology could be deployed. It will also consider where and how we can improve our existing biomass sustainability standards (already some of the world's most stringent) and examine the relationship between biomass, including how it is used, and our wider environmental targets, including air quality.

Resources, waste and F-gases

Resources and waste

44. The Government's Resources and Waste Strategy (RWS) set out the overall ambition and direction of travel for the waste sector. It made a commitment to increase municipal recycling rates to 65% and to ensure that no more than 10% of municipal waste is landfilled by 2035. Biodegradable waste sent to landfill today, however, slowly breaks down anaerobically, emitting methane for many years afterwards. Faster action will mean greater emissions savings. We will therefore explore policies to work towards the near elimination of biodegradable municipal waste to landfill by 2028. To support this commitment, we are bringing forward £295 million of capital funding which will allow local authorities in England to prepare to implement free separate food waste collections for all households from 2025.

45. To work towards these goals, we are delivering the reforms announced in the RWS. Consistent collections of household and business waste will be introduced via the Environment Bill. The powers will allow us to require local authorities to separately collect a core set of materials for recycling, including paper and card, glass, metal, plastic, food waste and household garden waste. This will divert significant volumes of biodegradable waste from landfill and provide a high volume of emissions savings. A deposit return scheme for drinks containers and extended producer responsibility for packaging, placing the net costs of disposing of packaging on producers, will also be introduced. These two measures will increase the volume of materials being recycled and decrease our consumption of virgin materials, thereby reducing the amount of waste sent to landfill and reducing emissions from other sectors.

46. Complementing these measures, the introduction of the plastic packaging tax from April 2022 will encourage greater use of recycled plastic in plastic packaging, instead of new (virgin) plastic. The tax will be charged at £200 per tonne and be paid by manufacturers and importers of plastic packaging that contains less than 30% recycled plastic. It is estimated that this will lead to an increase in the use of recycled plastic by 40% in 2022-23, equal to carbon savings of nearly 200,000 tonnes of CO2 emissions. The government will also review aspects of the Landfill Tax in England and Northern Ireland in due course, as announced in Spring 2021. This will ensure the tax continues to support the government's ambitious environmental objectives.

47. Government is committed to moving to a more circular economy. This means keeping built assets, products, and materials in use for longer, including through repair and reuse, and making greater use of secondary materials, thus reducing waste arising. Recycling and material substitution, especially of carbon intensive materials such as steel, aluminium, and cement, are also an important part of our approach. The draft *Waste Prevention Programme for England (WPP)* (recently consulted on) sets out the overall approach to improving resource efficiency across key sectors and announced government's intention to consult on introducing extended producer responsibility in other areas, including textiles. The *Industrial Decarbonisation Strategy*, meanwhile, outlines our high-level ambition for resource efficiency measures across industry. At least one legislative target in the area of resource efficiency and waste reduction will be set under the Environment Bill. For further information on our plans for resource efficient manufacturing see the *Industry* chapter.

48. Government is also committed to eliminating food waste to landfill and delivering the UN Sustainable Development Goal 12.3 to halve food waste by 2030. The Environment Bill will require all local authorities in England to separately collect household food waste, preventing it from being sent to landfill. This will create carbon savings and support the shift to a circular economy, as food waste is instead turned into biogas and digestate (a soil improver) through anaerobic digestion. In addition, government will continue to work with Waste and Resources Action Programme (WRAP) and industry, and to support the Courtauld 2030 voluntary agreement with food and drink businesses, the Food Waste Reduction Roadmap, and the Target Measure Act approach, as well as campaigns in the public and private sector to reduce food waste, including the annual Food Waste Action Week.

49. Wastewater emissions will decrease due to improved treatment processes and expected data improvements. Water company research and investment into reducing process emissions from wastewater treatment plants will result in reductions in municipal process emissions via alternative treatment processes such as anaerobic treatment, membrane activated biofilm reactors, alternative ammonia removal processes and nature-based solutions. Improvements in the way companies, and government, report on industrial emissions, and the way they are calculated, are also likely to result in reductions to the values on record.

F-gases

50. Government will continue to impose the requirements of the F-gas Regulation, which covers England, Wales and Scotland. The regulation requires a range of measures to reduce emissions, including controls on gas placed on the market, product bans, leak checks and mandatory certification for handlers of F-gases. These actions will help us to meet the Kigali Amendment target of reducing HFC consumption by 85% by 2036, as well as the F-gas Regulation's target of a 79% reduction by 2030.

51. A review of the F-gas Regulation has commenced and is due to complete no later than 2022. This will be used to assess whether we can go further than the current requirements and international commitments, including by looking at what additional reductions in F-gas use can be made to help the UK meet net zero by 2050.

Working together across the UK

Examples of policy action by the Scottish Government, Welsh Government and Northern Ireland Executive

UK Government is working across all levels of government and with Devolved Administrations to ensure consistent action to reduce emissions across the Natural Resources, Waste and F-Gases sectors, and across the UK.

Wales

In November 2020, the Welsh Government published its National Peatland Action Programme to target peatland bodies most in need of restoration, with the aim of delivering 600-800 ha of restoration per year.[84] It will also safeguard those in good and recovering condition. Activity will be delivered by Natural Resources Wales and partners across a range of land uses on both private and public land.

When the Senedd first sat in 1999, Wales recycled less than 5% of its municipal waste. In 2020, Wales highest ever recycling rate of over 65% put it third in the world, with 403,000 tonnes of CO_2 avoided in 2019/20.

This success is due to a truly collective effort by local authorities, communities and households, while the Welsh Government has set targets and funded infrastructure. Food waste is collected from every household and recycling centres are evolving into modern eco-parks where businesses and enterprises capture the value in materials and keep resources in use.

Scotland

The Scottish Government has set ambitious targets to restore 250,000 ha of peatland by 2030 and for 18,000 ha of new woodlands to be created annually by 2024/25, with woodland cover increased from around 19% to 21% of the total area of Scotland by 2032. Scottish Forestry and Forestry and Land Scotland will work with investors, carbon buyers, landowners, and market intermediaries to increase private investment in new woodlands to increase the woodland carbon market by at least 50% by 2025.

I n its recent Programme for Government, the Scottish Government allocated an additional £150 million for forestry and woodland creation: Scottish Forestry will use £100 million of this to support new tree planting; and Forestry and Land Scotland will use £30 million to expand Scotland's national forests and land, and £20 million to invest in modernising nursery facilities to increase tree production.

A new Scottish Agriculture Bill will be brought forward in 2023 to replace the EU Common Agricultural Policy. Co-development and co-design with rural partners will be central to the development of future support structures and delivery. The Agriculture Reform Implementation Oversight Board (ARIOB) will be asked to incorporate recommendations from farmer-led groups, into the work implementing policy reform. These groups were established to develop proposals to cut emissions across agriculture, support sustainable and high quality food production, and design a new support system. A preliminary package of funded measures will be agreed COP26, and the ARIOB will also consider responses to the public consultation launched in August on the same themes.

Northern Ireland

The Forests for our Future Programme aims to plant 18 million trees by 2030 to create 9,000 ha of new woodland. The programme will improve the resilience of Northern Ireland's forests and woodlands and increase their contribution to a sustainable, healthy environment; increase the contribution of forests and woodlands to Northern Ireland's sustainable and inclusive economic growth; and increase the use of Northern Ireland's forest resources to enable more people to improve their health, wellbeing, and life chances.

Legislative provisions to help to limit emissions from F-gases (which have a high greenhouse warming potential) and ozone depleting substances have also been brought into operation in Northern Ireland.

3vii. Greenhouse Gas Removals

Balancing residual emissions to achieve net zero

Our Key Commitments

- Set the ambition of deploying at least 5 $MtCO_2$/year of engineered removals by 2030, in line with CCC[85] and National Infrastructure Commission assessments.[86]
- Deliver £100 million innovation funding for Direct Air Carbon Capture and Storage (DACCS) and other GGRs.
- Develop markets and incentives for investment in greenhouse gas removal methods, by consulting on our preferred business models to incentivise early investment in GGRs, in 2022.
- Working in partnership with the devolved administrations, we will aim to launch a call for evidence in the coming months exploring the role of the UK ETS as a potential long-term market for GGRs, as part of our upcoming consultation on the UK ETS.
- Explore options for regulatory oversight to provide robust monitoring, reporting and verification (MRV) of GGRs, following the recommendations of the BEIS-led MRV Task & Finish Group involving experts from industry and academia.
- Seek an amendment to the Climate Change Act to enable engineered removals to contribute to UK carbon budgets.

Progress to date

1. The primary method of achieving net zero is to take ambitious decarbonisation measures across society. However, we must also acknowledge that sectors such as industry, agriculture and aviation will be difficult to decarbonise completely by 2050. Greenhouse gas removals (GGR) are therefore essential to compensate for the residual emissions arising from the most difficult activities to reduce or eliminate from within polluting sectors. This approach is supported by the Climate Change Committee,[87] the Energy Systems Catapult,[88] the National Infrastructure Commission and the National Grid ESO (the GB electricity system operator).[89]

2. GGR is the name given to a group of methods that actively remove greenhouse gases, predominantly CO_2, from the atmosphere, also commonly referred to as Carbon Dioxide Removal (CDR) methods and Negative Emission Technologies (NETs). The range of GGR approaches fall broadly into two categories:

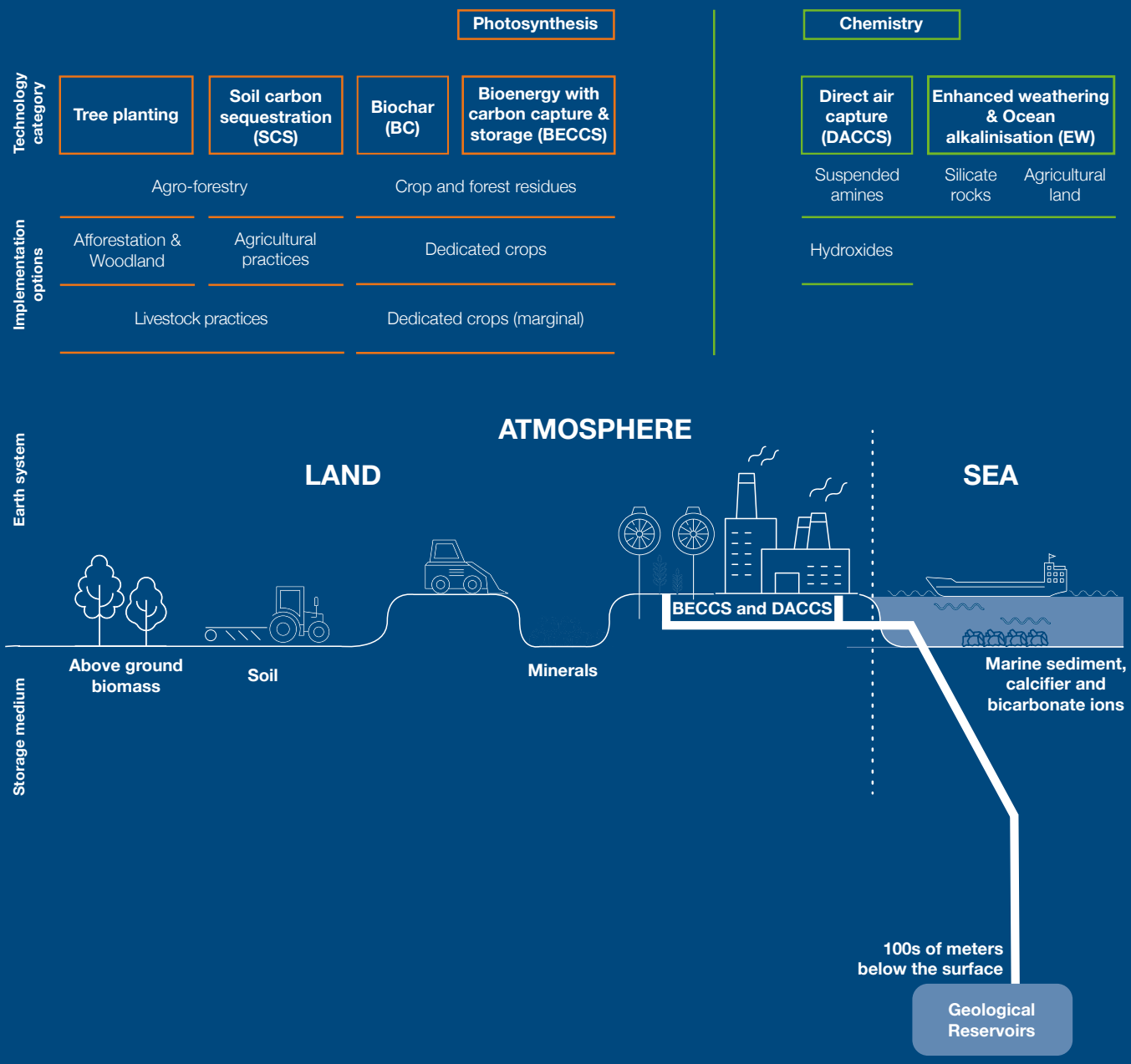
- Nature-based approaches: such as afforestation, and soil carbon sequestration.
- Engineering-based approaches: such as Direct Air Carbon Capture and Storage (DACCS), Bioenergy with Carbon Capture and Storage (BECCS), wood in construction, biochar, and enhanced weathering (EW).

3. Following the sector classification adopted by the CCC and in this Strategy, this chapter focuses on engineered removals. Nature-based solutions, such as afforestation, are discussed in the *Natural Resources, Waste and F-gases* chapter.

4. The 2017 *Clean Growth Strategy* was the first time the UK government formally addressed the need to deploy GGR methods. Since then, we have:

- Committed up to £100 million funding to research and develop nascent GGR;
- Published a call for evidence on GGR in December 2020; and
- Commissioned 4 studies to further our evidence base on the potential for GGR deployment in the UK and understanding of possible policy incentives.

Figure 25: Non-exhaustive illustration of the current portfolio of GGRs.[90]



5. In December 2020, BEIS and HM Treasury jointly launched a Call for Evidence on GGRs, which invited views on the role of GGRs in reaching net zero and potential mechanisms which government could consider to enable their deployment. A Summary of Responses to the Call for Evidence has been published alongside this Strategy.

Net zero transition and opportunities for the sector

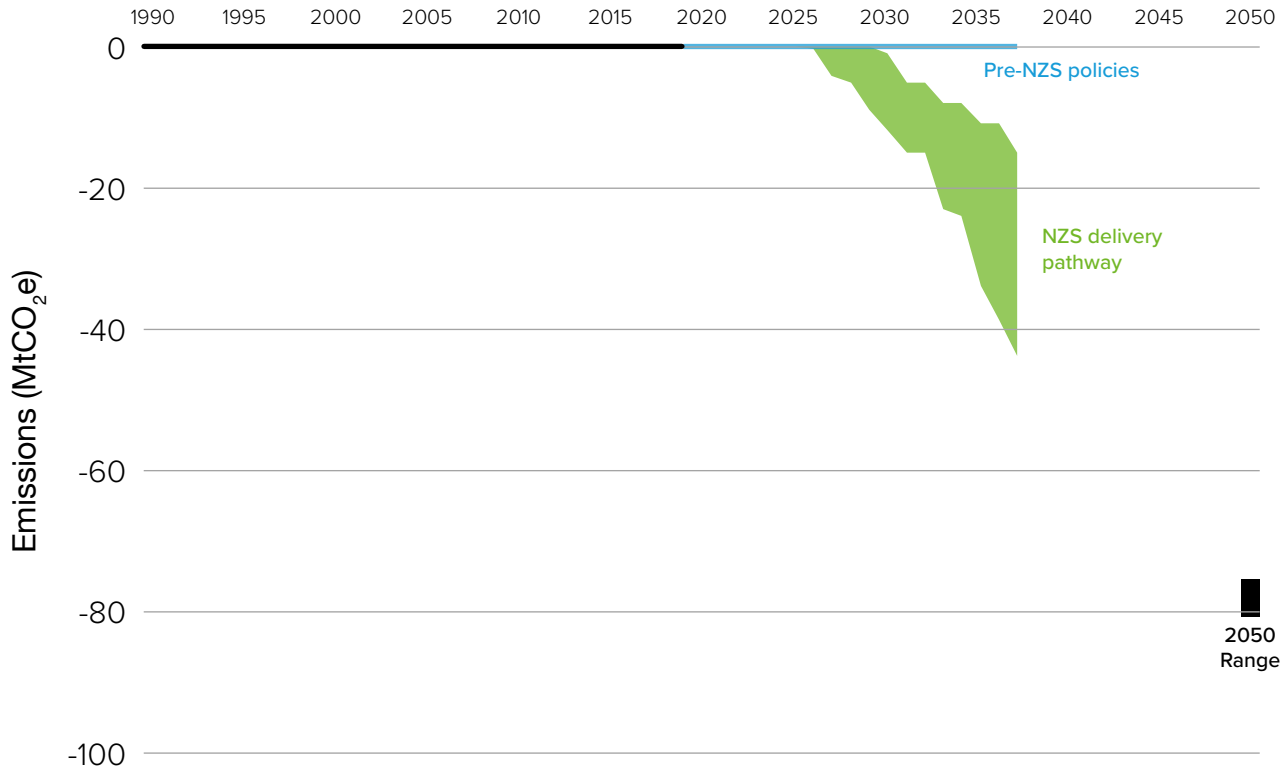
Our 2050 vision and how we get there

6. We are clear that the purpose of greenhouse gas removals is to balance the residual emissions from sectors that are unlikely to achieve full decarbonisation by 2050, whilst not substituting for ambitious mitigation to achieve net zero. GGRs must not be pursued as a substitute for decisive action across the economy to reduce emissions, often referred to as mitigation deterrence.[91]

7. There is also a need to ensure that GGRs result in a permanent net reduction in atmospheric carbon. This is a complex task which, at least in the near-term, may require case-by-case scrutiny of the carbon intensity of GGR supply chains and long-term indirect emissions of GGR projects. Developing a robust approach to the Monitoring, Reporting and Verification (MRV) of negative emissions is essential to the deployment of GGRs at scale. Future markets in which negative emissions are traded, whether voluntary or otherwise, will require careful regulation to ensure that capital is being invested into permanent, verifiable carbon removal.

8. Evidence around scale-up potential of engineered removal solutions in the UK is rapidly evolving, alongside innovation in the sector. This evidence[92,93] suggests that the next decade will be critical and several GGR solutions, such as Direct Air Capture, will have to be developed or scaled-up significantly during the late 2020s and early 2030s to contribute effectively to later carbon budgets and our net zero target, as well as to build our evidence and experience in the sector.

Figure 28: Indicative greenhouse gas removal (negative) emissions pathway to 2037



Source: BEIS analysis

9. Both nature-based and engineered removal methods will be necessary. For engineered removals, a portfolio approach, supporting innovation, demonstration, and commercialisation of a wide range of removal solutions in the 2020s, is needed to ensure GGRs can contribute effectively to meet our NDC and CB6 targets. The government's current suite of innovation programmes for DACCS and other GGRs will help ensure we continually target efficiency improvements, cost reductions and novel GGR technologies to inform our approach over the coming decades.

10. Based on the current evidence base and projects in the pipeline, our analysis indicates that engineered removals would be expected to deploy from 0 $MtCO_2$ today to at least 5 $MtCO_2$ by 2030 and to around 23 $MtCO_2$ by 2035, with higher and lower deployment possible depending on sector-specific and wider economy developments.

11. By 2030 we envisage significant deployment of mature BECCS technologies and commercial scale deployment of DACCS. BECCS technologies will include retrofit applications in the power and industry sectors. BECCS applications in the power sector could be deployed by the late 2020s, and potentially achieve ambitious contributions to our NDC target by 2030. Engineered removals are likely to be located within or near industrial clusters, benefitting from access to CO_2 transport and storage infrastructure, essential to support delivery of net-negative emissions.

12. By the early 2030s the portfolio of GGRs deployed at scale will expand as technologies mature and demand from end-use sectors increases. Beyond the contribution of power BECCS to the electricity grid, production of hydrogen, biogas/biomethane fuels with BECCS could also support the decarbonisation of transport, industry and potentially power and heat in buildings. Industry may also benefit from BECCS applications in sectors such as cement. When applicable in these areas, BECCS can represent a cleaner form of energy production than fossil fuel counterparts, whilst also bringing the additional benefit of negative emissions. The early 2030s could also see progress in deployment of DACCS technologies, thanks to efforts in demonstration and piloting during the 2020s through the support of our Direct Air Capture and other GGRs innovation competition.

13. By 2050, deployment of engineered removals at large scale, between 75 and 81 $MtCO_2$ per year, will be needed to help compensate residual emissions. This is expected to be equivalent to around 45-80% of total emissions captured across the UK economy and will see predominantly the scale up of DACCS and BECCS with gasification technologies.

Greenhouse gas removals in the context of the wider net zero system

There will be several complex interdependencies between GGR methods and the wider net zero system. Progress towards decarbonisation in other sectors will affect the extent to which GGR deployment will be required to hit our emissions targets. Conversely, GGRs have resource requirements that will impact other sectors. For example, deployment of engineered GGRs in the early years will likely be constrained by the availability of CO_2 transport and storage injection capacity and any development of GGR business models will need to consider interactions with Industrial Carbon Capture and hydrogen business models, along with wider carbon pricing policy. We have committed to consider how the UK Emissions Trading Scheme could be expanded in future to provide a long-term support mechanism for GGRs.

Biomass availability and supply

Biomass policy is highly interdependent with GGR deployment. Sustainable biomass is a unique renewable organic material, and the future availability of sustainable biomass directly influences the scale GGRs such as BECCS and biochar can deploy to. Constraints on demand for perennial energy crops and solid recovered fuels, related mostly to technological and financial challenges, will need to be overcome via research and innovation to see significant increase in the take up of these biomass feedstocks. The upcoming Biomass Strategy (due to publish in 2022) will review the amount of sustainable biomass available to the UK and set out a framework for how this resource can be best utilised across the economy to help achieve our net zero target. The upcoming biomass policy statement gives an early indication of this framework, setting out the principles and policy aims for biomass up to 2050.

The Strategy will also assess the UK's current sustainability standards, to see where and how we can improve them even further. Any future BECCS project would be required to meet stringent sustainability requirements for the production and use of biomass, as will be set out in the Biomass Strategy.

Using our land effectively

Land use change will be required to accommodate GGRs, either directly through nature based GGRs such as afforestation or indirectly from increased production of woody biomass, such as perennial energy crops or short rotation forestry, to use for BECCS or other opportunities in the wider bioeconomy.

What is best grown, where, in what quantity, and for what purpose, determines the feasibility of a GGR through land-use change. Feasibility therefore must consider, amongst others: alternative land use, feasible technological options for production, the net impact on GHG emissions, interactions with competing land demands for other strategic government objectives such as food security, nature conservation and housing, as well as social implications such as integration of GGRs into existing farm practice and environmental co-benefits/risks.

Further research is required into best practice for establishing GGRs in a productive and biodiverse landscape, and what levers may be required to establish such measures on land that is largely privately owned. Research projects through the UKRI SPF on GGRs and NERC GGR Research Programme will start to address these evidence gaps. GGR deployment will require alignment with HMGs schemes to reward environmental land management for example: Sustainable Farming Incentive (SFI), Local Nature Recovery (LNR) and Landscape Recovery Schemes. We will also need to consider interactions with private sector demands, such as through the domestic voluntary carbon market.

Uncertain impacts from climate change such as impacts to national stocks of high-grade farmland also demands consideration of what is both feasible now and on the way to 2050. Differences in spatial and temporal scales between removal technologies, such longer pay-back times for afforestation as opposed to short rotation forestry, create opportunities to maximise carbon removals to 2050 through a mix of land based GGRs.

Managing environmental risks and benefits

There are significant opportunities for maximising environmental co-benefits through nature based GGRs. For example, integrating perennial energy crops (e.g., short rotation coppice (SRC)) into existing farm systems can increase the abundance and diversity of flora and fauna at a field scale, though these benefits depend on factors such as historic cropping patterns and spatial distribution. At a landscape scale, afforestation can deliver co-benefits through natural flood management and urban cooling. However, benefits depend on sustainable forest management and choosing the right location and species of tree in the ecosystem.

We must ensure that GGR technologies do not create new environmental risks. For instance, feedstock production for BECCS, biochar and wood in construction have potentially significant land requirements which if mismanaged could pose risks to biodiversity. The deployment of BECCS could also potentially impact local air quality and we must ensure that regulation and abatement on emissions other than CO_2 develop to reflect this. It is also necessary to ensure resilience to the impact future climate change might have on the feasibility to deliver GGRs and wider environment objectives.

CO_2 Transport and Storage networks

By the early 2030s, CO_2 transport and storage infrastructure availability could potentially constrain GGR deployment, as the significant overall expansion of CCUS projects creates competition for access to the network.

Seizing new opportunities

14. The UK is well placed to take a leading role in GGR policy development and deployment. We have world-leading academic and industry expertise in relevant sectors, as well as a rapidly developing carbon capture usage and storage (CCUS) sector and access to large volumes of quality geological CO_2 storage. Enabling GGR deployment will not only help us hit net zero but can support the UK's ability to export skills and expertise to other nations with comparable ambitions for the sector.

15. To achieve the level of negative emissions indicated by our central delivery pathway to 2037 and keep us on track to deliver net zero, we will need additional public and private investment of around £20 billion. Scaling up the GGR sector will also regenerate communities and open up new employment opportunities right around the UK.

16. It will be crucial to ensure that future GGR policy maximises the economic and regional development opportunities of developing the low carbon economy in our industrial heartlands. Economic benefits include creating new, highly skilled jobs in our industrial heartlands and safeguarding those existing in adjacent sectors with the potential to be adversely affected by the transition to net zero, as well as supply chains.

Policies & proposals

17. Government has a clear role to play in responsibly deploying GGRs, and is committing to an ambition of deploying at least 5 $MtCO_2$/year of engineered removals by 2030. To achieve this, we are taking ambitious steps to enable commercial demonstration and deployment of engineered GGRs such as Direct Air Capture. We are addressing their financial and regulatory barriers, whilst also working to build the evidence base and address continued uncertainty around how GGRs can most effectively and sustainably be deployed and verified. Our role will change over time, as GGRs become more established, and the sector matures.

Addressing financial barriers and attracting investment

18. One of the fundamental barriers to GGR deployment is the lack of an established market or customer demand for engineered removals. GGR technologies are associated with high capital and operational costs, making private investment unattractive in the absence of a stable revenue stream for the provision of negative emissions.

19. The government's vision is to establish a liquid market for carbon removals, in which polluters have a strong policy or financial incentive to invest in GGRs to compensate for their remaining emissions. The UK Emissions Trading Scheme (ETS) is a possible market-based solution for stimulating investment by GGRs – moving us towards a single, integrated compliance market for carbon, with negative emissions supporting liquidity as the ETS allowance cap falls over time.

20. GGR credits could function within an ETS market through, for instance, allowing polluting sectors to meet their obligations through the procurement of negative emissions alongside conventional abatement options. In the *Energy White Paper*, the government committed to exploring how the UK ETS could incentivise the deployment of GGR technologies. We aim to work with our Devolved Administration colleagues to launch a call for evidence in the coming months on the role the UK ETS could have as a potential long-term market for engineered or nature-based GGRs. This may explore possible eligibility criteria for participation in the UK ETS, different types of GGR market design, and timings for when GGRs could be added to the market.

21. We recognise that a market for GGRs will take time to establish and a phased approach is likely to be necessary. In the short-term, there may be a role for government in providing bespoke support for initial projects to de-risk investment decisions and provide revenue certainty for technology developers. Yet we also recognise the potential for early support instruments to integrate with market-based approaches, such as combining contract mechanisms with inclusion of GGRs in the UK ETS.

22. To advance our ambition to stimulate the GGRs sector, we will consult on business models for engineered GGRs in Spring 2022. This will set out details of our preferred mechanisms to incentivise early investment and enable commercial demonstration of a range of GGR technologies from the mid-to-late 2020s. The consultation will consider how GGR incentives interact with policies and business models currently under development for CCUS, hydrogen production, sustainable aviation fuels and other relevant sectors, along with wider carbon pricing policy. It will also consider how near-term policy incentives can most effectively leverage private investment and enable a transition towards a market-led framework as the sector matures.

23. Our proposals will be informed by a study currently being conducted for BEIS by Element Energy, as well as a recent study on commercial frameworks for first-of-a-kind Power BECCS projects which is published alongside this document.

24. Whilst seeking to capitalise on the economic benefits of GGR development in the UK, we are also mindful of potential disruption to existing markets and the effects on consumers and businesses. The cost of support for GGRs is likely to be shared between the public and private sector. We will seek to develop an appropriate balance of risk allocation over the short, medium, and long term. Potential policy frameworks to enable developing GGR solutions will require careful consideration to guard against unintended effects. We will ensure that support for GGRs does not distort the development and commercialisation of decarbonisation technologies in other sectors.

Innovation

25. The majority of GGR techniques are at a pre-commercial stage and require innovation and demonstration support to be ready for commercial deployment. To address this GGR technologies were included as one of ten innovation priority areas announced in the *Ten Point Plan* for a green industrial revolution.[94] Together with UKRI, we are investing £100 million in the research, development, and demonstration of greenhouse gas removals across multiple programmes. This includes the DAC and other GGR innovation competition which will support the construction of pilot plants for a range of promising technologies to help them achieve commercial realisation.[95] The programme's pilot projects could remove between 100 and 1,000 tonnes of CO_2e per year in 2025 and have the potential to scale up to millions of tonnes by the 2030s.

26. Through the government's Strategic Priorities Fund, UK Research and Innovation (UKRI) will invest £31.5 million in five land based GGR demonstrator projects and a central hub. The hub will lead on coordination across the programme, as well as conducting cross-cutting research on the environmental, economic, social, ethical and governance implications of GGR approaches.

27. The Biomass Feedstocks Innovation Programme aims to increase the production of sustainable domestic biomass by funding innovative ideas that barriers production. The sustainable, increased supply of biomass for bioenergy conversion is a critical factor for the success of BECCS.

28. We are also publishing the outputs of two BEIS commissioned research projects designed to further our understanding and evidence base on GGR methods and their deployment. An updated assessment of greenhouse gas removal methods and their potential deployment in the UK provides a comprehensive and up-to-date assessment of lifecycle costs, TRL and deployment potential to 2050.

Monitoring, reporting and verification of GGRs

29. Once atmospheric carbon has been captured, the length of time it remains captured becomes crucial in verifying the effectiveness of a GGR process. This applies to both nature based and engineered solutions and is often referred to as the 'permanence' or 'durability' of GGRs. Establishing robust Monitoring, Reporting and Verification (MRV) protocols is highly complex, particularly for some nature-based solutions.

30. In 2021, we established a GGR MRV Task and Finish Group, comprised of experts across government, industry, academia, and regulatory services. The role of the group was to provide advice and guidance on the development of a MRV policy approach for GGRs. A recommendation made by the group is the need for an independent audit function to be responsible for a monitoring, reporting and verification regime. This would ensure that the amount and permanence of removals are quantified, robustly and transparently, which will be essential to developing and supporting a market for GGRs.

31. Alongside this document we have published a report summarising the work of the group, including proposed principles to guide our MRV approach, initial suggestions for how MRV protocols could operate, and the future work required to advance the development of an MRV policy for negative emissions. The government will carefully consider the Group's advice as we take forward future work in this area.

32. Accounting for emissions associated with international supply chains presents a challenge for GGR carbon accounting, and we will engage with our international counterparts to ensure best practice is achieved. Accounting for possible re-emissions, e.g., of CO_2 captured internationally but stored in the UK may be a particular challenge. We commit to collaborating with international partners to ensure alignment on any future MRV framework.

Legal and regulatory

33. Currently the Climate Change Act 2008 only recognises removals from Land Use, Land Use Change and Forestry (LULUCF) as counting towards our carbon budgets, a definition which does not allow engineered removals and some nature-based solutions to contribute. We propose to bring forward legislative amendments to address this.

34. An MRV regime will be required to ensure that the amount and permanence of removals are quantified, robustly and transparently, with tolerable uncertainty. We will explore options for establishing a regulatory function to provide this oversight, taking into consideration the advice of the MRV Task and Finish Group.

Working together across the UK

Example of policy action by Scottish Government

UK Government is working across all levels of government and with Devolved Administrations to ensure consistent action on Greenhouse Gas Removals, and across the UK.

Scotland

Storegga and Carbon Engineering have announced a partnership to develop commercial Direct Air Capture (DAC) projects in the UK, potentially contributing to the removal of millions of tonnes of CO_2 each year. One location being considered for their first proposed plant will sequester up to 1 mtpa, connected via pipeline to the Acorn Carbon Capture and Storage project at St Fergus. The proposed DAC facility would deliver permanent CO_2 removal by capturing CO_2 from the air then safely and permanently storing it deep below the seabed in an offshore geological storage site. The offshore Acorn CO_2 storage site is aiming to be operational by the mid-2020s and the first DAC project could be operational within two years of the store opening.

The Scottish Government's Climate Change Plan committed to a detailed feasibility study of opportunities for developing negative emission technologies (NETs) in Scotland. This will identify specific sites and applications of NETs, including developing work to support policy on Direct Air Capture and its role in our future energy system. The launch of a £180 million Emerging Energy Technologies Fund to support Hydrogen, CCS, and NETs projects has also been announced.

Endnotes

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3 BEIS (2021) 'Early phase out of unabated coal generation in Great Britain' - https://www.gov.uk/government/consultations/early-phase-out-of-unabated-coal-generation-in-great-britain

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[17] Marginal emissions sources that fall outside these categories, but are accounted for in the sector's emissions, include methane leakage from closed coal mines, nuclear fuel production and collieries.

[18] For further detail on the current role of hydrogen, see chapter 1 of Analytical Annex to UK Hydrogen Strategy. BEIS (2021), 'Hydrogen analytical annex', https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1011499/Hydrogen_Analytical_Annex.pdf

[19] DfT (2020), 'Renewable Fuel Statistics 2019 Final Report', https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/932933/renewable-fuel-statistics-2019-final-report.pdf

[20] These hydrogen production capacity ranges capture uncertainty in hydrogen demand across all sectors that use hydrogen. BEIS (2021), 'UK Hydrogen Strategy', BEIS (2021), 'Hydrogen analytical annex', https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1011499/Hydrogen_Analytical_Annex.pdf; BEIS (2021), 'Hydrogen analytical annex', https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1011499/Hydrogen_Analytical_Annex.pdf.

[21] Assuming plants operate at 95% load factor. In practice, plants may run at lower load factors, requiring even higher hydrogen production capacity to be installed. These are estimates of production capacity for two illustrative delivery pathways where demand is within the range presented in the Hydrogen Strategy, and only capture uncertainty around hydrogen demand for heat.

[22] BEIS analysis on capital investment required to deliver production capacity.

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[28] Welsh Government, Decarbonisation of Homes in Wales Advisory Group, https://gov.wales/decarbonisation-homes-wales-advisory-group

[29] ONS (2021), 'Annual Business Survey', https://www.ons.gov.uk/businessindustryandtrade/business/businessservices/datasets/uknonfinancialbusinesseconomyannualbusinesssurveysectionsas

[30] ONS , 'Gross Domestic Product (GDP), https://www.ons.gov.uk/economy/grossdomesticproductgdp

[31] ONS (2021), 'Annual Business Survey', https://www.ons.gov.uk/businessindustryandtrade/business/businessservices/datasets/uknonfinancialbusinesseconomyannualbusinesssurveysectionsas

[32] UK in a Changing Europe (2020), 'Manufacturing and Brexit', https://ukandeu.ac.uk/research-papers/manufacturing-and-brexit/

[33] The definition of manufacturing and refining used above is similar but not identical to the definition of industry used here, this is due to a different taxonomy being used (SIC codes and IPCC codes respectively).

[34] BEIS (2021), 'Final UK greenhouse gas emission national statistics: 1990 to 2019', https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-national-statistics-1990-to-2019 Industry sector emissions include emissions from industrial processes, manufacturing, and production, including fuel combustion and product uses in industrial buildings, as well as emissions from refineries and construction machinery. This definition of industry is broader than the definition used in the Industrial Decarbonisation Strategy and the Hydrogen Strategy, which excluded the non-road mobile machinery and construction sectors.

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[37] National Atmospheric Emissions Inventory (2021), 'Greenhouse Gas emissions reports', https://naei.beis.gov.uk/reports/reports?section_id=3

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[46] ONS (2020), 'Households projections for England', Table 401, https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationprojections/datasets/householdprojectionsforengland ; BEIS (2020) 'Non-domestic National Energy Efficiency Data-Framework' based on 2018 data, https://www.gov.uk/government/statistics/non-domestic-national-energy-efficiency-data-framework-nd-need-2020

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[48] This figure includes only emissions from direct energy use in buildings. Including emissions from producing the energy used, the figure is 26%. BEIS Analysis, BEIS (2021), 'Final UK greenhouse gas emissions national statistics: 1990 to 2019', https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-national-statistics-1990-to-2019; ONS (2021), 'Energy Consumption in the UK', https://www.gov.uk/government/statistics/energy-consumption-in-the-uk-2020. This figure includes not only emissions from direct energy use in buildings but also emissions from producing the energy used.

[49] Building Services Research and Information Association (BSRIA) (2020), Domestic boilers market analysis – United Kingdom, 2020, https://www.bsria.com/uk/

[50] These figures are on an indirect basis, i.e. include emissions from producing the energy used. On a direct basis, the equivalent figures are 99% and 17%. BEIS Analysis, BEIS (2021), 'Final UK greenhouse gas emissions national statistics: 1990 to 2019', https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-national-statistics-1990-to-2019; ONS (2021), 'Energy Consumption in the UK', https://www.gov.uk/government/statistics/energy-consumption-in-the-uk-2020.

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[55] MHCLG (2020), 'English Housing Survey 2019 to 2020', https://www.gov.uk/government/statistics/english-housing-survey-2019-to-2020-headline-report

[56] MHCLG (2020), 'English Housing Survey 2019 to 2020', https://www.gov.uk/government/statistics/english-housing-survey-2019-to-2020-headline-report, Annex table 2.8

[57] 'Fabric first' means installing measures that upgrade the building fabric (e.g. walls/lofts) before making changes to the heating system.

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Supporting the Transition across the Economy

Chapter 4

4i. Innovation for net zero

Harnessing UK strengths in R&D to reach net zero

Our Key Commitments

- Increase government **investment in R&D to £22 billion;** increase total R&D investment to 2.4% of GDP by 2027.
- Publish the **UK's first Net Zero Research & Innovation Framework** to set out the key research and innovation challenges for the next 5-10 years; and a future update to demonstrate how the government is delivering against these.
- **Deliver a Government programme of innovation to enable decarbonisation –** funding of at least £1.5bn during next spending review period expanding a portfolio of cross government net zero innovation to fund BEIS-led programmes on power, buildings and industry; DfT-led programmes across transport; and DEFRA led programmes on natural resources, waste and F-gases, to target priorities aligned with the Net Zero Research & Innovation Framework. This spending includes new programmes set out in this Strategy such as £60m Heat Pump Ready programme.
- Take a **leadership role in Mission Innovation 2.0,** a global initiative working to accelerate clean energy innovation.[1]

The challenge

1. Innovation is central to our approach to delivering net zero. It will require a step change in the rate of new technologies and processes being developed and deployed into the market and being adopted by businesses and consumers. Continued investment in cutting-edge research, development, and demonstration, will be integral to achieving this transformation and to the UK leading the world in areas of existing and potential competitive advantage. This investment will also support businesses to grow and solutions to be delivered at scale. Research, development, and innovation are needed to allow government, industry and business to make decisions about what new technologies and systems are promising. To respond, government must enable the efficient scaling of technologies, systems, and business models to pull them through to commercialisation for 2050 - and beyond.

Our goal

2. Our goal is for the UK to be a global leader in the technologies, processes, services, and business models needed to decarbonise our economies, protect our environment, and adapt to a changing climate. We will support our world class innovators, entrepreneurs, and financial institutions to develop and deploy the key technologies of the future. This will need to take place alongside other cross-cutting policies, regulatory changes, and commitments.

3. By supporting innovation, we could unlock the potential for 300,000 jobs in exports and domestic industry through new commercial opportunities across low carbon sectors.

4. In the Prime Minister's *Ten Point Plan for a Green Industrial Revolution,*[2] we restated our commitment to raise total private and public R&D investment to 2.4% of GDP by 2027 – enabling the next phase of green innovation to help bring down the cost of the net zero transition, nurture the development of better products and business models, and understand consumer choices. We have started delivering on this with funding announced for programmes across the portfolio including renewables, energy storage and flexibility, and hydrogen.[3] This is contributing to levelling up across all regions of the UK whilst helping us to achieve our net zero target.

The role of innovation

5. Innovation can significantly reduce costs of the technologies, processes, and systems needed to reach net zero. This goes beyond just developing technologies. It also means exploring new business models, approaches to financing, the regulatory environment and how consumers respond. Taking a whole systems approach to innovation will be integral to maintaining and developing the UK's global leadership in areas where we have, or can develop, an international comparative advantage or unique capability. We must harness the UK's international reputation to attract inward investment and anchor existing and emerging supply chains in the UK. International collaboration will also be critical to ensure that clean technologies become cheaper and more readily available.

6. Innovation is a process which occurs within an ecosystem of interacting actors, technologies, and institutions. This requires technologies, systems or processes to progress through multiple phases of development – from basic research, through to commercialisation and diffusion. However, innovation does not flow neatly in one direction from one phase to the next; it is unpredictable and serendipitous, involving constant cycles of learning, testing, refining, and discovery. At each phase of the innovation process there are different market failures and barriers, requiring distinct interventions. In the early stages, there are often minimal incentives for private actors to invest in innovation and direct funding policies can help 'push' technologies towards demonstration and early commercialisation. In the later stages, the importance of attracting private finance grows. Market incentive policies support the development of markets and leverage private finance to 'pull' technologies towards deployment and diffusion.

7. The Prime Minister's *Ten Point Plan for a Green Industrial Revolution*, our *Plan for Growth* and our new *Innovation Strategy* bring together ambitious policies and significant public investment to achieve net zero, whilst seeking to mobilise substantial private investment. These commitments will position the UK to take advantage of export opportunities in global markets presented by these low carbon technologies and services.

Case study: Glass Futures with Encirc pilot project

Through government's 2016-21 Energy Innovation Programme, BEIS funded Encirc (a glass container manufacturer) and Glass Futures (an industry research and technology organisation) to lead a trial project based in Derrylin, Northern Ireland to help determine the most effective approach to using low carbon fuels in manufacturing in the glass sector.

This revolutionary project has proven that new bottles can be made from 100% recycled glass by using energy only from burning low carbon biofuels. It is thought that this world-first initiative will set a global standard and make way for an industry-wide reduction in carbon emissions in the glass sector.

When made from waste organic materials, biofuels are a renewable and much more sustainable fuel source than those traditionally used by the glass sector and can reduce the carbon footprint of each bottle by up to 90%. By using up to 100% recycled glass to create new bottles, the trial has further minimised the lifetime impact of these new products.

Supporting innovation for net zero

8. Achieving net zero will require profound changes to the UK economy. It will mean increasing our low carbon electricity supply, making the transition to low carbon buildings, decarbonising transport, building a hydrogen economy, decarbonising industry, rolling-out carbon capture and storage, transforming the way land and marine spaces are used, improving agricultural management, adopting better waste management, and deploying technologies to remove greenhouse gases from the atmosphere. This should include innovation to mitigate any environmental impacts from new technologies on our pathway to net zero.

9. In each of these sectors, known technologies, business models, services and approaches will need to be demonstrated and then deployed at scale, while novel technologies need R&D support now to determine whether they can be affordable and viable options in the longer-term. Underpinning this will be research to understand consumer acceptability and behaviour, and to create economic incentives will also be required for lasting change.

10. We're publishing the *Net Zero Research & Innovation Framework* which sets out the critical net zero research and innovation challenges across the UK that require development over the next 5-10 years, and presents timelines of short, medium, and longer-term priorities. The framework will help to align current and future government funding around agreed priorities and to crowd-in effort and investment from the private sector and research communities by providing a clear signal on our areas of focus.

Government R&D Support

11. Government investment in research drives progress on our goals, from the physics underpinning battery technology to the mathematics underlying climate modelling. In November 2020, we committed to increasing investment in core UK Research and Innovation (UKRI) and National Academy funded research by more than £1 billion by the April 2024 (the 2023/24 Financial Year). UKRI investment in research, innovation, and skills creates the conditions for the UK to address the complex and interrelated challenges of achieving net zero by 2050.

12. Beyond early-stage research, investment in new technologies is essential for bringing them closer to commercialisation. We will expand our cross government portfolio of net zero innovation support, delivering at least £1.5 billion during the next spending review period. This will accelerate the commercialisation of low carbon technologies, systems, and business models across the economy.

13. The Transport Decarbonisation Plan committed to implementing a range of innovation programmes to support the decarbonisation of transport, with successful projects for zero emission road freight trials and hydrogen transport pilots recently announced. Building on the success of our £20 million zero emission road freight trials, we will expand these to trial three zero emission HGVs technologies at scale on UK roads to determine their operational benefits, as well as their infrastructure needs. The accompanying *Jet Zero: our strategy for net zero aviation* proposes a suite of policies to reduce aviation emissions, including accelerating the development of sustainable aviation fuels and supporting the development of zero emission flight. The *Agricultural Transition Plan* set out the commitment to boost innovation and help farmers and growers increase productivity, sustainability, and resilience to a changing climate. Given the importance of R&D to deliver emissions savings across the natural resources, waste and F-gases sectors, we are also committing to spend £75 million on net zero related R&D in these sectors over the next three years.

14. We will prioritise innovations where there is a strong case for UK Government investment, while leveraging additional funding from industry. It will also support the UK in maintaining its leadership in the development of technologies such as nuclear reactors and fusion energy,[4] which are expected to complement renewable sources in the future. With high levels of innovation alongside ambitious policy support in technologies, the UK's low carbon sectors with the largest potential could unlock £60 billion of GVA in the UK.[5]

15. The Industrial Strategy Challenge Fund (ISCF),[6] delivered by UKRI and its partners, drives UK growth and productivity by directing innovation across sectors and disciplines behind government's strategic priorities. ISCF has to date allocated £824 million to eight challenges aligned to the 2017 Industrial Strategy Clean Growth Grand Challenge. Examples include the Transforming Food Production Challenge; the Faraday Battery Challenge; the Driving the Electric Revolution Challenge.

16. The government's *Innovation Strategy* sets out our plans for a refreshed Innovation Missions programme to build on UK leadership in mission-driven innovation and bring government together with industry, civil society, and academia to respond directly to major challenges confronting the UK. As referenced in the *International* chapter, Missions can play an important role in stimulating and leveraging innovation for tackling complex problems while simultaneously promoting growth and improved business outcomes and restoring the UK's place as a science superpower.

17. It is a strategic focus of our *National Space Strategy* to utilise space technology in the fight against climate change. Satellites provide an extraordinary insight into our climate and environment and enable us to understand and monitor how climate change is impacting the Earth. We will strive to remain at the forefront of Earth Observation (EO) technology and know-how. This supports our ambition to be a global science and technology superpower and to lead the world in tackling climate change and biodiversity loss.

18. It is essential that we track cross-government activity and ensure that innovation funding is strategically aligned to deliver the government's net zero ambition. This will be supported by the Net Zero Innovation Board (NZIB), chaired by the UK Government's Chief Scientific Advisor.

19. Alongside our policies that specifically support our net zero objectives, there will be continued significant public investment in R&D to support all sectors. This includes the creation of a new institution – the Advanced Research and Invention Agency (ARIA) – to fund high-risk, high-reward research. ARIA's leadership will have full scope to determine the areas in which it will invest.

Case study: Hy4Heat Programme and Hydrogen Fuelled Appliances

The Hy4Heat programme was launched by BEIS in 2017 to explore the use of hydrogen gas for heating by seeking to demonstrate technical feasibility and safety. It aims to define quality and technical standards, and to develop domestic and commercial hydrogen appliances. The programme, with up to £25 million funded by BEIS, is supporting the innovation journey of a range of domestic hydrogen appliances and meters including world-first hydrogen-ready boilers, cookers, and fires.

These hydrogen appliances and meters are being installed at a hydrogen home facility, developed in partnership with Northern Gas Networks (NGN) and Cadent. This will enable industry and members of the public to see how these appliances work in a home setting. These properties will be the first UK houses to demonstrate the use of hydrogen appliances in a real-world setting.

Policy and regulatory frameworks

20. As set out in the *Ten Point Plan* and *Energy White Paper*, we will continue to develop a policy environment and regulatory framework which incentivises further deployment of new technologies, services, and business models. The UK's Electricity Market Reform is an example of how government can drive significant cost reductions in low carbon technology. Furthermore, while supporting the deployment of offshore wind through the Contracts for Difference scheme, costs have reduced by >50% in the last decade. This provides a clear example of policy 'pull' whereby open competition worked to drive cost reductions through deployment and innovation. As noted throughout the strategy, government will work with industry, businesses and consumers to consider the removal of regulatory barriers which may be hindering our transition to net zero.

Encouraging private sector investment

21. To deliver net zero, it is essential that public investment catalyses significant flows of private investment into innovative companies and activities. This means creating the right conditions for all businesses to innovate and giving them the confidence to do so. The right conditions will often involve de-risking capital in the forms of grants (allowing freedom to innovate) and concessionary capital (allowing businesses to commercialise and scale their operations). Providing the private sector with clarity on government R&D priorities can also help to build the confidence to invest in innovative companies and activities. As outlined, our *Net Zero Research & Innovation Framework* sets out a structure for this and a future update will demonstrate how the government is delivering against this Framework.

22. In *Build Back Better: our plan for growth*, and the *Innovation Strategy*, we set out our aim to unlock the potential of the £2.2 trillion held in UK pension schemes by addressing barriers to long-term investment. The government has established the Productive Finance Working Group, which published its roadmap for increasing productive finance investment in September 2021,[7] and is progressing policy development through several Department for Work and Pensions consultations. These workstreams explore ways to make it easier for schemes to invest in alternative assets, including equity investment in innovative firms; creating the conditions for capital to flow into the UK's most promising firms will help ensure that finance is available for the innovation required to meet our net zero goals and improve outcomes for UK savers. Government will continue to engage closely with pension funds and the investment industry to understand the scope for industry-led initiatives that take advantage of innovation investment opportunities.

23. We will also provide the right conditions to attract private investment in R&D and innovation, including through tax and regulatory frameworks as well as policy signals from government. At Spring Budget 2021, the Government announced a review of R&D tax reliefs with the publication of a wide-ranging consultation. The review will ensure that the reliefs are up-to-date, competitive and well-targeted.

Case study: Energy Entrepreneur's Fund (EEF)

Since 2012, the UK government's Energy Entrepreneurs Fund (EEF) has awarded £72 million worth of grants, supported 156 projects, and leveraged more than £500 million in private investment – a figure that is still growing. The EEF supplies innovation grants for SMEs and start-up companies to back the development and demonstration of disruptive technologies whilst also supporting our decarbonisation targets.

Axis Energy Projects (AEP) was funded with over £200,000 with £40,000 of match-funding from the private sector. AEP tested floating offshore wind (FOW) technology in Edinburgh, Scotland simulating how FOW can be resistant to 100-year storm events in water depths of 65 – 100 metres. The project has increased technology readiness levels from 3 (research) to 6/7 (deployment). The programme has had several achievements including supporting the displacement of over 21 million kilograms of CO_2 per year and it will also help to lower the Levelised Cost of Energy (LCOE) with a 30% reduction in comparison to other FOW designs and comparable offshore fixed installations. AEP's research and testing has also reduced the operating costs including low-cost deployment and reduced dependency on specialist vessels. A new company has been formed – Axis Energy TLB Ltd. – which will enable the commercialisation of the technology, having secured trademarks and patents around the world. A recent report from the Offshore Renewable Energy Catapult (OREC) predicts that the UK FOW industry could support up to 17,000 jobs by 2050 and generate a gross value added (GVA) of £33.6 billion.

Wider support

24. Non-financial support in the form of engagement with businesses is also key to the development and deployment of new technologies, systems, policies and business models to achieve net zero. This includes, for example, support provided through UKRI, its Knowledge Transfer Network, and other bodies like the Catapult network and Intellectual Property Office. It also includes UKRI's digital platform pilot programme, which will be used to bring net zero businesses together with investors for deal flow and to make information on companies more accessible to investors. The *Innovation Strategy* set out how we will build on this important support and provide advice, networking opportunities, skills development, and testing facilities. This includes a new online Innovation hub from Innovate UK, which will make it easier for businesses to navigate the government's funding offer, and expansion of the Innovate EDGE service which helps firms to enhance their investment readiness. More detail on our approach to green jobs and skills is set out in the *Green jobs, skills, and industries* chapter.

25. The *Innovation Strategy* also set out our ambition for government departments to procure more innovative solutions. Departments will produce clear policy problem statements that describe the priority outcomes that they want to solve or achieve. Alongside this, every major project[8] should publish an outcome statement. Both measures will improve demand-signalling from departments, allowing them to procure innovation to accelerate the UK's transition to net zero. This will help us to leverage public procurement as a tool that drives greener and more resilient outcomes across public services.

International collaboration and leadership

26. Building on our approach domestically, we are committed to continued active membership of Mission Innovation as the primary forum to strengthen international cooperation on clean energy innovation which is essential for our long-term climate and energy goals. An ambitious second phase of Mission Innovation is a priority for government. We will provide global leadership and commit to co-leading missions to build a renewable-powered future and deliver low cost, low carbon hydrogen.

27. Elsewhere, UK participation in Horizon Europe, the world's largest collaborative research programme worth around €95 billion over the next decade, will help us reach our net zero goals. With a minimum of 35% of funding earmarked for climate change projects, this collaboration with other world leaders in net zero research will drive further progress.

28. Further detail on government's plans for international collaboration and leadership, including Mission Innovation, can be found in the *International leadership and collaboration* chapter of the strategy.

Case study: Horizon 2020

- **Secure, Clean and Efficient Societal Challenge -** Between 2014 and 2020, around €5.9 billion was allocated through Horizon 2020, to support non-nuclear research through the Secure, Clean and Efficient Energy Societal Challenge. This aimed to support transition to a sustainable and competitive system focused on efficiency, low carbon technologies and smart cities.
- **Nova Innovation -** Nova is an Edinburgh-based tidal energy device and project developer based in Edinburgh and Shetland. Nova was awarded a total of €32.9 million in funding from Horizon 2020, including €20 million funding from Societal Challenge for Secure, Clean and Efficient Energy for their projects investigating tidal energy. The project allowed Nova to access infrastructure that is not available in the UK, for example testing facilities in the Netherlands, and provided networking opportunities that led to Nova working with major multinational companies to create bespoke components.

4ii. Green Investment

Leading the world in green finance

Our Key Commitments

- Use the UK Infrastructure Bank (UKIB) to crowd in private finance, support more than £40 billion of investment, and pull through low carbon technologies and sectors to maturity and scale.
- Continue to issue green gilts following the success of the UK's debut sovereign green bond in September 2021, which aims to raise a minimum of £15 billion this financial year. Issue a National Savings & Investment Green Retail Savings Product.
- Support the British Business Bank's new objective to incorporate net zero and wider environmental, social and governance strategy across all activity, as well as the updated FCA and Bank of England's remit reflecting the importance of environmental sustainability and the transition towards net zero.
- Introducing new Sustainability Disclosures Requirements through *Greening Finance: A Roadmap to Sustainable Investing*, including through:
  - Becoming the first G20 country to make disclosures aligned to the Taskforce for Climate-Related Financial Disclosures (TCFD) mandatory across the UK economy.
  - Developing a UK Green Taxonomy and creating the Green Technical Advisory Group to advise on greenwashing and how to implement the taxonomy in a UK context.
- We published our roadmap setting out our approach to sustainability disclosures ahead of COP26. This includes a commitment to publish a second iteration of the *Green Finance Strategy* for the UK which will outline the pathway to net zero for finance in the UK.
- We will work with external partners and data providers to better track private investment into the net zero economy going forward.

The challenge

1. Both public and private investment will be crucial for any path to net zero. While we expect most investment to come from the private sector, market failures mean the private sector alone will not deliver emissions reductions and innovation at the pace required.

2. Our 2019 *Green Finance Strategy* demonstrated how the strategic use of public funds, long-term policy frameworks, and signalling can leverage private investment into the technologies and infrastructure that will be needed to deliver net zero. Each technology and sector will present its own challenges, and long-term government support for a large pipeline of projects will be needed.

Our goal

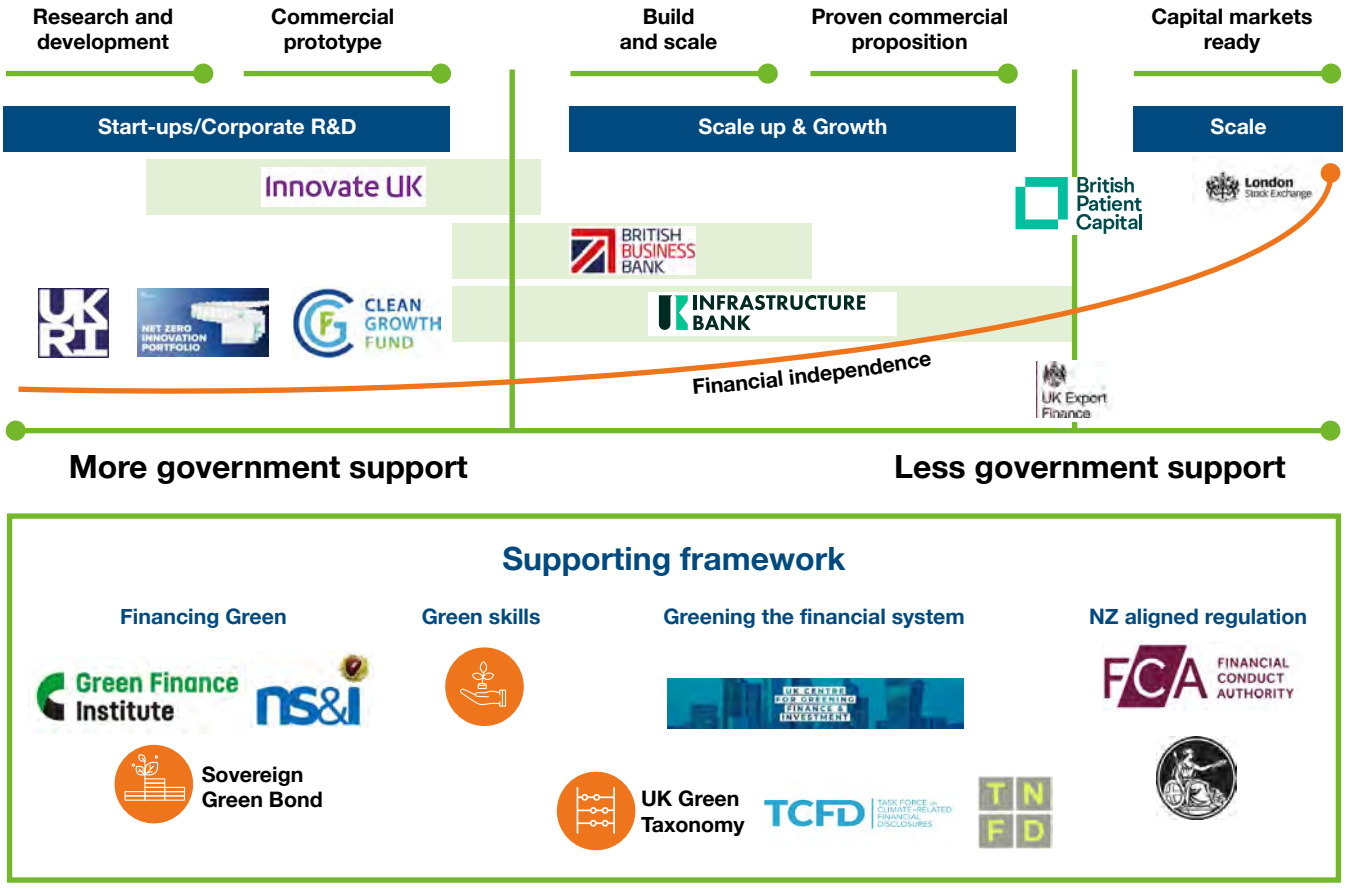
3. We will work with the private sector to deliver a world-leading net zero financial system, ready to seize the opportunities of net zero. Climate-related financial risk will be embedded into our regulatory frameworks to help guide capital flows to green investments.

4. We estimate that additional capital investment must grow from present levels to an average of £50-60bn per year through the late 2020s and 2030s. Most of this investment will come from the private sector, providing new opportunities for businesses and investors.

5. This will mean supporting the full funding cycle, from emerging technologies through to infrastructure and project finance, to deliver the economic transition. Each green technology and infrastructure will require different types of financial support depending on its maturity, as shown in figure 28. We must engage all types of capital, from early-stage grant and angel investment through to institutional finance like pension fund investors.

6. The UK is a world leading financial hub, with access to global capital pools, outstanding professional services, and a robust legal and regulatory framework. As such, the UK financial services industry is poised to enable private capital to flow into our net zero investment needs.

Figure 27 - Public Finance Interventions across the different stages of commercialisation[9]



7. Public funds will be used strategically to support new technologies, as well as emerging sectors, as they move from the innovation stage through to commercialisation and deployment. Early-stage R&D is supported by various government grants. Later-stage organisations can reach commercialisation and benefit from investment through the Clean Growth Venture Capital (VC) Fund or support from the British Business Bank (BBB). These stages of support are essential for scaling the necessary technologies and supporting the growth of businesses aligned to meeting our net zero ambitions.

8. Providing the suitable conditions for regulatory and early-stage innovation is a significant part of our Net Zero Strategy, but we must also mobilise the wider financial sector to meet the upfront investment challenge. This means stimulating new ways of providing information to markets on green investment and exposure to climate related financial risk, and providing the investment conditions to mobilise private capital into a portfolio of net zero financing.

9. We are driving more disclosure and transparency in the markets on climate risks and opportunities through the introduction of Sustainability Disclosure Requirements, as outlined in *Greening Finance: A Roadmap to Sustainable Investing*. These bring together and streamline UK sustainability reporting requirements, including reporting aligned with the Taskforce for Climate-Related Financial Disclosures (TCFD) recommendations and UK Green Taxonomy disclosures.

10. Targeted public intervention via the British Business Bank (BBB), UK Export Finance and the UK Infrastructure Bank (UKIB) will pull through investment from the private sector. For instance, British Patient Capital, a commercial subsidiary of the BBB, is contributing to the transition to net zero through its existing investment strategy: 9% of its underlying investment portfolio is in clean growth, sustainability, and mobility companies.

11. This builds on the growing voluntary commitments from financial institutions to a net zero transition that are already pivoting financial flows towards net zero in the run-up to COP26.[10] For example, the Glasgow Financial Alliance for Net Zero (GFANZ), which was launched as part of the COP26 Presidency, brings together many of the world's biggest banks, asset owners, asset managers, insurers and service providers that are credibly committed to achieving net zero emissions. Using the UN's Race to Zero as the entry criteria, the gold standard for net zero commitments, GFANZ has raised, deepened, and broadened the global financial sector's net zero ambitions. GFANZ has launched as ambitious body of technical work to support net zero aligned investment and accelerate the transition to a net zero financial system and global economy.

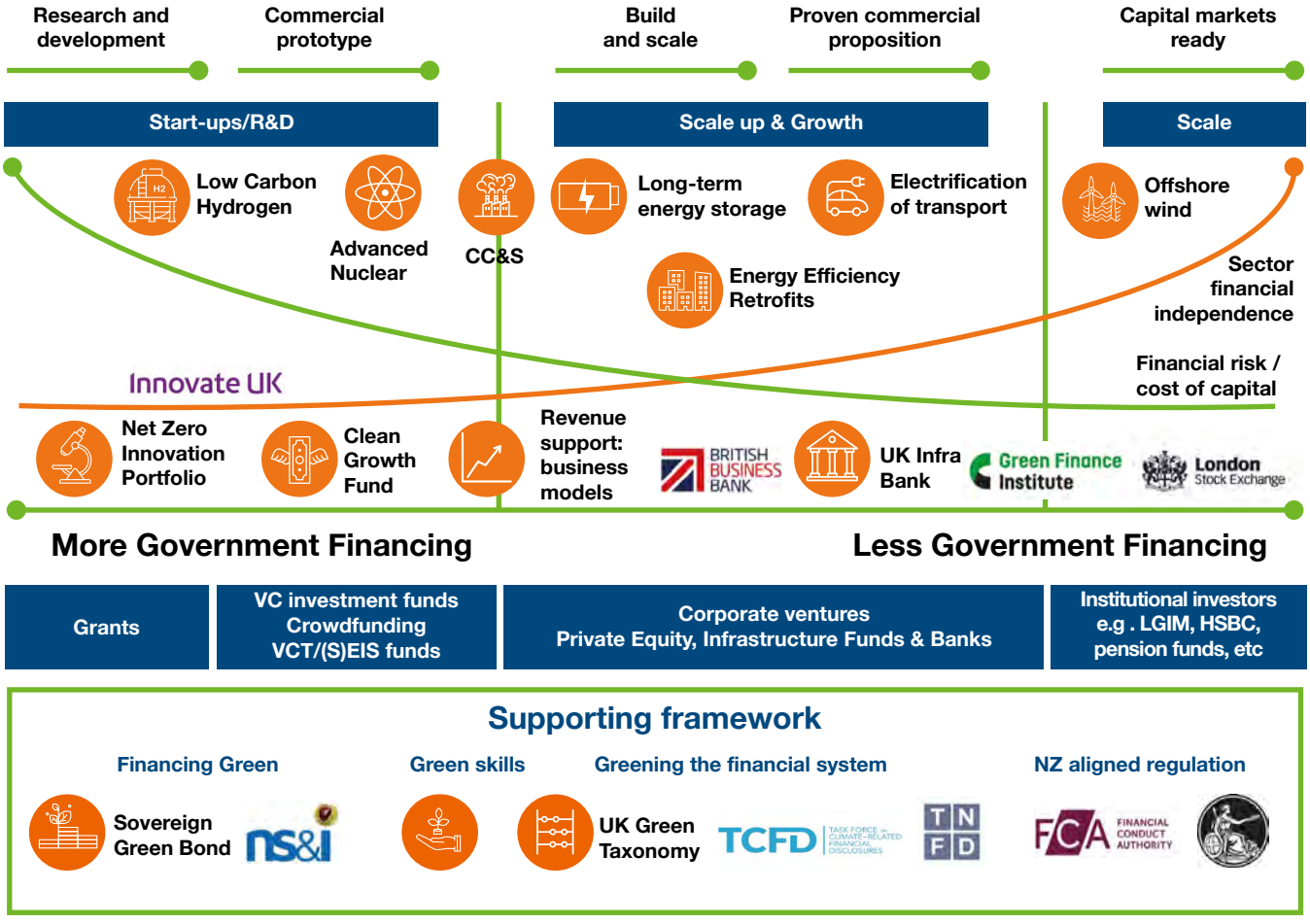
12. We will publish an update to the *Green Finance Strategy* in 2022 which will include a net zero transition pathway for the UK financial sector. This will set out how this crucial sector will transition to net zero as a whole.

Financing green

13. The scale of the net zero challenge and persistent market failures mean that public sector intervention is needed to shape and accelerate the flow of private capital. The right policy signals can act as a catalyst for private sector investment, as shown by by £90 billion of new investment in renewable energy since 2012, in part facilitated by the Electricity Market Reforms (EMR).[11] By bringing down the cost of capital through strong policy frameworks, we will reduce the financing costs of reaching net zero, delivering a better deal for the taxpayer.

14. The pathways set out in this strategy demonstrate that, whilst each sector requires its own policy framework, there are cross-cutting interventions required to support the transition to net zero. We will replicate the success of offshore wind and take actions to secure access to finance across the economy, ensuring that all sectors are able to access private investment going forward. For example, the Industrial Decarbonisation and Hydrogen Revenue Support (IDHRS) scheme (see paragraph 19), will unlock private sector capital for industrial carbon capture and hydrogen production projects by providing long-term certainty to investors, de-risking revenue streams in these sectors.

Figure 28 - Low carbon sectors commercial maturity and associated capital requirements[12]



15. Through the net zero innovation portfolio, funding is provided for low carbon technology innovation. As these technologies, and sectors, commercialise, they can benefit from further investment readiness support to help them access repayable private finance. For example, the Natural Environment Investment Readiness Fund (NEIRF),[13] launched by Defra and the Environment Agency in 2021, will build the portfolio of potential investments for net zero investors in nature.

16. Some of these technologies may also avail of venture capital to allow them to scale rapidly. Government has shown its support for this necessary innovation underpinning its clean growth objectives with a £20 million cornerstone investment in the venture capital Clean Growth Fund[14]. This Fund aims to accelerate the deployment of innovative clean technologies that reduce greenhouse gas emissions, alongside catalysing the UK clean growth venture capital market and leveraging private sector funding into early-stage clean tech start-ups. For example, the fund led a £4.7 million investment round into Piclo (the independent energy trading marketplace) with co-investment from Mott MacDonald Ventures.

17. The BBB is a government-owned economic development bank with a mission to drive sustainable growth and prosperity across the UK, and to enable the transition to a net zero economy, by improving access to finance for smaller businesses. UK Government has worked with the BBB on their new mission and objective to support the UK's transition to a net zero economy and incorporate environmental, social and governance issues across of its activities. The new net zero objective will support firms looking to move towards net zero, helping the UK reduce its energy consumption and mitigate the impacts of climate change.

18. Going beyond SME finance to larger scale infrastructure finance, there are significant pools of private finance ready to deploy into UK projects but there can be a mismatch between market appetite and the risk profile of projects. Infrastructure investment is vulnerable to market failure, as it is often complex, large, novel and long-term. Launched in June 2021, the new UK Infrastructure Bank can play a pivotal role in this space, crowding in private sector investment in important areas and helping to kick start new sectors. Across the Bank's full mandate (also covering regional growth), it has £12 billion of equity and debt capital and will be able to deploy £10 billion of government guarantees. We expect the Bank to use this to crowd in private investment as a cornerstone investor or guarantor to enable more than £40 billion of investment in the areas most prone to market failure, and to help deliver its dual policy focus of tackling climate change and supporting regional and local economic growth. Furthermore, the Bank will play a pivotal role in catalysing the role of local government in the transition, by financing strategic infrastructure projects led by local authorities, and providing advice and expertise in order to strengthen the pipeline of investable projects.

19. Industries will need to be supported in their transition away from high carbon emitting operations. For example, the IDHRS scheme will provide a revenue mechanism to enable deployment of industrial carbon capture and hydrogen production. UK Export Finance (UKEF)'s Transition Export Development Guarantees (TEDG), launched in 2020, will ensure that businesses, including those in the supply chain, are supported at all stages of their transition journey. This product can be used by a company for working capital, capital expenditure or R&D needs, provided they have a credible transition plan. The first TEDG was announced in August with UKEF providing an 80% guarantee on the £430 million commercial loan to Wood Plc. This support from UKEF will help Wood to continue to capitalise on opportunities linked to clean

energy, hydrogen and decarbonisation. Furthermore, this instrument will support the export of low carbon technology from the UK as evidenced by this guarantee which will support Wood to take advantage of green trade opportunities.

20. The UK financial system is also taking a global leadership role transition financing and sustainable finance more widely. An example of transition finance leadership is the London Stock Exchange Group (LSEG) which was the first exchange globally to launch a dedicated Transition Bond Segment. This distinct transition label is the application of globally recognised standards, enhancing visibility and providing assurance to issuers and investors. We have seen the financial sector in the UK take the lead in net zero transition (for example, through the Glasgow Financial Alliance for Net Zero[15]) as well as leading financial innovation (such as Green Home Finance Innovation fund).

21. The Chancellor, in his Mansion House speech[16] in July 2021, set out how the government will ensure that the financial system in the UK plays a major role in the delivery of the UK's net zero target and ambition for a 'nature positive' future. This will build on the investment principles outlined in the 25 Year Environment Plan including 'do no significant harm' to the environment with investment, and implement a series of programmes aimed at building the portfolio of investable assets across the UK. This will involve providing grant programmes like the Natural Environment Investment Readiness Fund (NEIRF) to help nature-based projects become investment ready, but also providing capital through public-private impact funds such as the Big Nature Impact Fund to leverage in private finance. In addition to investing in climate and environmental solutions, government is also committed to ensuring sufficient private capital is available for investment into adaptation and resilience measures.

22. Furthermore, the government is supporting the development of a Taskforce on Nature-Related Financial Disclosures (TNFD). This will provide a framework for corporate and financial institutions to report and act on evolving nature-related risks to support a shift in global financial flows away from nature-negative outcomes and toward nature-positive outcomes. This market-led, global initiative will build, consult on, and test, its framework over the next 2 years and will be designed to complement the TCFD by building on its 4-pillar approach and drawing on its lessons learnt.

23. These interventions are important to driving the desired 'nature-positive' future. As set out in the Prime Minister's *Ten Point Plan*, we hope that the UK will also become a leader in high-quality voluntary carbon markets (VCMs). For these private markets to scale successfully in support of net zero, their integrity and use as an addition (rather than alternative) to rapid decarbonisation will be critical. The government is closely following the important work of various sector-led initiatives including: the Taskforce for Scaling Voluntary Carbon Markets (TSVCM); the Voluntary Carbon Markets Integrity Initiative UK VCM Forum; and, the Financing UK Nature Recovery coalition.

24. The UK Government issued its inaugural green gilt on 21 September 2021. This was a landmark transaction for sterling markets and the UK. At £10 billion, it was the largest sovereign green bond issuance to date and attracted the largest ever order book for a sovereign green bond. The inaugural green gilt also achieved the largest "greenium" for any debut sovereign green bond to date, demonstrating good value for money for the taxpayer (a "greenium" refers to more favourable pricing achieved by the issuer of a green bond compared to that for a hypothetical, equivalent conventional bond). The UK will then be following up with a second issuance in mid-to-late October, as the UK looks to build out a green yield curve. This

followed the successful publication of the UK Government Green Financing Framework on 30 June 2021, which outlines how proceeds raised from the green gilts will help tackle climate change, biodiversity loss and other environmental challenges.

25. NS&I will issue its retail Green Savings Bonds later in 2021. These bonds will be the first standalone retail product to be tied to a sovereign's green bond framework and will allow all UK savers to contribute to the fight against climate change and the government's other environmental objectives. It gives UK savers the opportunity to take part in this collective effort to tackle climate change by contributing to public spending on green, whilst increasing awareness in the government's green initiatives. This series of wholesale and retail green financing issuances demonstrate the UK's commitment to sustainable finance ahead of COP 26 in November.

26. We are also committed to tracking finance flows, to complement how we measure carbon. Hence, we will be working with external partners and data providers to better track private investment into the net zero economy going forward. This will enable the UK to robustly, and regularly, assess the alignment of the UK's financial flows with net zero.

27. The UK launched the Green Finance Education Charter in our 2019 *Green Finance Strategy*,[17] reflecting the need for UK and global financial services industries to develop the capabilities of their workforce in green finance principles and practice. Since then, twelve leading professional bodies representing over 1 million finance professionals have signed up to the Charter, hosted by the Green Finance Institute. To further build UK capacity, capability and climate leadership, we will look to expand Charter membership to universities and others, and work with the Institute for Apprenticeships and Technical Education (IfATE). We will also seek to internationalise the Charter by encouraging similar development overseas.

Case study: The Green Finance Institute model

The Green Finance Institute (GFI) was established in 2019 with funding from HMG and the City of London Corporation, though it operates independently of government and is commercially focused.

Sitting at the nexus between the public and private sectors, the GFI provides critical guidance to government and the financial sector and delivers programmes which mobilise investment and lending towards real economy outcomes. Through the application of the GFI's rigorously designed financing solutions, they have already identified and co-designed effective interventions that have deployed capital towards a net zero, carbon resilient economy.

The GFI primarily operates by convening and leading coalitions of global experts that focus on different sectors and seek to identify scalable financial solutions that accelerate sector-specific transitions to a low carbon future.

There are several coalitions and initiatives that the GFI now operate:

- The Coalition for the Energy Efficiency of Buildings (CEEB) is the GFI's flagship programme, set up in 2019 to develop the market for financing a net-zero climate-resilient built environment. Today, the CEEB has over 300 members and accounts for 70% of the UK mortgage market. This work is now expanding into Europe.
- In September 2020, the CEEB launched the Green Home Finance Principles, in collaboration with the Loan Markets Association, to embed transparency and consistency into the green home finance market. Today, the Principles have supported 11 financial institutions with combined mortgage balances of +£480 billion to launch, or commit to launch, green lending products that minimise the risk of greenwashing.
- The Coalition for the Decarbonisation of Road Transport (CRDT) was established in May 2021 to unlock financial barriers to the decarbonisation of road transport and enabling infrastructure.
- The GFI played a key role in the Dasgupta Review and is also working on a series of potentially transformative funding mechanisms to support the UK's 25-year Environment Plan alongside Defra and the Environment Agency.
- The GFI was appointed Chair and convener of the Green Technical Advisory Group (GTAG), tasked with providing independent expert advice to government on how to implement a taxonomy in the UK.
- The GFI is also hosting the Executive Secretariat for the Taskforce on Nature-related Disclosures and launching an initiative this November to unlock the barriers to channel private finance towards nature in the UK.
- In partnership with the City of London Corporation, the GFI will host a Green Horizon Summit at COP26, which will focus on mobilising capital in the transition to net zero.

Greening finance

28. Financing the technologies required for our transition to net zero is only part of the solution. The transition represents both a risk and an opportunity for the real economy and the financial system that supports it. It is therefore vital that climate-related financial risks and impacts are factored into investment decisions and reflected in the cost of finance for different technologies and companies. To achieve this, we will harness the international reputation of the UK's leading financial sector to encourage private investment to support low carbon innovation and manage climate-related financial risk.

29. As the Chancellor outlined in his Mansion House speech,[18] the government intends to introduce economy-wide Sustainability Disclosure Requirements covering the whole economy. This will include requirements to report on businesses and investment products impact on the climate and environment, as well as the risks and opportunities these impacts pose to business. Our approach is detailed in *Greening Finance: A Roadmap to Sustainable Investing*.

30. The UK has already established itself as a world leader on green finance regulation, becoming the first G20 country to make disclosures aligned with the Task Force on Climate-related Financial Disclosures (TCFD) recommendations fully mandatory across the economy by 2025. As part of the roadmap to delivery, BEIS consulted earlier in the year on mandatory climate-related financial disclosures by publicly quoted companies, large private companies and the largest Limited Liability Partnerships (LLPs) from the 6th April 2022. Following widespread support for the proposals, we will shortly be setting out regulations to bring this into force, including a requirement for scenario analysis - a powerful tool to support companies in their assessment of climate-related risks and opportunities.

31. Alongside measures to implement mandatory disclosures aligned with the TCFD recommendations for companies and LLPs:

- The Financial Conduct Authority has already introduced a listing rule for premium listed companies which commenced on 1 January 2021. This requires companies to include a statement in their annual financial report which sets out whether their disclosures are consistent with the recommendations of the TCFD, and to explain why if they have not done so.
- Government introduced regulations, in force from 1 October 2021, to require pension schemes with £5 billion or more in assets to report line with the TCFD's recommendations. By October 2022, over 80% of members of occupational pension schemes – and more than 70% of assets under management – will be in schemes reporting in line with the TCFD recommendations.

32. Our stated objective is to increase the quantity and quality of climate-related financial disclosures in a proportionate manner. This is to ensure market participants have better information to adequately understand climate-related financial risks and opportunities to support the transition to net zero.

33. In November 2020, the Chancellor announced that the government is implementing a UK Green Taxonomy. This will clearly set out the criteria which specific economic activities must meet to be considered environmentally sustainable. The first two Technical Screening Criteria (TSC) on climate change mitigation and adaptation will be made by the end of 2022. To support the development of the TSCs, we have since announced the appointment of a Green Technical Advisory Group (GTAG) in June 2021. Made up a of range of financial

and business stakeholders, taxonomy and data experts, and subject matter experts, and chaired by the Green Finance Institute, this will provide independent, non-binding advice to the government on developing and implementing a Green Taxonomy in the UK context. For example, we have established an Energy Working Group as part of the GTAG to provide advice on key technologies such as hydrogen and carbon capture and storage. Taken together, these enhanced Sustainability Disclosure Requirements will support companies to communicate clear and credible low carbon transition plans needed by investors.

34. Key to delivering enhanced disclosure on climate change is the availability of data financial institutions can use. The UK Centre for Greening Finance and Investment (CGFI) is a national centre established to accelerate the adoption and use of climate and environmental data and analytics by financial institutions internationally. CGFI will equip financial institutions with the tools and capacity required to effectively allocate capital to meet net zero ambitions and ensure global UK leadership in green finance and green finance data and analytics.

Case study: Providing a net zero-aligned regulatory environment

In March 2021, the Chancellor outlined his recommendation to regulators that they should "have regard to the government's commitment to achieve a net zero economy by 2050". There has already been significant work by the Bank of England and the Financial Conduct Authority.

The Bank of England

The Bank's approach to climate change is to play a leading role, through its policies and operations, in ensuring the financial system, the macroeconomy, and the Bank of England itself, are resilient to the risks from climate change and supportive of the transition to a net zero emissions economy.

Recent actions to deliver this include:

- In April 2019, the Bank published a comprehensive set of supervisory expectations for how banks and insurers should enhance their approaches to managing the financial risks from climate change. This was followed up in July 2020 with a Dear CEO letter, which included additional guidance and set a deadline for firms to embed fully these expectations by the end of 2021.
- In June 2021 the Bank launched its Climate Biennial Exploratory Scenario (CBES) exercise to assess the resilience of individual banks, insurers, and the wider UK financial system to three different climate scenarios. These scenarios are based on those published by the international central banks and supervisors Network for Greening the Financial System (NGFS), of which the Bank is a founding member and where it chairs the workstream developing the NGFS climate scenarios.
- In November 2020, the UK joint regulator and government TCFD Taskforce, of which the Bank is a member, published an interim report and roadmap for mandatory TCFD-aligned disclosure requirements across the economy by 2025.
- The Bank has also sought to lead by example and in 2021 became the first central bank to publish a climate-related financial disclosure which included analysis of financial asset portfolios held for monetary policy purposes. The Bank also committed to reduce the emissions from its physical operations to net-zero by 2050 at the latest.

The Financial Conduct Authority (FCA)

The FCA's work on climate change and sustainable finance aims to make sure market participants can manage the risks, impacts and opportunities from moving to a more sustainable economy and can capture opportunities from the net zero transition. Key developments in 2021 include:

- Introducing a TCFD-aligned Listing Rule for premium-listed commercial companies, and consulting on new proposals to extend the application of the rule to issuers of standard listed equity shares, and to implement new disclosure rules for asset managers, life insurers, and FCA-regulated pension providers with a focus on the information needs of clients and customers;
- Co-chairing work on climate-related and sustainability disclosures at the International Organisation of Securities Commissions and the Financial Stability Board;

- Issuing a supervisory letter to the chairs of Authorised Fund Managers, including a set of guiding principles to help clarify the FCA's expectations for the design, delivery and disclosure of retail responsible and sustainable funds – both as applications are submitted for authorisation and on an ongoing basis;
- Launching a comprehensive innovation work programme on sustainability, including the announcement that the next cohort of the Digital Sandbox Pilot will focus on sustainability and climate change; the FCA has begun work with the City of London Corporation and industry to support the development of solutions to ESG data and disclosures issues via a digital testing environment, and is aiming for this environment to go live in Q1 2022; and,
- Alongside the other financial regulators, publishing an inaugural Climate Adaptation Report (CAR) setting out the actions the FCA and financial services industry are taking to adapt to the challenges of climate change; the CAR will include a chapter on net zero which will explore net zero commitments, targets, tools and challenges.

4iii. Green Jobs, Skills, and Industries

Creating the skilled workforce to deliver net zero and putting UK supply chains at the forefront of global markets

Our Key Commitments

- Publish sector and supply chain development plans for key low carbon sectors and work with business to encourage investment in green skills and industries in the UK.
- Publish a UK Critical Minerals strategy, setting out our approach to securing technology-critical minerals and metals.
- Support the development of a skilled, competitive supply chain for key green industries in the UK.
- Reform the skills system so that training providers, employers and learners are incentivised and equipped to play their part in delivering the transition to net zero – including by legislating for skills required for jobs that support action on climate change and other environmental goals to be considered in the development of new local skills improvement plans.
- Deliver a Lifetime Skills Guarantee and grow key post-16 training programmes (such as apprenticeships, Skills Bootcamps and T levels) in line with the needs of employers in the green economy, helping individuals get the training they need for a job in the green economy, either at the start of their careers or when retraining or upskilling once already in the workforce.
- Introduce a sustainability and climate change strategy for education and children's services which will include a focus on equipping children and young people with the knowledge and skills they need to contribute to the green economy.

The Challenge

1. The national and global shift towards net zero provides a once in a generation opportunity to level up the country, create new green jobs, and put the UK at the forefront of growing global markets in green technologies. Delivering on this promise, whilst meeting our ambitious climate and environmental targets, will be in a large part dependent on having a sufficiently skilled workforce and robust, competitive supply chains in the UK.

2. Recent developments have thrown into sharp relief the inherent vulnerabilities associated with complex global supply chains and shocks to the global economic system. The transition to net zero will change the nature of the UK's critical supply chains. Our aim is to help ensure that supply chains critical for the transition to net zero are secure, ensuring that we have access to the materials, minerals, and chemicals that our growing green economy will need. Our approach is that there is no "one size fits all" model for building resilience in individual supply chains: often a combination of levers may be the best solution to address a vulnerability.

3. We will need tens of thousands of engineers to build and maintain new offshore wind farms off the coasts of northern England and Scotland, construct nuclear power stations in the South of England, and manufacture electric vehicles in the Midlands; skilled builders and trades people to retrofit homes and buildings across the country; and conservation and biodiversity professionals to deliver nature-based solutions to climate change.

4. Alongside a broader shift to digitisation and automation, we can expect the transition to net zero to be one of the dominant labour market trends in the next 30 years: approximately 6.3 million jobs in the UK, about one in five, are likely to be affected by the transition to a green economy, with workers experiencing either an increase or decrease in the demand for their skills.[19]

Our Goals

5. The government's ambition is to:

- Support up to 440,000 jobs across net zero industries in 2030, contributing towards a broader pivot to a greener economy which could support 2 million jobs in green sectors or by greening existing sectors by:
  - Working with business to grow green industries, supply chains and skills in the UK, and ensure our resilience to international changes in supply chains; and,
  - Using our net zero policy and funding to promote the growth of green skills and the green economy.
- Enable workers, industries, and places to transition to a net zero economy by 2050, and support industry to develop the skilled workforce to deliver a green industrial revolution by:
  - **Reforming the skills system** to make it more responsive to the needs of employers, so that training providers, employers, and workers are incentivised and equipped to support the transition to net zero;
  - **Ramping up support for workers in the high carbon economy to transition to green jobs**;
  - **Working with business to ensure people from all backgrounds can access the opportunities in the green economy**, including through career advice; and,
  - **Providing children and young people with the high-quality education and training they need to work in a future green career**, through improving teacher training and development in STEM and other key subjects, and expanding post-16 training programmes in line with the needs of the green economy.

The Green Jobs Taskforce

To better understand how the UK could grasp opportunities of the Green Industrial Revolution, the Department of Business, Energy and Industrial Strategy and the Department of Education launched the Green Jobs Taskforce in November 2020. The Taskforce provided an independent assessment of the potential skills and labour market impacts of the net zero transition, including how we can ensure green jobs are open to all and support workers to transition to the green economy.

The independent Taskforce, which included representatives from industry, trade unions, the skills sector and community organisations, took a broad view of green jobs, as "employment in an activity that directly contributes to, or indirectly supports, the achievement of the UK's net zero emissions target and other environmental goals, such as nature restoration and mitigation against climate risks." Its report, published in July 2021, included 15 recommendations for government, industry and the skills sector, which focused on three themes across the "life cycle" of green jobs: driving investment in net zero to support good quality green jobs in the UK; building pathways into good green careers; and supporting workers in the high carbon economy to transition.

The ideas generated through the Taskforce and its engagement with industry have informed the development of this Strategy.

Working with business to grow green UK industries and resilient supply chains

6. The investment needed for the transition to net zero will primarily be delivered by the private sector. As such, our first priority is to provide businesses, investors, workers, and skills providers with policy certainty to unlock investment, ensuring we support green industries to develop in the UK.

7. In line with *Build Back Better: Our Plan for Growth*, we are taking action across a range of low carbon industries with the greatest economic potential and competitive strength. In doing so, we will support the growth of UK supply chains and create new opportunities for UK businesses and level up the country. We are acting to build green industries such as offshore wind in North East England and in Scotland, carbon capture and hydrogen production in our industrial heartlands, electric vehicles manufacture in the midlands and Northeast of England, and the restoration and protection of nature in rural areas.

8. We also recognise that the starting position when building resilience in critical supply chains should be to take a market-first approach. The UK prospers under an open economy and openness itself confers resilience. We will leverage the UK's competitive strengths across the supply chain, while deploying those levers available to the Government – including UK Export Finance and the new Office for Investment – to ensure that we exploit our strengths, while supporting those areas that could be vulnerable to global shocks.

Case studies: Driving investment into green supply chains in the UK

The Prime Minister's *Ten Point Plan*, and our subsequent sectoral strategies, put in place a range of funding and policy initiatives to enable green industries and supply chains to develop in the UK, supporting our ambition to deliver on green jobs:

Building the Offshore Wind Supply Chain

Announced as part of the *Ten Point Plan*, the UK's offshore wind manufacturing industry has already seen almost £1.5 billion of investment unlocked by the £160 million Offshore Wind Manufacturing Investment Support scheme, which aims to further develop the UK's offshore wind capabilities. The investments have seen a significant boost over the summer with up to 3,600 jobs supported across the Humber region. This continues to lay the groundwork to deliver 40 GW of energy from offshore wind by 2030 and for UK businesses and workers to take full advantage of the booming offshore market in the UK and internationally, support up to 60,000 jobs in the industry and its supply chain, and help eliminate the UK's contribution to carbon emissions by 2050.[20]

We are preparing for the next wave of deployment around the UK, with world leading 1 GW deployment targets for innovative floating offshore wind turbines. The government has set up a floating offshore wind demonstration programme to support development of state-of-the-art technologies and products in the floating offshore wind industry.

Net Zero Hydrogen Fund

Government has set an ambition to deploy 5 GWs of low carbon hydrogen production capacity in the UK by 2030, supported by a package of measures including the Net Zero Hydrogen Fund (NZHF). The NZHF will kickstart the hydrogen economy in the early 2020s by supporting projects with upfront costs, stimulating private sector investment, and developing the pipeline of projects needed to deliver hydrogen production at scale by 2030.

Transforming automotive manufacturing

The UK is already capitalising on opportunities from the global shift to electric vehicles, as demonstrated by recent investments made by Stellantis in Ellesmere Port, and Nissan and Envision AESC in Sunderland. Allocating a further £350 million of our up to £1 billion Automotive Transformation Fund (ATF) to support the electrification of UK vehicles and their supply chains. This will help ensure the UK maximises the benefits from the transition to a zero emission vehicle future and support tens of thousands of high-quality green jobs across the UK. Government and industry have also jointly committed around £1 billion through the Advanced Propulsion Centre for collaborative research and development in the next generation of low carbon vehicle technologies. A further £318 million of government funding has been provided to put the UK at the forefront of the design, development, and manufacturing of electric batteries through the Faraday Battery Challenge and nearly £80 million to Driving the Electric Revolution to accelerate growth in the supply chain for power electronics, machines and drives.

Driving investment and jobs in the natural environment

Government's Green Recovery Challenge Fund is supporting over 150 projects across England that are tackling climate change, restoring nature, and supporting 2,500 green jobs. The Nature for Climate Fund is also contributing to net zero and creating and supporting green jobs by funding new woodland creation and peatland restoration. In addition, the £9 million Natural Environment Investment Readiness Fund is stimulating a pipeline of nature projects that can attract private sector investment.

9. We are working in partnership with our world-class sectors to enable them to take part in the transition, for example through the *North Sea Transition Deal*, which committed to focusing on supporting the transformation of the oil and gas supply chain to service the low carbon energy sector. Building on this, we have established the Energy Supply Chain Taskforce (UKESC) as a joint enterprise between industry and government to guide policy making and maximise the jobs and business opportunities from the transition in the UK. The UKESC cover all energy sectors and regions of the UK and, building on work already underway, it will map the energy project pipeline and identify higher value segments of the supply chain to prioritise in the UK.

10. The *Integrated Review Security, Defence, Development and Foreign Policy* committed to 'a resilient UK able to withstand and proactively tackle the challenges of today and the future', including a specific focus on supply chain resilience, committing to 'using all our economic tools and our independent trade policy to create economic growth that is distributed more equitably across the UK and to diversify our supply chains in critical goods'. Similarly, the *Plan for Growth* outlines the importance of international markets to ensuring diverse supply sources for the goods and services we need, improving the resilience of our supply chains and benefitting prosperity.

11. The development of resilient, efficient, and competitive supply chains will be a collaborative strategic endeavour. To support this, in May 2021 we published the *CCUS Supply Chain Roadmap*, which sets out how government and industry can work together to harness a strong UK supply chain, and we have committed to publish a hydrogen sector development action plan in 2022, which will outline how the government will support companies to secure supply chain opportunities, skills and jobs in the sector. We will build on this by working with industry to publish further sector and supply chain development plans for those low carbon sectors where the UK has the potential to capture an economic advantage. This will include ensuring we are resilient to international changes in supply caused by external shocks, including climate-related disruption, spikes in global demand, rising commodity costs, or artificial constraints on supply. For example, we will need to ensure we have access to a diverse range of sources of chemicals, given they feed into 95% of our manufacturing base. As we move forward, where possible, government will provide more visibility around planned deployment cycles to increase the opportunity for suppliers to invest in long-term production, infrastructure, and training.

Deep Dive - Critical Minerals, Supply Chains and Net Zero

The transition to Net Zero means new supply chains are becoming critical to the UK's energy production. Critical minerals are metals and non-metals that are vital for a defined economic activity and for the well-being of the country, yet whose supply may be at risk owing to geological distribution, lack of substitutes and/or other factors. Such minerals provide materials essential for components in many of today's rapidly growing clean energy technologies – from off-shore wind turbines to electric vehicles. The World Bank suggests that the production of minerals such as graphite, lithium and cobalt, could increase by nearly 500% by 2050 to meet the growing demand.[21]

The government is committed to working with industry and with international partners to safeguard these supply chains and our future economic resilience. We are actively supporting the adoption of transparent, ethical and responsible mining practices, reflecting environmental, social and governance (ESG) considerations, and are participating in the development of global standards through the British Standards Institution.

We will establish an Expert Committee on Critical Minerals to provide independent advice to government on the scope and content of a critical minerals strategy and will publish an updated list of these minerals to guide investment decisions. We will establish a Critical Minerals Intelligence Centre to provide robust, dynamic analysis on stocks and flows to guide our decision-making.

Going forward, the government will publish a UK Critical Minerals strategy in 2022, setting out our approach to securing the technology-critical minerals and metals aimed at:

- Ensuring the UK has a reliable supply of critical minerals and metals;
- Establishing an enabling environment for growing the sector in the UK;
- Showing leadership through working bilaterally and multilaterally to support work on international standards to extend and strengthen the circular economy in technology-critical minerals;
- Ensuring our work to build critical mineral supply chain resilience supports our international development priorities;
- Using our R&D resource to build a better understanding of markets and prices to help mitigate the impact of supply shocks and demand spikes, and to enable better foresight and early intervention; and,
- Work with UK industry (including SMEs) to consider how private and public sectors can better share risks to promote investment and drive innovation at all levels.

We will support the engagement of the UK's mining sector in new and existing markets, facilitating investment and collaboration in extraction and processing opportunities. We will also champion free and open global trade including through Free Trade Agreements to support this ambition and will explore use of Freeports to support opportunities for the UK to develop as a critical minerals processing hub supplying Europe and beyond.

Supporting workers, industries, and places to transition and develop the skills needed to deliver net zero

12. There are urgent and emerging skills challenges across the green economy which we will need to address over the short and long term if we are to meet our ambitions for a Green Industrial Revolution. We aim to quadruple our offshore wind capacity to 40 GW, with the growth in this sector supporting up to 60,000 jobs in 2030.[22] In the construction and heating sectors, up to 230,000 skilled trades people could be required in 2030 to deliver the retrofitting of houses[23] and to meet our ambition of installing 600,000 heat pumps a year by 2028, we will need to rapidly increase the number of qualified installers from around 3,000 to 35,000 within the next 7 years.[24] As the automotive manufacturing sector transforms to producing electric vehicles, as many as 50,000 workers in the UK's automotive manufacturing sector could need reskilling by 2025.[25] In forestry and its supporting sectors, industry estimates point to projected labour demand of approximately 2,000 jobs over the next five years.[26]

13. As well as specialists in these sectors, employers will also need workers with wider cross-cutting skills to deliver net zero, including digital and data skills, project management, communications and change management. [27] There will also be increased need to work in a multidisciplinary way due to the way work will change in some sectors such as whole house retrofitting will need knowledge of multiple technologies.[28]

14. The impact of the transition on the labour market will not be evenly spread across the UK, reflecting the geographical distribution of where existing industries will need to adapt and others new ones will flourish.[29] However, there are opportunities for workers in transitioning sectors, such as oil and gas, to utilise their specialist skills in key important green sectors, sectors such as hydrogen and CCUS with these two sectors expected to grow from the middle part of this decade.

Working with industry and key partners to support good green jobs and skills

15. Industry and government will need to take action to ensure the UK has the skilled workforce to deliver net zero and that workers, industries and places are supported on the transition. This will be particularly important given the pace and scale of the change, and the specific challenges faced by smaller companies in some sectors and supply chains. To drive this forward we have announced a cross-cutting delivery group to include representatives from industry, the skills sector and other key stakeholders to support the development and delivery of the Government's plans for green jobs and skills. We will set out further details of the membership and mandate of the cross-cutting delivery group later this year.

16. To support this work, and monitor our progress, it is vital that we continue to develop the evidence on how net zero will impact jobs and skills. The Office for National Statistics will seek to refine our understanding and measurement of the green economy as the UK transitions to net zero, including looking at such issues as quality of work and diversity within the green economy.

17. Join up between local bodies, employers and local communities will be key to ensuring an effective transition. Building on the measures set out in the *Local Climate Action* chapter, and our skills system reforms, we will assess how local areas are working to support workers and communities with the net zero transition across England.

18. We want to see continuous improvement in the quality of jobs in the UK, both in the creation of new high-quality jobs which support Government priorities such as net zero, and through in-work progression. We will continue to drive this agenda forward through the Employment Bill, which will support our ambition to make the UK the best place in the world to work and grow a business, and the cross-cutting delivery group will consider how government and industry can work together to ensure green jobs are good jobs.

19. While skills policy is a devolved matter, the Government also welcomes close engagement with the devolved administrations, Mayoral Combined Authorities and the Greater London Authority, on this agenda, to ensure everyone across the UK has access to green skills and jobs.

Working together across the UK

Examples of policy action by the Scottish Government, Welsh Government and Northern Ireland Executive

Northern Ireland Executive

The forthcoming *Green Growth Strategy*, will be a multi-decade strategy to balance climate, environment and the economy. It means a move from a high to a low greenhouse gas emissions economy to improve people's quality of life through green jobs and a clean environment.

Innovation is key to the disruptive transition required. '10X Economy' sets out the vision for the 2020s as a decade of innovation bringing opportunity and growth. The focus on innovation is reinforced in the Energy Policy Options paper also strongly advocating innovation. New skills will be critical to allow innovation to flourish into delivery. The Skills Strategy consultation recognises that a transformational change in skills is required to take advantage of Northern Ireland's scale, yet addressing the challenges in the skills sector.

To take one example, the decarbonisation of gas infrastructure will involve the development of new supply chains for production of biomethane from anaerobic digestion plants and development of hydrogen production technologies, which will support green jobs and new skills in these sectors.

Scotland

The Scottish Government has set out a package of measures to create good, green jobs, reskill those that need it and provide a career platform for the next generation. It includes:

- a £100 million Green Jobs Fund to help businesses create new, green jobs. Related funding will make focused investments in machinery and equipment and research and development in five priority sectors: energy transition; transport; manufacturing; construction; agriculture and land use;
- a £25 million National Transition Training Fund with a focus on:
  - The provision of green skills;
  - A Young Person's Guarantee for 16-24 year olds;
  - The use of public procurement to build low carbon supply chains.

The Climate Emergency Skills Action Plan (CESAP) sets out a clear direction for the change of Scotland's skills system, and signals the role that businesses, communities and individuals across Scotland will play in achieving this.

The CESAP focuses on immediate action as well as the longer-term systemic change that needs to take place by 2045. It is being driven by senior representatives of central and local government and its agencies, skills providers, industry and independent experts, and is chaired by Professor Dave Reay of Edinburgh University.

The Scottish Government's Green Jobs Workforce Academy was launched in August 2021. The Academy will make it easier for people from a wide range of backgrounds to launch a green career, and to access

appropriate training. The Academy will support delivery of a skills guarantee for workers in carbon-intensive sectors.

Wales

Since its launch in 2010 the £30+ million BEACON, a collaboration led by Aberystwyth University, working with Bangor and Swansea Universities and the University of South Wales, has built up a strong skill base in the bio business sector by providing collaborative R&D support for Welsh businesses[30]. BEACON has worked successfully with hundreds of companies, enabling them to develop and trial ideas on an industrial scale, and to get their products and services closer to market. Products include bio plastics, food additives, building materials and fuel.

Reforming the skills system

20. We are driving forward reforms to put employers at the heart of the skills system and ensure colleges are responsive to the needs of local economies. As demand for green skills continue to grow across the UK, employers in the green economy must prioritise investment in the retraining and upskilling of their workforce, and actively take the opportunity to engage with education providers to shape local provision.

21. Central to our strategic reforms are the plans set out in the Skills for Jobs White Paper, which will enable local employers to set out their green skills needs to drive provision in local colleges. The programme is made up of two parts: local skills improvement plans and the Development Fund.

22. First, the Trailblazers for local skills improvement plans, led by employer representative bodies will identify and articulate unmet and future local skills needs and work with further education providers to adapt their technical training offer so that it becomes more responsive to employers' needs. Through the Skills and Post-16 Education Bill, we are legislating to put the employer leadership of these plans on a statutory footing and ensure they have regard to skills needed to help deliver on our net zero target, adaptation to climate change, and other environmental goals.

23. Second, our £65 million Development Fund pilots in 2021-2022 will support work to identify employers' skills needs, design provision to respond, and build the capacity of local further education providers to deliver. Where local areas identify a skills need, for example increasing the number of trained retrofitters, providers could use this funding to purchase equipment, train their staff, bring in industry expertise to provide training, or deliver new provision. The majority of the 18 pilots announced in July 2021 include a project focused on green skills, covering areas including decarbonisation, renewable energy, and electric vehicles.

24. Alongside this. we want people to get the advanced technical and higher technical skills they need to get good jobs. Colleges' place at the centre of their local communities and economies means that they are key to unlocking opportunities across the country and to building back better. We are, therefore, reforming the adult skills funding and accountability system for further education colleges and other training providers in a way that will help improve our skills provision. We are consulting on a range of proposals to make sure colleges are better supported to focus on helping their students into good jobs; reduce the complexity of funding so that colleges can focus on their core role of education and training; and define clearer roles and responsibilities for the key players in the system. This means that, for the first time, we will be able to reflect the value that relevant courses deliver to the taxpayer in the funding rate colleges receive for putting on courses. This will encourage providers to put on courses in subjects where there is strong demand from employers. We will hold colleges to account for delivering good outcomes, and are consulting on proposals to introduce new Accountability Agreements setting out national priorities against which we expect colleges to deliver, for example enabling students to access opportunities in the green economy.

25. Supporting the transition through the skills system will require teachers in the further education sector to have a strong understanding of sustainability. To deliver this, we have worked with employers to develop a refreshed apprenticeship standard for further education teaching (Level 5 Learning and Skills Teacher), which came into effect in September 2021. For the first time, all further education teachers training via an apprenticeship will be required to integrate sustainability into their teaching, including through modelling sustainable practices and promoting sustainable development principles in relation to their subject specialism. Early estimates from the Trailblazer Group suggest around 1,500 teachers each year could train using this apprenticeship standard. This standard will soon be incorporated into all future further education teaching qualifications, so that all teachers across all subject areas will be able to embed and promote sustainability in their teaching.

Ramping up support for workers in high carbon sectors to transition to green jobs

26. Over 80% of the workforce of 2030 is already in work today[31], as such meeting our ambitious targets for climate action in the next decade, and reaching net zero by 2050, will require government and industry to work together to ensure workers in high-carbon sectors can retrain and upskill as they move into jobs in the green economy. Much of this will take place in industry (see the case study below) and we will support this through our targeted programmes for industries and workers.

Case study: Industry action on reskilling for the transition

Centrica

Centrica have announced plans to hire 3,500 Smart Energy Apprentices by 2030, with the first 1,000 apprentices recruited by the end of 2022. Apprentices joining Centrica receive technical skills training and knowledge for the job at the company's academies in Dartford, Hamilton, Leicester, and Thatcham. Many have taken up the opportunity to upskill at Centrica to become domestic electrical installers, with skills in Electric Vehicle charging point installation, or to achieve gas boiler service and repair capability.

Upskilling training for domestic electrical installers lasts 20 weeks and is offered after Smart Energy Engineers have finished their apprenticeship. The gas boiler service and repair programme also takes place after completing the Smart Energy Apprenticeships, and is split over two years. Every year, Centrica's academies train and assess 5,000 engineers to keep all British Gas engineers compliant with their specific roles' regulatory and industry requirements.

27. In key sectors, we will ramp up our support to develop UK supply chains and enable workers to access green jobs. This will include working with industry on a Heat Network Skills Programme to increase the capacity and capability of the UK supply chain to support the sector to reach its growth potential. Our Public Sector Low Carbon Skills Fund will enable public sector organisations to acquire expert skills in order to unlock decarbonisation projects. Alongside this, we will work with industry to support training and new routes of entry to help boost heat pump installer numbers and other areas of skills shortage to support the decarbonisation of buildings. We will also support the development of new green skills for hydrogen, CCUS and industrial decarbonisation to ensure the UK workforce is ready to deploy low carbon technologies. Our funding for the Aberdeen Energy Transition Zone will position the region as an exemplar for low carbon development, supporting the transition of existing oil and gas skills to renewable energy sectors. We also will continue to support the forestry sector to improve its training and career services.

28. Through the Lifetime Skills Guarantee, we are supporting workers to gain the skills they need to transition to the green economy, including through targeted support for retraining. As part of this, through the National Skills Fund (NSF) investment we are delivering Skills Bootcamps, which are short, flexible courses covering digital, technical and green skills. Green Skills Bootcamps are available in areas such as housing retrofit, solar, nuclear energy and vehicle electrification. Overall, we expect there will be approximately 16,000 Skills Bootcamp places available across the country in financial year 2021-22. We will undertake robust evaluation of this exciting training model to explore potential future plans. In addition, our Free Courses for Jobs offer has, since April 2021, been supporting adults that do not have a qualification at Level 3[32] or higher to access over 400 Level 3 courses for free. The offer currently includes qualifications linked to green sectors such as Agriculture, Building and Construction, Engineering, Environmental Conservation, Horticulture and Forestry and Science. An estimated 11 million adults over the age of 24 in England are eligible for the Free Courses for Jobs offer. We will continue working closely with employers to understand where the offer could be extended further to enable more adults to access qualifications to give them skills needed for the net zero transition.

29. This will be underpinned by the Lifelong Loan Entitlement (LLE) from 2025, which will provide individuals with a loan entitlement equivalent to up to four years of post-18 education to use over their lifetime. As part of the pathway towards the LLE, we will trial short course provision at Levels 4-6 to support in-work adults to upskill and retrain, enabling learners to flexibly build towards a full qualification in subjects crucial for net zero including STEM and digital innovation.

30. Through the NSF we are also delivering an Emerging Skills Project in electrification and battery technology, which commenced in June 2021.Alongside this, our NSF funded In-Work Skills Pilot, launched in September 2021, will seek to respond to immediate skills shortages required for net zero, stimulate demand for short course provision at levels 4-5 across STEM sectors, and boost worker's career and progression opportunities in key green sectors, such as electrification in the auto industry and low carbon engineering.

31. Given the pace and the scale of the transformation, we are considering how government can work more closely with sectors in the future to support them in the green transition, and identifying where we can adapt and enhance our support for people at risk of redundancy to support a transition to green jobs. This builds upon our existing work coach interventions and targeted provision including Sector-based Work Academy Programmes (SWAPs), traineeships, apprenticeships and other skills provision which are ensuring jobseekers can develop the right skills to move into green jobs.

Working with business to support people from all backgrounds to have a green career

32. We support the Green Jobs Taskforce's recommendation that industry should prioritise ensuring that people from all backgrounds can work in green jobs, building on existing good practice and capitalising on the unique opportunity of young people's interest in climate change and the environment. A more diverse workforce will aid the transition by expanding the talent pool, encouraging new ways of thinking, enhancing innovation, and boosting profitability and productivity across the economy.[33]

33. To drive this important work forward we will continue to encourage industry to ensure there is equal opportunity for all to work in the green economy, building on our support for industry initiatives such as the POWERful Women campaign and commitment under the 'Equal by 30 Campaign' to close the pay gap, improve female representation in senior roles and opportunity for women in the global clean energy sector by 2030. Through the cross-cutting delivery group we will explore what actions can be taken across industry to improve diversity in the green economy, including improving data collection and transparency.

34. Alongside this, we will continue to work with green employers to raise awareness of the opportunities in the green economy through an integrated careers information, advice and guidance offer through schools, colleges, universities, and employers to raise awareness of different career pathways in low carbon sectors.

35. To further break down perceived barriers to working in the energy sector, boost diversity and increase STEM skills, our Build Back Better campaigns will seek to inspire people from all walks of life to work in the green economy, and raise awareness of green education, training, and careers.

36. The UK's joint presidency of COP26 brings a unique opportunity to showcase green careers to a new generation of children and young people. We are capitalising on this by working with industry to launch the Faces of The Energy Transition campaign to showcase the inspiring people, projects and organisations working to achieve the clean energy transition, and supporting green careers events at COP26 in Glasgow.

Building a foundation for future green careers

37. Schools and colleges will play a vital role delivering high-quality education and training to equip young people with the knowledge and skills required for the green economy. This will help to grow the pipeline of skilled workers needed to help deliver the net zero transition.

38. The science, geography and citizenship programmes in the National Curriculum at both primary (KS1-2) and secondary (KS3-4) cover key content which supports knowledge and understanding of sustainability and climate change. An environmental science A Level was introduced in 2017. Equipping students with secure knowledge and skills in STEM and other key subjects will be critical in supporting them to progress to skilled jobs in the green economy. We are, therefore, supporting teachers to deliver high-quality

teaching in these subjects by creating a world-class teacher development system that builds from initial teacher training through to early career support, specialisation and onto school leadership. Our vision is that a golden thread of training, support and professional development - informed by high-quality evidence - will run through each phase of a teacher's career. We are also funding several initiatives to support subject-specific professional development in STEM subjects across all key stages. We are working with Oak National Academy to give teachers access to high-quality curriculum resources to support their teaching, including in subjects that cover sustainability and climate change. We are also working with industry, through programmes such as Tomorrow's Engineers Code, to showcase the diversity of roles and people that make up the STEM sector, encouraging more young people from different backgrounds to choose a career in the sector.

39. We will build on this by bringing forward a strategy which will set out how our children's services, education and skills systems will support the UK to meet its net zero target, become more resilient to climate change and improve biodiversity. This will include a focus on ensuring excellence in education for a changing world, which will prepare children and young people with the knowledge and skills they need to contribute to the green economy.

40. At post-16 level, we will continue to build on our apprenticeship reforms, set out in the *Skills for Jobs White Paper*, to align the majority of post-16 technical education and training with employer-led standards by 2030. A strengthened system of employer-led standards, underpinning apprenticeships, T-levels and new higher technical qualifications will ensure employers, including in low carbon sectors, have a central role in designing and developing qualifications and training.

41. To ensure this system reflects the needs of the green economy, the Institute for Apprenticeships and Technical Education (IfATE) has convened a Green Apprenticeships Advisory Panel (GAAP) to work with employers to align apprenticeships to net zero objectives. Work is underway to map existing apprenticeship standards against green occupations and identify opportunities to create new standards in areas including retrofit, agri-tech and renewable energy and the GAAP has endorsed existing apprenticeships which support green career pathways. We have already seen positive engagement in the energy sector with over 1,000 apprenticeship starts in Wind Turbine Maintenance and Operations Engineering Technician standards in 2019/20. The GAAP will build on this list into 2022, in line with the *Ten Point Plan* and the findings of the Green Jobs Taskforce. The work of the GAAP will also support other key post-16 programmes that are underpinned by the same standards as apprenticeships (such as T levels and higher technical qualifications) to align with the needs of the green economy.

42. In 2021, we introduced the first occupational traineeships, in collaboration with sector bodies, to provide a clear, planned transition to an apprenticeship at Level 2-3 for young people aged 16-24. Going forward, we will consider the potential to develop and introduce other occupational traineeships, including in priority and green sectors to ensure that young people secure the jobs of the future.

43. We are continuing to roll out T Levels that support green careers, providing high quality technical qualifications as an alternative to A Levels which are underpinned by the same employer-led approach as apprenticeships. The building services engineering for construction T Level, launched in September 2021, will cover housing retrofit and heat pump installation. From September 2022, new T Levels will be available in Engineering, Manufacturing, Processing and Control, with

Agriculture, Land Management and Production available by September 2023. IfATE is exploring the suitability of potential future T Levels and occupational specialisms, focusing on areas to support green skills.

44. IfATE has introduced an approval process for Higher Technical Qualifications (HTQs) at Levels 4 and 5. HTQs will be rolled out for teaching from September 2022, covering eleven occupational routes - including qualifications in digital, construction and engineering – coming on stream up to 2025. Future roll-out will continue supporting the development of skills for the transition to net zero as a key government priority. The goal is to grow the number of learners undertaking high-quality level 4 and 5 qualifications to meet skills needs at this level. Earlier this year, we launched an £18 million higher technical education provider growth fund to allow investment in new equipment that will support providers to expand technical studies, and boost local employer links. Our growth fund is supporting 15 universities and 87 FE colleges to teach HTQs from next year.

45. Finally, our network of Institutes of Technology (IoTs) across England are utilising their state-of-the-art facilities to offer training in green skills. This includes the East London IoT which offers training in green and zero carbon energy production, and the Greater Birmingham and Solihull IoT which focuses on sustainable engineering. The network is supporting increased participation from under-represented groups, including women, helping to grow the pipeline of individuals with STEM skills needed for green jobs. We are investing £120 million in the second wave of IoTs, to be up and running by 2022.

Next steps

46. The policies set out in this chapter represent a first step in addressing the challenges identified by the Green Jobs Taskforce. We will progress further work through the cross-cutting delivery group, maintaining the momentum generated by the Taskforce to drive action across the green skills agenda. Working alongside industry, we will continue to build the evidence on the skills gaps which could hamper the net zero transition if left unaddressed, assess how far existing interventions are on course to address those skills gaps, and where appropriate identify further opportunities to flex key skills programmes to support green sectors and occupations.

4iv. Embedding Net Zero in Government

Climate considerations underpinning policy across Government

Our Key Commitments

- Require the government to reflect environmental issues in national policy making through consideration of five environmental principles.
- Ensure that decisions taken on government spending are informed by their impact on meeting net zero.
- New measures to reduce emissions from Government's £292 billion procurement spending – and ensure suppliers have plans for achieving net zero on major qualifying public contracts.
- Continue to fund the Public Sector Decarbonisation Scheme at £475 million per year to drive ambitious emissions reductions in schools, hospitals, and other public buildings, whilst taking further action on skills, reporting, and targets.
- Publish an annual progress update against a set of key indicators for achieving our climate goals.
- Expand climate change training to ensure the Civil Service has the skills and people it needs to deliver net zero.

The challenge

1. Net zero is a complex and transformative undertaking for the UK. The way the government operates must rise to meet this challenge. This means reducing the public sector's own carbon footprint – but also changing how we are organised and how we take decisions. Building on our recent historic progress, we are now going further to ensure the whole government meets the challenge of net zero.

Our goal

2. Since setting the net zero target, a huge effort has taken place across government to ensure we are set up in the right way to deliver on our climate ambitions. We have gone further than ever before to put the climate at the heart of our decision-making. This includes:

- Establishing two Cabinet Committees dedicated to climate change;
- Announcing as part of the Integrated Review of Security, Defence, Development and Foreign Policy that tackling climate change and biodiversity loss will be the Government's number one international priority;
- Using the Environment Bill to require the government to reflect environmental considerations in national policy making through consideration of five environmental principles;
- Taking new approaches to embed net zero in spending decisions;
- Establishing the No.10 Delivery Unit to ensure the government maintains a sharp focus on delivering the country's key priorities. One of the four priorities for this Unit is the delivery of net zero; and,
- Setting out in collaboration with key net zero delivery departments, a high level strategy for delivering on the UK's net zero commitments through the BEIS Outcome Delivery Plan 2021-2022. This plan identified key programmes critical to delivery and set out an evaluation plan to monitor and assess progress.

3. These efforts put climate change at the heart of our decision-making and have led to the ambitious announcements set out in recent years: the Prime Minister's *Ten Point Plan for a Green Industrial Revolution*, dedicated strategies for key sectors of the economy, and this Net Zero Strategy; and set us up to deliver on those commitments.

4. Our goal is to go even further to embed net zero across government activity. This will mean that government takes net zero into account when taking decisions, public sector buildings will emit less carbon, our procurement decisions will lead to greener supply chains, and civil servants across government will have the skills they need to deliver this mission.

5. To do this we must understand the interactions between climate change and other UK priorities. The measures set out in this chapter are crucial for ensuring that the UK takes a whole system approach to tackling climate change:

- Multiple forums – including Cabinet Committees – that bring together different perspectives on net zero and its interaction with other priorities;
- Delivering climate skills and training across the Civil Service – not just to civil servants working directly on climate issues;
- Close working relationships with local government and the Devolved Administrations; and,
- Embedding net zero in a wider range of decision-making levers.

Net zero in government decision-making

6. In the last two years the Government has made commitments to strengthen governance around net zero. Two Cabinet committees were established in 2020 to rationalise climate governance and put net zero at the heart of government decision-making. This is driven by the Prime Minister, who chairs the Climate Action Strategy Committee (CAS). This Committee considers matters relating to the delivery of the UK's domestic and international climate strategy. In addition, the Climate Action Implementation Committee (CAI) which is chaired by the COP President Designate. It considers the delivery of COP 26, net zero and building the UK's resilience to climate impacts. These committees' ability to scrutinise progress and take whole system decisions will be strengthened by the new measures described in this chapter.

7. These committees are supported by well-established and robust governance at official level. This includes a cross-government Director General group that was established in 2019 to ensure a whole-of-government approach to climate policy, with oversight at the most senior levels. Chaired by the BEIS Director General for Net Zero and International, this group brings together officials from across government, creating a whole system perspective, to support the delivery of significant climate announcements, including those contained in this Strategy.

Consistency of approach across the UK

8. To reach net zero we must take a UK-wide approach. The UK Government and the Devolved Administrations are committed to working together to deliver coordinated policy action to meet respective emissions reduction targets across the UK. Combined, Scotland, Wales and Northern Ireland produced 22% of UK emissions in 2019,[34] and accounted for 16% of the UK's population, 13% of economic activity[35] and nearly half of the UK's land area (46%).[36] Powers and policies to deliver ambitious emissions reductions in the Devolved Administrations Scotland, Wales and Northern Ireland are partly reserved to the UK Government and partly devolved.

9. The UK Government and the Devolved Administrations have established governance arrangements to ensure a joined-up and collaborative approach to climate change. At the bimonthly Net Zero, Energy and Climate Change Inter-Ministerial Group, UK Government ministers meet with Devolved Administration counterparts to discuss emerging policies that will contribute to delivery of net zero targets across the UK, such as delivering a UK-wide Emissions Trading Scheme, and the level of the sixth carbon budget which was set in law in June 2021. The Group is supported by the official-level Net Zero Nations Board on alternate months.

Embedding net zero in government decisions

10. Climate change is a major issue for all governments in the 21st century. Our mission to reduce emissions, seize economic opportunities, and adapt to extreme weather events will affect many more of the decisions that the Government takes than it would have done in previous decades. To that end, it is essential that we put in place new levers to ensure that all the Government's decisions adequately take climate change into account. This Strategy sets out key measures we will take to ensure a climate-focus on key future decisions made by the government.

11. We are using the Environment Bill to require the government to reflect environmental issues such as climate change in national policy-making through consideration of five environmental principles:

- The integration principle is the principle which states that policy-makers should look for opportunities to embed environmental protection in other fields of policy that have impacts on the environment.
- The prevention principle means that government policy should aim to prevent, reduce or mitigate harm.
- The rectification at source principle means that if damage to the environment cannot be prevented it should be tackled at its origin.
- The polluter pays principle is the principle that those who cause pollution or damage to the environment should be responsible for mitigation or compensation.
- The precautionary principle states that where there are threats of serious or irreversible environmental damage, a lack of scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.

12. The duty to consider these principles should be applied in the early stages of policy development and considered throughout. In doing so, the extent to which a policy will contribute to climate change should be considered alongside other impacts of the policy on the environment. Net zero will therefore be facilitated by the principles where they are applied to relevant decisions.

13. The integration principle will create a prompt for policy makers to embed environmental protection in policy making, triggering consideration of the government's priorities for environmental protection (such as net zero) and whether these priorities can be supported through the new policy. The polluter pays and prevention principles could also help to contribute to net zero targets, through encouraging policies that reduce carbon emissions and prevent adverse impacts on climate where possible. These principles will ensure the environment is at the heart of policymaking across government.

14. Ensuring spending decisions contribute to net zero is a major priority for HM Treasury. The Green Book already mandates the consideration of climate and environmental impacts in spending. It has been updated so that policies must be developed and assessed against how well they deliver on the Government's long-term policy aims such as net zero.

15. Spending reviews are critical moments for the Government to look strategically at the country's priorities and make spending decisions based on these. At Spending Review 2020 (SR20), guidance required departments to state the greenhouse gas emissions of bids, and their impact on meeting Carbon Budgets and net zero. Allocations to departments were informed by this information, and £12 billion was committed to green measures. We have reviewed the learning from this exercise to further embed climate change in spending decisions in the next spending review and in the long term.

16. In September 2021, the Government published updated guidance on how impacts on greenhouse gas emissions should be measured in policy decisions. As a result, departments must place a significantly higher value on emissions in determining policy, as the values now fully reflect the UK's increased ambitions on climate. This complements wider considerations on natural capital impacts in policy decisions – and represents a significant step forward in incorporating environmental impacts into policy development.

17. As set out in the *Green Investment* chapter, we have also taken steps to ensure net zero is embedded in government funding and regulation of the financial system. Arm's-length bodies, such as the British Business Bank, have adopted net zero as a core objective. This will expand the flow of finance to those innovative firms that will help us reduce our energy consumption and mitigate the impacts of climate change.

18. This builds on important announcements in the 2021 Budget, particularly the new UK Infrastructure Bank that will use its £22 billion of financial capacity to crowd-in private investment to support economic growth, accelerate our progress to net zero, and help level up the UK. One of the Bank's objectives is to help the UK transition to net zero emissions by 2050.

19. We will make sure that the reformed planning system supports our efforts to combat climate change and help bring greenhouse gas emissions to net zero by 2050. For example, as part of our programme of planning reform we intend to review the National Planning Policy Framework to make sure it contributes to climate change mitigation and adaptation as fully as possible.

Supporting UK businesses

20. We are considering net zero through our support to business too across government activity. Innovate UK is the UK's Innovation Agency, it drives productivity and economic growth by supporting UK businesses to commercialise new ideas and address the big societal challenges facing the UK today.

21. As the UK moves to a net zero economy, Innovate UK is supporting businesses to exploit new ideas, develop supply chains, and thrive in growing global markets. Last year Innovate UK committed to spend £276 million with UK businesses to tackle net zero.

Net zero in the work of regulators

22. Many of the UK's regulators will play a role in facilitating delivery of the infrastructure, technologies and activities that will deliver the net zero transition. Several examples are set out in the sector focused chapters in this strategy. The government is also considering whether and how the functions of those regulators most important to the transition can be strengthened.

23. For example, to provide strategic guidance to Ofgem on the government's energy policy, the *Energy White Paper* committed the government to consulting on an energy sector strategy and policy statement (SPS) for Ofgem during 2021. The SPS will set out the strategic priorities and policy outcomes of the government's energy policy, with net zero as the driving theme. This will impose a legal obligation on Ofgem to have regard to the strategic priorities and policy outcomes when exercising its regulatory functions. To provide clear legal accountability, Ofgem will be required to report on how it intends to implement the SPS at the outset, and then report annually on its performance and its plans for the coming year.

24. The Competition and Markets Authority (CMA) is reviewing how the UK can better use the tools available under competition and consumer law to achieve net zero and our sustainability goals. The CMA will provide this advice in early 2022. This follows recent CMA work on misleading environmental claims, its market study into electric vehicles and its publication of information to businesses on sustainability agreements.

25. The National Infrastructure Strategy committed to taking a long-term approach to investment for the benefit of both investors and consumers, responding to the findings of the National Infrastructure Commission's report on the future of economic regulation in key infrastructure. The government also committed to publishing an overarching policy paper in 2021. The policy paper will set out next steps on key issues including: the consideration of duties in the round to ensure they reflect new challenges such as achieving net zero, promoting coherence, and supporting a transparent strategic framework; and the exploring of the merits of a cross-sector-strategic Policy Statement to provide clarity on government's overarching strategic vision for the regulated sectors.

26. In addition, the Government has recently consulted on proposals for reforming the UK's regulatory framework. When the consultation response is published, it will include the Government's decisions on how regulators can be encouraged to consider themes such as competition, innovation and net zero in their regulatory activities. For example, the consultation sought views on whether regulators might be granted more flexibility by government to choose how they intervene in their sectors, to allow more agile, smarter regulation. The Government would like to see a consistent approach taken across the various regulated sectors and will set out more thinking on this in due course.

Demonstrating progress towards net zero

Increasing transparency of progress

27. Every year the government comprehensively reports the UK's historic emissions since 1990 and publishes projections of future emissions.[37] The UK's 'Energy and Emissions Projections' is a world-leading approach to projecting the UK's annual emissions, by sector, according to United Nations Framework Convention on Climate Change guidelines.

28. We are now going further to clearly demonstrate the tangible milestones that the UK will have to reach to achieve net zero, and to communicate and invite scrutiny on this progress to the public.

29. It is critical for public and industry confidence that the UK has a clear plan for achieving net zero – and that we are transparent about how this plan progresses and changes over time. The *Journey to Net Zero* chapter of this Strategy report set out a delivery pathway: an indicative trajectory of emissions reductions based on potential in each sector of the economy, which keeps us on track to meet the sixth carbon budget ending in 2037. Sector chapters set out policies and proposals in line with this indicative pathway to ensure we are on track for net zero. While it is impossible to predict every path to net zero, this pathway sets out the decisive action we know is needed and acts as the best plan we have to measure progress against.

30. We are therefore committing to provide a public update every year on progress in the previous year against the delivery pathway to net zero set out in this Strategy. This will include:

- An update on progress against the targets and ambitions set out in this Strategy (see Table A), building on this list over time to incorporate additional Government targets and wider non-Government indicators of progress;
- Commentary on contextual changes that might affect the exact pathway to meeting decarbonisation commitments; and,
- A summary of key areas of progress made against this pathway the policies and proposals in this strategy.

The following targets and ambitions will form part of the Government's annual update on progress towards net zero:

Power	By 2035 all our electricity will come from low carbon sources subject to security of supply. 40GW of offshore wind by 2030, including 1GW floating wind.
Industry	Ambition to deliver 6 $MtCO_2$ per year of industrial CCUS by 2030, and 9 $MtCO_2$ by 2035.
Fuel supply and hydrogen	5GW of low carbon hydrogen production capacity by 2030. Achieve a final decision on whether to enable blending up to 20% hydrogen by volume into the Great Britain gas network by 2023, subject to successful completion of safety trials. The offshore oil and gas sector to have an absolute reduction in production emissions of 10% by 2025, 25% by 2027, and 50% by 2030 on the pathway to net zero by 2050.[38]
Heat and buildings	Aim to reduce direct emissions from public sector buildings by 75% by 2037 compared to 2017. Achieve a minimum market capacity of 600,000 heat pumps per year by 2028. As many homes to reach EPC Band C as possible by 2035, where practical, cost effective, and affordable. As many fuel poor homes as reasonably practicable to Band C by 2030.

Transport	Double cycling from 2013 to 2025.[39] Increase walking activity by 2025.[40] Deliver 4,000 new zero emission buses and the infrastructure needed to support them. 25% of the government car fleet ultra low emission by December 2022 and 100% of the government car and van fleet zero emission by 2027. 100% of new cars and vans sold are zero emission by 2035. 100% of new HGV sold are zero emission. 100% of new buses/coaches sold are zero emission. Maximise GHG savings from low carbon fuel use in transport by increasing the Renewable Transport Fuel Obligation main obligation from 9.6% in 2021 to 14.6% in 2032.
Natural resources, waste, and F-gases	Restore at least 35,000 ha of peatlands in England by 2025 and approximately 280,000 hectares of peat in England by 2050. Increase tree planting rates from 13,660 hectares across the UK in 2020 to 30,000 hectares each year by the end of this Parliament. Deliver the UN Sustainable Development Goal 12.3 to halve food waste by 2030. Explore policies to work towards the near elimination of biodegradable municipal waste to landfill by 2028. Meet the Kigali Amendment target of reducing HFC consumption by 85% by 2036, as well as the F-gas Regulation's target of a 79% reduction by 2030.
Greenhouse gas removals	At least 5 $MtCO_2$/yr of engineered removals by 2030.

31. We will publish an updated Net Zero Strategy when we set the next Carbon Budget.

Strengthening delivery oversight of net zero projects and programmes

32. Significant recent steps have been taken to oversee the delivery of key projects and programmes that will contribute to net zero. This year, the Prime Minister established the No. 10 Delivery Unit to ensure the government maintains a sharp focus on delivering the country's key priorities. One of the four priorities for this Unit is the delivery of net zero. BEIS in parallel has developed a new model for monitoring net zero delivery and reporting on programme and project-level risks – ensuring decision makers get early visibility of common issues and inter-dependencies across all programmes delivering net zero. This will enable them to make informed, timely decisions to enable us to stay on track to meeting net zero.

33. This complements work led by the Infrastructure and Projects Authority (IPA). The IPA is the government's centre of expertise for infrastructure and major projects, supporting the successful delivery of all types of major projects. The IPA sits at the heart of government, reporting to the Cabinet Office and HM Treasury. The Project Outcome Profile Tool launched in July 2021, ensures that projects and programmes are clearly linked to government priorities (such as net zero) from the outset and support their delivery. Its assurance toolkit has recently been updated

to include key tests and key questions on the environment, climate adaptation, and net zero, in the Government's gateway process. Through the IPA's *Transforming Infrastructure Performance: Roadmap to 2030*, it is driving the use of whole life carbon reporting to reduce embodied carbon in the built environment.

Government leading by example

Decarbonising the public sector

34. Government and the wider public sector will lead by example during the transition to net zero. As well as ensuring that net zero is reflected in our structures and practices, we will continue to take ambitious action to reduce public sector emissions, showing leadership to the wider economy, and making a direct contribution to reaching net zero.

35. Direct emissions from public sector buildings account for around 2% of total UK emissions, and the public sector has reduced its emissions by around 40% since 1990.[41]

36. We intend to act in three areas to ensure we are on track to achieve net zero: investment, transparency, and capacity and capability, and in doing so will aim to reduce direct emissions from public sector buildings by 75% against a 2017 baseline, by the end of Carbon Budget 6.

Investment

37. Reducing direct emissions from public sector buildings requires investment in measures to reduce fossil fuel use, including the installation of low carbon heating and complementary energy efficiency improvements, and the installation of low carbon electricity systems such as rooftop solar PV. The Public Sector Decarbonisation Scheme is providing over £1 billion in grants over 2020/21 and 2021/22 for public sector bodies to fund heat decarbonisation and energy efficiency measures.

38. Building on the success of the Public Sector Decarbonisation Scheme, we will continue and extend the scheme to ensure that public sector bodies have access to finance to continue decarbonising their estates , investing a further £1425 million over 2022/23 to 2024/25.

High standards with transparency

39. Public sector organisations should be taking steps to achieve net zero now should report their progress so they can be held accountable and as publicly funded organisations. Government departments and their arm's length bodies already set and report against targets to reduce their greenhouse gas emissions in Greening Government Commitments. The updated Greening Government Commitments framework for 2021-25 will ensure the public estate continues to reduce its environmental footprint, align with commitments in our 25 Year Environment Plan and be consistent with a trajectory to achieving net zero greenhouse gas emissions by 2050.

40. All public sector bodies should now be monitoring their energy use and have targets to reduce emissions, particularly, to reduce the direct emissions for which they are responsible. To ensure we are on track to reach net zero, emissions from the public sector should be reported and monitored on a consistent and coherent basis. We will provide guidance to make clear the government's expectations in this regard.

41. We will also legislate to enable us to require the reporting of public sector emissions on a consistent and coherent basis if this is not done on a voluntary basis, and, if insufficient progress is made on reducing emissions in the public sector, to require that all public sector organisations are working toward and reporting against a legally-binding target to reduce their greenhouse gas emissions.

Capacity and capability

42. Reducing emissions requires specialist skills and expertise, as well as funding. Action at an unprecedented scale is required to reduce emissions from public sector estates in line with net zero, and organisations need the right skills and structures to deliver on this. We will continue to work with partners across government and the wider public sector to understand these needs, and provide the support needed to address them.

Delivering net zero through public procurement

43. The Government is determined to leverage public procurement to help achieve net zero. We will use our buying power to drive decarbonisation and to create the policy tools and training to enable public procurers to grasp this opportunity.

44. Clearly establishing the strategic importance of net zero at project design stage, as described above, will mean that it is easier to draw through this 'golden thread' when reaching procurement stage. The government has recently announced three distinct new policies that can all help public procurers fully embed net zero into their work. These all kick in at different stages of the commercial cycle, complementing each other in terms of their scope and their reach.

45. *The National Procurement Policy Statement* (NPPS), published in June 2021, sets out clear principles that contracting authorities should be following organisationally. Tackling climate change and achieving net zero is one of the key considerations established – this should then be woven through individual procurements (for qualifying procurements).

46. The Procurement Policy Note on *Taking account of carbon reduction plans in the procurement of major government contracts* comes into effect from Autumn 2021. This will impact over £50 billion of procurement spend. For qualifying contracts, it requires suppliers who are bidding on central government contracts (over £5 million p/a in value) to commit to achieving net zero by 2050 and to detail their organisation's UK greenhouse gas emissions via the publication of a Carbon Reduction Plan. Failure to do so may mean exclusion at supplier selection stage. Government will continue to take action to reduce emissions, and this policy is an important step in ensuring our supply chain is sharing this ambition and taking similar steps to reduce their emissions.

47. The Social Value Model requires government to expressly evaluate environmental, social and economic benefits, with these factors comprising a minimum of 10% of the evaluation score for qualifying procurements.[42]

48. Throughout the development of these policy measures, government has been working with departments, suppliers and industry bodies to raise awareness of how environmental considerations can be brought into the commercial process, and to build capability in understanding and assessing suppliers' commitments. Several thousand buyers across government have completed Social Value training to develop the skills required to embed environmental policy outcomes and improve the sustainability of government contracts. We will continue to

support the adoption and implementation of environmental policy measures to deliver the best commercial and environmental impact for the UK.

49. These measures provide a platform for even stronger action. We have embarked upon a programme of major domestic procurement reform. This will enable us to use flexibilities provided by our departure from the EU to give even greater consideration to environmental factors in our decision making. One specific example is the proposal to break the subject matter of contract link so that a company's wider environmental proposals for the project can be factored into procurement decisions.

50. Domestically we also want to make it easier for procurers to balance carbon against cost. We want to underpin our net zero target and COP26 ambitions by developing tools to help us decarbonise the government's supply chains and stimulate innovation and growth in the UK's green economy. This work also takes into account the Climate Change Committee's (CCC) call for credible, quantifiable pathways for sectoral decarbonisation. We will also explore the possibility of establishing a new single unit for all sustainable procurement policy within government to strengthen performance, coordination, and oversight.

51. Our ambition is necessarily high – we are changing the expectations on ourselves when it comes to utilising £292 billion of annual procurement spend. In doing so we are also sending a clear signal to the market: data on carbon impact, and immediate ambition to reduce it, will be increasingly important in how we choose to do business with you.

Showing leadership on domestic and international standards

52. The BSI, in its role as the UK's national standards body, works across the sectors and topics that will be critical in achieving net zero, including greenhouse gas management, energy transition, biodiversity and sustainable finance. This work is helping the UK to take a global leadership role in net zero and influence change on a global scale. To this effect BSI and the International Organization Standardization have developed the London Declaration – a commitment to actively consider climate change in the development and revision of all international standards and to facilitate the involvement of civil society and those most vulnerable to climate change.

53. Through BSI's international reach, the UK will be able to help stakeholders reach consensus in international climate change standards and lead change globally in support of net zero.

Ensuring the right skills and talent in government

54. The government has established the Government Skills and Curriculum Unit (GSCU) to oversee the delivery of better training, knowledge and networks that the over 440,000 people working in the Civil Service will need today and in the future.

55. Net zero will continue to be a priority for the government until 2050 and beyond. To that end, BEIS and GCSU are reviewing the skills, training and networks that civil servants need to lead the UK's future efforts to decarbonise (see infographic below).

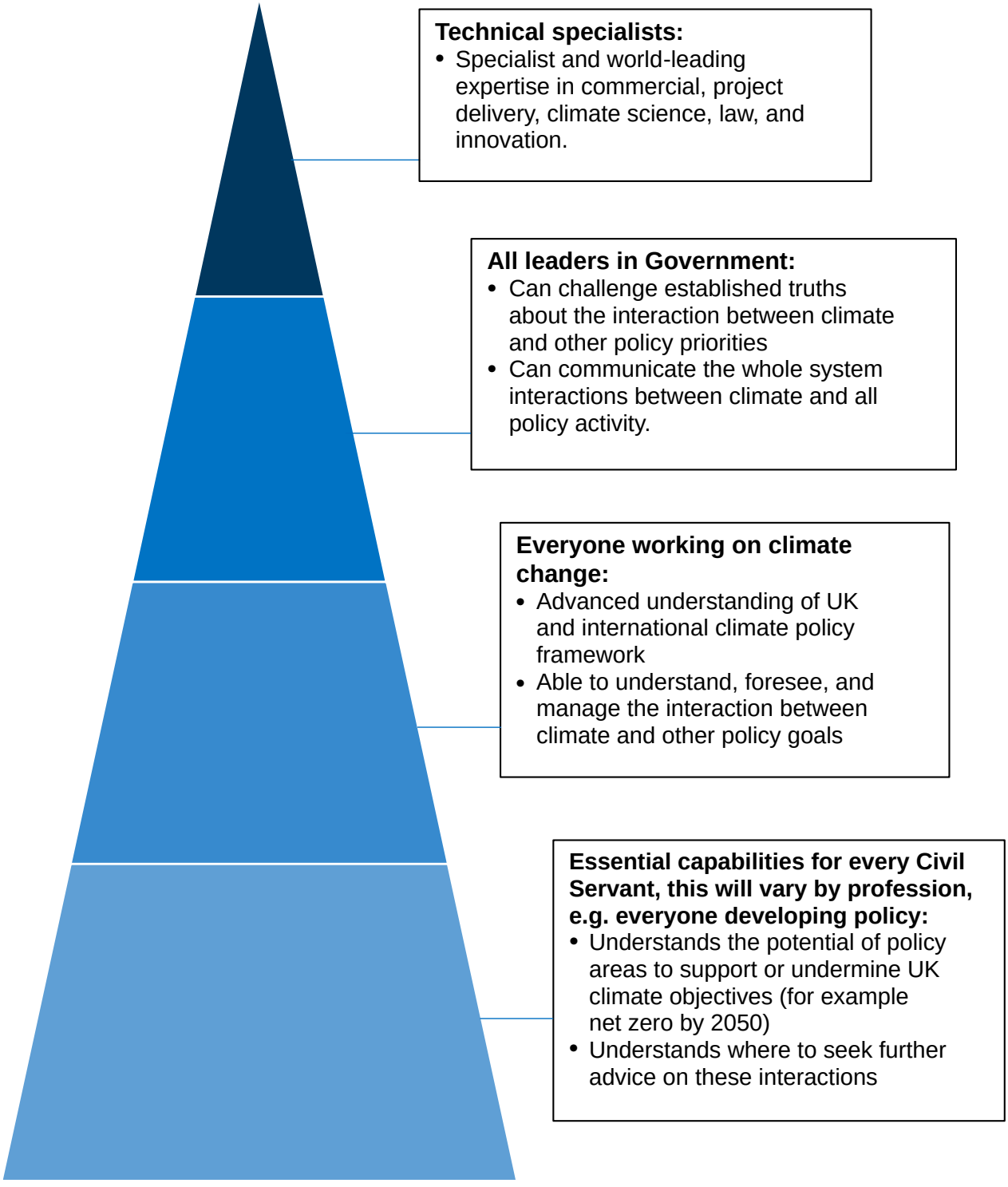
56. We are expanding the curriculum for civil servants to include specific training on climate change. We are also establishing climate specific training within the Civil Service Fast Stream curriculum.

57. We have also embedded climate considerations in the Policy Profession Standards, the competency framework that supports professional development for all civil

servants developing policy. For the first time, this makes explicit that good policymaking requires an awareness of the potential for all policy areas to contribute or undermine our climate goals.

58. We are establishing a new climate focus within the Civil Service Fast Stream Generalist Scheme, which will focus on providing relevant skills and opportunities to some of the future leaders of the Civil Service.

Ambition for climate capabilities across Government



4v. Local Climate Action

Supporting decarbonisation and regeneration in our local areas and communities

Key Commitments

- Set clearer expectations on how central and local government interact in the delivery of net zero.
- Build on existing engagement with local actors by establishing a Local Net Zero Forum to bring together national and local government senior officials on a regular basis to discuss policy and delivery options on net zero.
- Continue the Local Net Zero Programme to support all local areas with their capability and capacity to meet net zero. This includes provisions to:
    - Continue the Local Net Zero Hubs (previously known as the local energy hubs) to support all areas of England to reach net zero, including those lacking capacity and capability, or those facing unique challenges.
    - Promote best practice and support local authorities to develop net zero projects that can attract commercial investment.
    - Increase knowledge sharing to demonstrate and share successful net zero system solutions.

The challenge

1. Devolved and local government play an essential role in meeting national net zero ambitions. Across the UK many places have already made great strides towards our net zero future, having set their own targets and strategies for meeting local net zero goals. Taking a place-based approach to net zero is also vital to ensuring that the opportunities from the transition support the government's levelling up agenda.

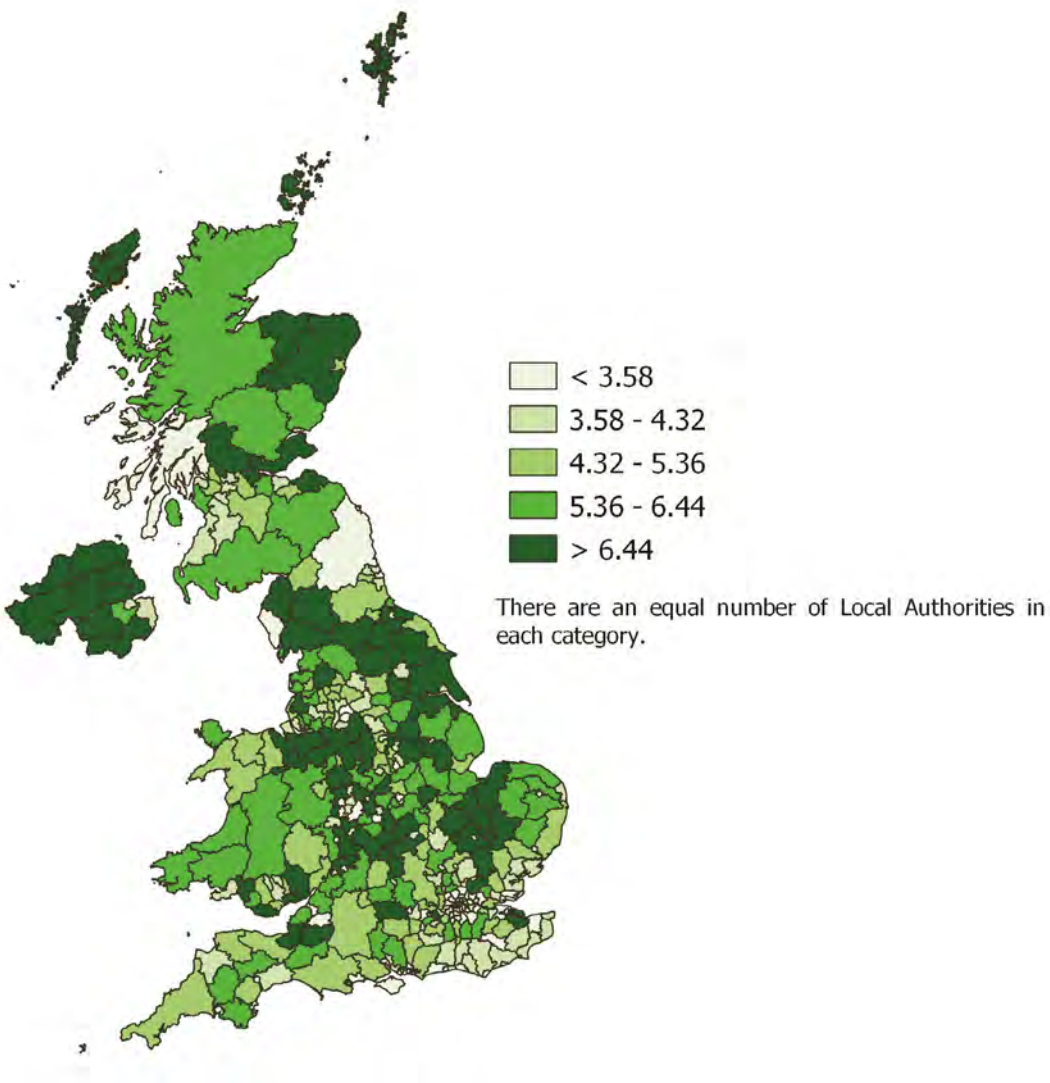
2. The combination of devolved, local, and regional authorities' legal powers, assets, access to targeted funding, local knowledge, and relationships with stakeholders enables them to drive local progress towards net zero. Not only does local government drive action directly, but it also plays a key role in communicating with, and inspiring action by, local businesses, communities, and civil society. Of all UK emissions, 82% are within the scope of influence of local authorities.[43]

3. Local leaders are well placed to engage with all parts of their communities and to understand local policy, political, social, and economic nuances relevant to climate action. The government currently works with the Core Cities Group, for instance, which undertakes a range of activities to promote climate change adaptation, raise awareness and foster leadership in cities. Local government decides how best to serve communities and is best placed to integrate activity on the ground so that action on climate change also delivers wider benefits – for fuel poor households, for the local economy, for the environment and biodiversity, as well as the provision of green jobs and skills.

4. Despite the excellent work already underway, we understand that there remain significant barriers to maximising place-based delivery on net zero. We know that some places are moving faster than others and that places and communities will face different challenges when meeting net zero commitments and adapting to climate change.

5. There are significant regional variations in the level of emissions (see Figure 29 below) and some of the hardest hit local economies that face multiple development and growth challenges are proportionally home to a greater number of lower skilled workers. Many of these areas are also where high-carbon industries are located.

Figure 29: Net emissions of carbon dioxide per capita by Local Authority (tonnes CO_2e per capita) in 2019



Source: ONS

6. We also recognise that certain types of communities, such as rural and coastal communities, face significant and unique challenges. For example, the increased age of rural housing makes it both more difficult and expensive to introduce energy efficiency measures and rural communities also have greater reliance on cars. Similarly coastal communities face significant challenges as they may be vulnerable to more frequent flooding, rises in sea level, and accelerated coastal erosion which will have the potential to affect public services and infrastructure. However different types of localities may also have opportunities available to them that do not exist everywhere. For instance, coastal communities may be able to utilise tidal energy or industrial scale water source heat pumps, and rural areas may have access to sustainable biomass.

7. There are currently no net zero statutory targets on local authorities or communities in the UK, and we do not believe that a new general statutory requirement is needed. This is because of the existing level of local commitment with the sector, and because it is difficult to create a uniform requirement that reflects the diversity of barriers and opportunities local places experience. However, we do understand that there is a real need to ensure local leaders across the board are supported by enhancing the capacity and capability of local areas to deliver net zero, coordinating engagement with local authorities, and clarifying expectations at a national level to accelerate local progress towards net zero.

8. Central and local government will need to work closely together to deliver net zero and our interim carbon budgets. Government analysis suggests that over 30% of the emissions reductions needed across all sectors to deliver on our Carbon Budget 6 target, as set out in this strategy, rely on local authority involvement to some degree.[44]

Our goal

9. The government will continue to set UK-wide priorities for meeting carbon budgets and for assessing how each sector will help meet those budgets. Local government has a key role in integrating delivery at a local and regional level to deliver more cost-effective routes to net zero and derive local co-benefits that embed climate action in the heart of local places and services. By taking this approach, we can achieve even more for net zero and for the economy locally and nationally; we recognise that a one-size-fits-all approach will not work. We want to build strong partnership working between central, devolved, and local government, increase the co-ordination and better support all levels of government to utilise the influences available to them.

10. We want to continue to empower our local leaders to take the actions which will lead to the biggest gains in emissions reduction, including the potential opportunities in building back greener and meeting our ambitions to level up the country. While the COVID-19 pandemic has severely impacted our communities, it has also reshaped how we think about place, community, and our natural and built environment.

11. Community empowerment, engagement, and action can play a role in supporting the UK's transition to net zero and enable communities to access the benefits that it brings, from greener jobs to improved health. Communities are especially well placed to help raise awareness and engage people in adopting net zero behaviours. For example, community ownership of renewables and other assets, often in partnership with other organisations, can be an important driver of reducing local emissions. It can also enable people to learn more about climate change and build sustainable behaviours.

12. We will continue to provide support for public and private investment opportunities in local places that will enable the local delivery of emissions savings across the sectors. In the sector chapters we have shown the range of programmes from building retrofit, heating, electric vehicle charging and many others where funding will go to local government to deliver action in their communities.

Enabling local areas to deliver net zero

13. To support all local government in developing and delivering their net zero delivery plans, we need to act in three key areas:

a. **Setting clearer expectations** for local places, clarifying how the partnership with local government should work, and considering how action at national, regional, local, and community levels fits together to tackle the emission and climate risk challenges we face, and the wider benefits the transition brings.

b. **Providing resources** for local places to deliver stronger contributions to national net zero targets, across dedicated funding streams for net zero and non-ringfenced funding, noting the number of broader priorities on which local government needs to deliver.

c. **Building capacity and capability** at the local level to support ambition and share best practice, while also providing support in areas that may not have made as much progress to date.

14. To act effectively across these areas, and for local government to translate national goals into local action, we will build on our existing engagement to improve the way local and national government collaborate on net zero. The Department for Business, Energy and Industrial Strategy (BEIS) will take overall responsibility for improving coordination with local government and other local actors on the effective design and delivery of local net zero policies, as part of the Department's overall responsibility and wider leadership on delivering net zero. Other departments will continue to lead on their specific policy areas such as Department for Transport on the decarbonisation of transport. We intend to build on many of the existing ways of working together to provide more consistency and clarity over roles and responsibilities between national and local government.

15. We will do this by establishing a Local Net Zero Forum to ensure that there is direct input from local leaders. Chaired by BEIS, the Forum will be cross departmental and bring together national and local government senior officials on a regular basis to discuss policy and delivery options on net zero. The forum will build on our current engagement mechanisms through the representative bodies such as the Local Government Association (LGA), Association for Public Service Excellence (APSE), Core Cities and the Association of Directors of Environment, Economy, Planning & Transport (ADEPT). The creation of the Forum also draws on the recommendations for a policy framework put forward by member network UK100. The Forum will support the establishment of clearer delivery roles for local government and provide a single engagement route into HM Government in a coordinated and coherent way.

16. On adaptation, local actors will be supported through increased Environment Bill powers to take effective action, reduced financial burdens from waste management and stronger abilities to improve health and social outcomes for local citizens.

17. Achieving our aims requires national decision makers to have the right knowledge and awareness to understand the local impacts of decisions. BEIS will work with other departments and stakeholders to demonstrate successful net zero system solutions by creating a network of experience that amalgamates learning through case studies and non-spatial planning tools.

18. We have already developed a Carbon Literacy toolkit for the delivery of Carbon Literacy training for local authorities. This training has been made available to all local authority staff and aims to increase awareness and ability to reduce emissions across all the policies and programmes local government work on. BEIS has created a sector course and places like Manchester and Sheffield are among the early adopters who have trained staff and councillors.

Funding

19. Funding for local climate action comes from a combination of the Local Government Finance Settlement, other government grants and support schemes, borrowing, and private finance. Collectively, this means there is a range of funding available for local authorities to act on climate change. Some have chosen to explore community bonds and crowdfunding. A third of local authorities say their climate change plans will be cost-neutral by incorporating goals into existing service area strategies, drawing on the funding available for those services.

20. An important part of the funding landscape is the diverse range of grant funding schemes provided by HM Government to support local delivery. The recent National Audit Office (NAO) review into local government and net zero identified 22 dedicated grant schemes for net zero work from central to local government. We recognise that longer term and more co-ordinated funding streams can enhance innovation and investment, reduce bureaucracy, and encourage more efficient and integrated decision making. We will explore how we could simplify and consolidate funds which target net zero initiatives at the local level where this provides the best approach to tackling climate change. Building on the vision in the Prime Minister's *Ten Point Plan*, we also will work across departments to explore how we can give certainty to investment in longer-term programmes supported by regeneration initiatives.

21. In addition to the above, the UK Infrastructure Bank (UKIB) will lend to local authorities for strategic and high value projects and invest in projects alongside the private sector, crowding in private sector capital. It has twin objectives of helping to tackle climate change, particularly meeting the UK's net zero emissions targets and helping to support regional and local economic growth across the UK. The UKIB will offer loans to local authorities for high value and strategic projects of at least £5 million. To complement this investment activity, over time, the UKIB will develop an expert advisory service to help local authorities develop and finance projects. The UKIB will build partnerships across the UK including with government departments, government sponsored bodies, local authorities and relevant representative organisations to foster collaboration and drive value for money. As it engages with the market, the UKIB will continue to learn and adapt, which will ensure that its loans to local authorities are as effective as possible.

22. The UKIB is currently operating in an interim form, as it expands its capability and capacity. It will continue to refine the Local Authority Lending Function over the coming months.

23. The Department for Business, Energy and Industrial Strategy will continue to work with partners and the finance sector to develop new finance and business models to support local delivery. These business models will look to develop aggregated projects and portfolios of projects building up scale and spreading delivery risk more effectively for investors.

Sectoral priorities at a local level

24. We understand that for local areas to deliver net zero they will need specific support to plan and identify priorities across different sectors of the economy.

Local energy

25. Decarbonisation of our buildings, transport systems and energy system will require significant action at a regional and local level. Generation and storage are becoming increasingly decentralised, with solar and batteries being deployed in buildings, vehicles, and local communities. Heat and transport decarbonisation in particular needs to be delivered in a way that meets local needs and with the involvement of local decision makers. Decarbonisation will require strong co-ordination across electricity, heat, hydrogen, transport, and buildings. That means local actors can be strong drivers of change, enabling coordinated non-spatial planning and engagement with markets, and supporting cleaner, cheaper and more efficient energy whilst providing a significant contribution towards local economic strategy.

26. Better engagement and information sharing across organisations can enable better forward-planning and a more coordinated approach. BEIS has work underway with Ofgem to develop a better understanding of the opportunities and challenges presented by local area energy mapping and planning (LAEMP) and are considering the most appropriate policy options to take forward. This work could help to bring together key local stakeholders to explore the impact of decarbonisation choices across sectors and how different technology options may impact on local energy networks.

27. The Government has committed up to £102.5 million of funding through the Industrial Strategy Challenge Fund to Prospering from the Energy Revolution. This is an innovation programme which develops smart local energy systems to provide investable, scalable local business models and finance mechanisms using integrated approaches to deliver cleaner, cheaper energy services. The programme is supporting three places to demonstrate the use of this framework today and a further ten places to develop detailed plans and business cases to deliver whole place decarbonisation.

28. The programme is designed to work across a range of different areas including, big urban conglomerations, cities, towns, industrial regions, regeneration projects and rural communities. Each of these face different challenges and opportunities in reaching net zero and the programme seeks to identify the economic as well as the social and environmental benefits of delivering integrated Smart Local Energy Systems, not just for the place but also nationally.

29. The government also provides funding to deliver programmes that support decarbonisation through the Local Net Zero Programme (previously known as the Local Energy Programme), which is supporting Local Enterprise Partnerships (LEPs), local authorities, and communities in England to play a leading role in decarbonisation and clean growth. Almost £22 million has been invested in the Local Energy programme to date, including funding for the creation and continuing support of 5 Local Net Zero Hubs. The Hubs promote best practice and support local authorities to develop net zero projects that can attract commercial investment. The Hubs are currently supporting local authorities to develop projects with a potential capital value of over £2 billion and have identified further possible projects that take the potential capital value of the pipeline to over £3 billion.

Heat and buildings

30. Local Authorities have been, and will continue to be, key delivery partners when it comes to improving the housing and building stock across the country, especially through integrating activity on energy efficiency, heating and retrofit. This has been recognised in recent years through their delivery of Green Home Grants, Home Upgrade Grant, and heat networks. As demonstrated in previous chapters (*Heat and Buildings*), local delivery of these schemes has been integral in reducing carbon emissions and supporting local economies. For example, over 200 local authorities have taken part in phase 1 of the Green Home Grants Local Authority Delivery Scheme (LAD) which is focussed on low-income households in homes that most need energy efficiency upgrades. Phases 1 and 2 of the Local Authority Delivery schemes aim to support around 50,000 households who will benefit from energy efficiency upgrades, making it easier and cheaper to heat their homes. Government has also delivered the Public Sector Decarbonisation scheme which provides grants for public sector bodies to fund heat decarbonisation and energy efficiency measures. Under Phase 1 of the scheme, over £500 million was awarded to local authorities.

31. National planning policies already recognise the importance of sustainable development and make clear that reducing carbon emissions should be considered in planning and decision making. The National Model Design Code provides tools and guidance for local planning authorities to help ensure developments respond to the impacts of climate change, are energy efficient, embed circular economy principles, and reduce carbon emissions. The government is considering how the planning system can further support our commitment to reaching net zero. We will make sure that the reformed planning system supports our efforts to combat climate change and help bring greenhouse gas emissions to net zero by 2050. For example, as part of our programme of planning reform we intend to review the National Planning Policy Framework to make sure it contributes to climate change mitigation and adaptation as fully as possible.

Local transport

32. To decarbonise the transport sector, in July, the government published its *Transport Decarbonisation Plan,* which sets out the commitments and the actions needed to decarbonise the entire UK transport system. One of the six strategic priorities of the plan is developing solutions that consider the needs of different locations, highlighting the importance of tackling emissions at a local level to ensure that every place in the UK has its own net zero transport network by 2050, serving the unique needs of its communities.

33. To support this, we will reform the way local transport infrastructure is funded to drive decarbonisation at a local level, engaging local areas about their investment priorities in the round, and making quantifiable carbon reductions a fundamental part of local transport planning. Later this year we will also publish a Local Authority Toolkit to help local authorities reduce emissions from transport. It will provide local authorities with guidance and information to help them build business cases, develop innovative policies, secure funding, and deliver measures on the ground.

Local green infrastructure and the environment

34. Government will launch a new National Framework of Green Infrastructure Standards in 2022. This will support local areas and regions to deliver well-designed green infrastructure where it is most needed to deliver multiple benefits. These networks of green and blue spaces and other natural features, including trees, provide an opportunity to benefit local economies and bring about long-term improvements in people's health and wellbeing. At the same time, it can help us to mitigate and adapt to climate change, through capturing and storing carbon, shading and cooling, and reducing flooding.

35. The Environment Bill is also creating a new system of spatial strategies called Local Nature Recovery Strategies to target action for nature and to drive the use of nature-based solutions to tackle environmental challenges like climate change. It is expected that there will be approximately 50 Local Nature Recovery Strategies covering the whole of England with no gaps and no overlaps. Preparation of each Strategy will be locally led and collaborative, with local government taking a critical role. This will provide local government with a new tool through which they can work with local partners to identify where effort to create or restore habitat would have greatest benefit for climate mitigation, whilst also having positive benefits for nature and the wider environment. Between 2021 and 2027, we will be doubling our overall investment in flooding and coastal erosion to £5.2 billion.

36. In addition, £200 million will be invested in the Innovative Flood and Coastal Resilience Innovation Programme. This will help over 25 local areas over six years to take forward wider innovative actions that improve their resilience to flooding and coastal erosion. The Environment Agency is also working with coastal authorities on a £1 million refresh of Shoreline Management Plans.

A universal offer to harness opportunities across the UK

37. We are committed to supporting all local areas and communities, ensuring that none are left behind and creating net zero solutions which work for all of them. As we are reducing emissions across the economy, we must also ensure that the transition to net zero is a fair one.

38. As outlined above, BEIS has been successfully running the Local Programme (previously known as the Local Energy Programme) to support all local areas capability and capacity to meet net zero and government has committed to continuing the Programme. The programme has developed over time and now takes a place-based approach to tackling net zero in the round, covering all net zero issues. The programme will continue to help places make faster progress towards net zero, improve cost-effectiveness, and significantly increase the economic benefits of the green industrial revolution by attracting commercial investment and supporting green jobs.

39. The programme will focus on all areas of England, including those lacking capacity and capability, or those facing unique challenges, such as rural and coastal communities. The programme will ensure that all local areas can engage on issues relating to net zero.

Case study: Investing in industrial heartlands

The government has invested £95 million for two new offshore wind ports to be constructed in the Humber region and Teesside, boosting the UK's world-leading industry, and creating thousands of new jobs in the North.

Able Marine Energy Park, on the South Bank of the River Humber, will receive up to £75 million government investment, and Teesworks Offshore Manufacturing Centre, on the River Tees, will benefit from up to £20 million. Construction will begin later this year to upgrade the two ports with new infrastructure - helping to revitalise these historic industrial heartlands. Together these new ports will have the capacity to house up to 7 manufacturers to support the development of the next-generation offshore wind projects, boosting the UK's offshore wind manufacturing base while directly creating up to 3,600 new green jobs.

40. The Government has embedded a net zero principle in initiatives which target different types of places, such as the Levelling Up Fund, the Towns Fund, and the Community Renewal Fund. This is to ensure that all funded schemes have considered how to align with our net zero ambitions. We will continue to monitor the impacts of these schemes and strengthen these criteria if necessary. We will take the same approach with other new schemes and priority places such as Freeports. Investment into places through the UK Shared Prosperity Fund should also align with the government's net zero objectives.

41. This year we are working with local businesses on the future role of Local Enterprise Partnerships (LEPs), ensuring local businesses continue to have clear representation and support in their area to drive the green recovery from the COVID-19 pandemic. LEPs have played a significant role in providing advice and incentives for businesses to reach net zero. As part of the LEP review, we are committed to ensuring a strong local business voice is retained, particularly to support businesses to transition to net zero.

42. In England, the government works closely with local government, and Defra hosts the Local Adaptation Advisory Panel (LAAP), a forum for dialogue on climate change adaptation between local authorities, central government, and delivery bodies. This supported the production of a guide on adaptation for local government, published in 2019 by the Association of Directors of Environment, Economy, Planning and Transport (ADEPT).

Case study: the Green Recovery Challenge Fund

The government's £80 million Green Recovery Challenge Fund is kickstarting over 150 nature projects across England. For example, the Wildfowl and Wetlands Trust was awarded £1.58 million to create and restore 130 hectares of nature-rich wetland habitat along the Somerset coast. This habitat will help increase flood resilience, improve soil, water quality, and help absorb carbon, increasing the robustness of the county's coastline overall. The GRCF is also support green jobs and is currently on track to support up to 2,000 jobs by the end of 2021, rising to up to 2,500 by the time all projects are completed in March 2023.

Working with local communities

43. To ensure that all parts of the UK benefit from the transition to net zero we also want local communities to take bold action that supports the transition. Local communities benefit from strong relationships and ties to their areas and their local authorities; these can be key to reducing emissions across the economy and making sure people stay engaged in the process. Where local authorities and communities work together effectively, we have already seen significant improvements in both delivery and in wider public engagement.

44. Some very ambitious campaigns on food, recycling, water, and other areas critical to climate action, have been launched and run by pioneering local communities and activists. Community projects can also act as a catalyst for raising public awareness and promoting green choices.

45. Community groups can bring together people, finance, and ideas to have a real impact on the behaviours, infrastructure, and attitudes locally. Community cohesion and grassroots initiatives are also central to locally based resilience to climate change risks, such as flooding and heatwaves.

46. Government understands the important role that communities have in the transition to net zero. Through the introduction of UK-wide growth funding schemes, such as the Community Renewal Fund, the Levelling Up Fund, and the Towns Fund, Government is enabling local areas to tackle net zero goals in ways that best suit their needs. For example, under the Towns Fund, Clay Cross in Northeast Derbyshire developed a Town Investment Plan setting out their low carbon energy ambitions. Government also works with community groups, both geographic and communities of interest, such as sports clubs, faith groups, and youth groups, on key behaviour change strategies and communications.

Case study: Clay Cross

Clay Cross, in Northeast Derbyshire, was one of the 101 Towns invited to develop a Town Investment Plan. The plan, submitted to Government in October 2020, set out their ambition to establish the town as an exemplar at the forefront of the low carbon revolution. This involved working with established local businesses, including the key local employer Worcester Bosch, to deliver innovation in clean energy and showing the potential to deliver a net zero economy. By 2030 they hope to be able to show significant reductions in the overall levels of emissions by ensuring clean growth principles underpin investment. These ambitions will be realised through a cohort of projects which include the development of a low carbon energy strategy for the town, a low carbon energy demonstrator project linked to the rebuilding of the local leisure centre, low carbon workspace and housing proposals, and a skills and enterprise training centre, which will have an emphasis on providing energy industry related skills.

Community Energy

47. Community Energy is an example of how communities can come together to reach local and national net zero targets. Community Energy England's 2021 *State of the Sector Report* outlined that there are 424 community energy organisations working across the UK to deliver a net zero future and with the appropriate support, they estimate that the community energy sector could contribute up to 5,270 MW, power 2.2 million homes, support 8,700 jobs and add £1.8 billion to the economy each year.[45]

48. Government has provided support to community energy projects through the Rural Community Energy Fund (RCEF), a £10 million fund to supporting community-run projects in England that benefit the energy transition to net zero. The fund has provided development stage grants to projects focusing on a variety of technologies including solar, wind, low carbon heating and electric vehicle charging. Communities have predominantly financed their schemes commercially through share offers and borrowing.

49. The Government has also supported Community Energy England to develop and maintain their knowledge sharing role which includes peer mentoring. This resource can help communities develop their own schemes across heat and power generation, transport, energy efficiency, and also wider approaches to net zero.

Case Study: Cuckmere Community Solar – a world first

Cuckmere Community Solar has an ambition to power the rail network in East Sussex with solar energy – a world first. Working in collaboration with Riding Sunbeams, an innovator focused on decarbonising rail networks, the organisation aims to establish a template for similar projects.

Cuckmere Community Solar plans to build a new 4 MW solar farm at Berwick, East Sussex. This will enable the local community to benefit from a higher income from renewable energy generation, and for the rail network to benefit from cheaper, low carbon power. The Rural Community Energy Fund has provided grant funding for the development stage of the project which includes the cost of studies, land agreements, investigation of the connection point, and legal work.

The project has also recently received capital funding support from the South East Local Enterprise Partnership's £85 million share of the government's Getting Building Fund, which aims to help economic recovery.

50. Ofgem also supports community energy projects and following a consultation process has announced that from February 2022 it plans to welcome applications from community interest groups, co-operative societies, and community benefit societies to the Industry Voluntary Redress Scheme. This will allow groups to apply for funds to deliver energy related projects that support energy consumers in vulnerable situations, support decarbonisation, and will benefit people in England, Scotland, and Wales.

51. To build on our existing actions, we intend to continue to work closely with Community Energy England and will reintroduce the Community Energy Contact Group. Since 2017, this group has been merged in a wider Local Energy Contact Group, but given the scale and pace of work being taken forward, and with the development of the Local Net Zero Forum, we believe that it makes sense to strengthen our engagement with the community sector further by reintroducing a dedicated forum for community groups to engage across Government.

4vi. Empowering the Public and Business to Make Green Choices

Moving towards a net zero society together

Our Key Commitments

- Explore how to improve and enhance public facing climate content and advice on gov.uk. We will also enhance our digitally-led Simple Energy Advice (SEA) service to provide homeowners with personal, tailored advice on improving and decarbonising their homes, including tailored retrofit advice in local areas, and links to local, accredited, trusted installers.
- Continue supporting UK businesses to meet their net zero commitments, including exploring a government-led advice service that consolidates and simplifies advice and other support on net zero.
- Increase awareness of net zero and empower businesses and the public to make green choices, by building on government communications and engagement, and exploring providing environmental impact labelling of products, goods, and services.
- Make green choices affordable and easy by working with businesses and industry to set strong regulatory signals and collaborating to reduce costs and provide better quality, longer lasting and lower environmental impact products, and services.

The challenge

1. Together we are moving towards a net zero society, led by technological innovation. We will see transformations to our economy, society, and the way we live and work: new low carbon technologies, infrastructure and job opportunities; cleaner air, greener spaces and reduced flooding; and changes to everyday life such as in the way we travel, heat our homes and save our money. To reach net zero, everyone will need to play their part. We know that public concern about climate change is high – with 80% in the UK either concerned or very concerned.[46] We also know that people and businesses recognise that change must happen – 80% of respondents in a recent survey believe the way we live our lives will need to change to address climate change.[47] Equally, however we know that the public is unsure of what net zero will mean in practice, what steps they can take, or they face barriers that stop them from acting.[48] This chapter sets out how government will support individuals and businesses to make green choices – an act of choosing the more, or most, sustainable option from a range of possibilities, such as using an electric vehicle instead of a petrol or diesel vehicle when it is time to change your family car, replacing an old gas boiler with a heat pump, or switching to innovative green financial products.

Our Goal

2. Our goal is to make the act of choosing green significantly easier, clearer and cheaper. We recognise that the best way to do this is to go with the grain of existing behaviour and trends and by working closely with partners like Local Authorities, voluntary sector organisations, social enterprise regulators, and businesses, who all play an important role in how we use and choose different services.

The role of green choices in meeting net zero

3. There are numerous individual actions – some one-off and some we take regularly – that people can take to contribute to our pathway to net zero. These individual actions combine to create wider systemic change required to meet net zero. New analysis on green choices,[49] has helped us to identify choices and behaviours that impact on net zero, broadly falling into three categories:

- **Adopting new low carbon technologies,** such as switching to zero emission vehicles.
- **Using energy, technologies, or services more efficiently,** such as using smart meter-enabled 'time of use' tariffs which reward consumers financially for using energy at off-peak times, or when there is excess clean energy available.
- **Everyday business and consumer choices,** such as choosing green financial products like the recently launched NS&I Green Savings Bond, or seeking more responsibly invested pension schemes.

4. We want to better understand the behavioural factors that need to be considered in the policies required to meet net zero. The Government Chief Scientific Adviser and Government Office for Science will be producing a scenario-based foresight report to understand the system wide implications of these factors, to be published in 2022.

Our approach for supporting green choices

5. We know that people want to play their part in achieving net zero. Our approach for how government will empower everyone to make green choices is underpinned by six principles.[50] Although they were developed with the public in mind, many of them equally apply to green choices taken by businesses, particularly medium or small enterprises. The principles reflects wider public engagement from across the country and Parliament.

6. Public engagement, including through communications campaigns such as Together for Our Planet, plays a significant role in driving green choices. We will deliver public engagement on net zero to:

a. Communicate a vision of a net zero 2050, build a sense of collective action, improve understanding of the role different actors play in reaching net zero, and how and when choices can be made;

b. Ensure there is trusted advice and support for people and businesses to make green choices;

c. Mobilise a range of actors and stakeholders to increase and amplify their communication and action on net zero and green choices; and

d. Give people opportunities to participate in and shape our plans for reaching net zero, thereby improving policy design, buy-in and uptake of policies.

Principles underpinning green public and business choices

Principle 1: Minimise the 'ask' by sending clear regulatory signals

7. By targeting measures at an industry level, rather than at the individual consumer, we can make green choices much simpler for the consumer. This will also help grow a stronger market for low carbon goods and give businesses clear, early signals. For example, the 2030 phase out date for petrol and diesel cars and vans sends a signal to industry and will improve the availability and quality of zero emission vehicles on the market. Similarly, as set out in the *Heat and Buildings Strategy* there are a range of policies we will introduce that will bolster the low carbon heating market, creating new opportunities for business, and better choice for the consumer.

8. We are taking action to ensure that products are more sustainable, both in relation to their energy efficiency during use and use of materials over their lifetime (resource efficiency) through developing proposals for new regulatory product standards and better consumer information. We are exploring updating and expanding 'Ecodesign' product regulation which sets minimum requirements to phase out the least energy and resource efficient products from the market.

Principle 2: Make the green choice the easiest

9. By addressing all the major, practical barriers to individual behaviours we can make it easier for people to make green choices. We will ensure that we take a consumer-centred approach to net zero policy design, removing frictions and minimising disruptions to people's lives.

10. In our *Transport Decarbonisation Plan*, we have committed to better integrating transport modes, with more bus routes serving railway stations and improved integration of cycling and walking networks, so that opting to make a green travel choice is easier. This is in addition to delivering interventions to enable more people to walk and cycle for short journeys such as a national e-cycle support programme. Our vision is that half of all journeys in towns and cities will be cycled or walked by 2030. We are also committed to increasing road vehicle occupancy. This will help decarbonise and decongest our roads. We will publish guidance for local authorities on support for shared car ownership and shared occupancy schemes and services and are continuing to build our evidence base to understand the barriers and potential policies to increase the uptake of shared mobility.

11. We are committed to removing inconvenience and increasing availability of green choices. Following the commitments made in our Resources and Waste Strategy, the Environment Bill will introduce powers that will allow us to require separate food waste collections in all local authorities in England, which will help people to reduce emissions from food waste with ease.

Principle 3: Make the green choice affordable

12. We are already seeing the upfront cost of green choices, such as electric vehicles, drop. We are looking across all sectors to see how we can continue this trend and make green choices more affordable.

13. Through the Smart Export Guarantee (SEG) energy suppliers are moving to increasingly innovative tariffs which support electric vehicle deployment while continuing to enable households to access a market-led route for exporting and receiving payment for their unused electricity. As committed to in our *Heat and Buildings Strategy*, the Boiler Upgrade Scheme will provide grants to help households transition to low carbon heating. We are also supporting motorists through plug-in vehicle grants, which provide support towards the upfront purchase of eligible cars, vans, motorcycles, and trucks.

14. We are supporting the public to both save and contribute towards public spending that helps the UK reduce its emissions through the NS&I Green Savings Bond. The Green Finance Institute and Abundance Investment, supported by UK100, Local Partnerships and Innovate UK, have also launched a national campaign to help local authorities issue a type of municipal finance investment – Local Climate Bonds. For citizens, the Local Climate Bond provides a low-risk and fixed return investment, and a way to mobilise their savings to help tackle the climate change in their area.

Principle 4: Empower people and businesses to make their own choice.

15. Consumer preference can shape producers' decisions, but sometimes consumers and businesses lack clear information to make informed choices. As announced by the chancellor in his Mansion House speech in July 2021, we will work with the Financial Conduct Authority to introduce a sustainable investment label - a quality stamp - so that consumers and retail investors can clearly compare the impacts and sustainability of their investments for the first time.

We plan to help empower people to make informed choices about the goods and products they buy and services they use by exploring how we better label these with their emission intensity and environmental impact. We are also exploring the use of product labelling to show the durability, repairability and recyclability of products, as well as their environmental footprint with a view to stimulating demand for better quality items. We continue to explore the evidence base for environmental labelling within food production and disposal, including the most accurate methodologies to monitor and verify the carbon emissions, and environmental impact, of food items.

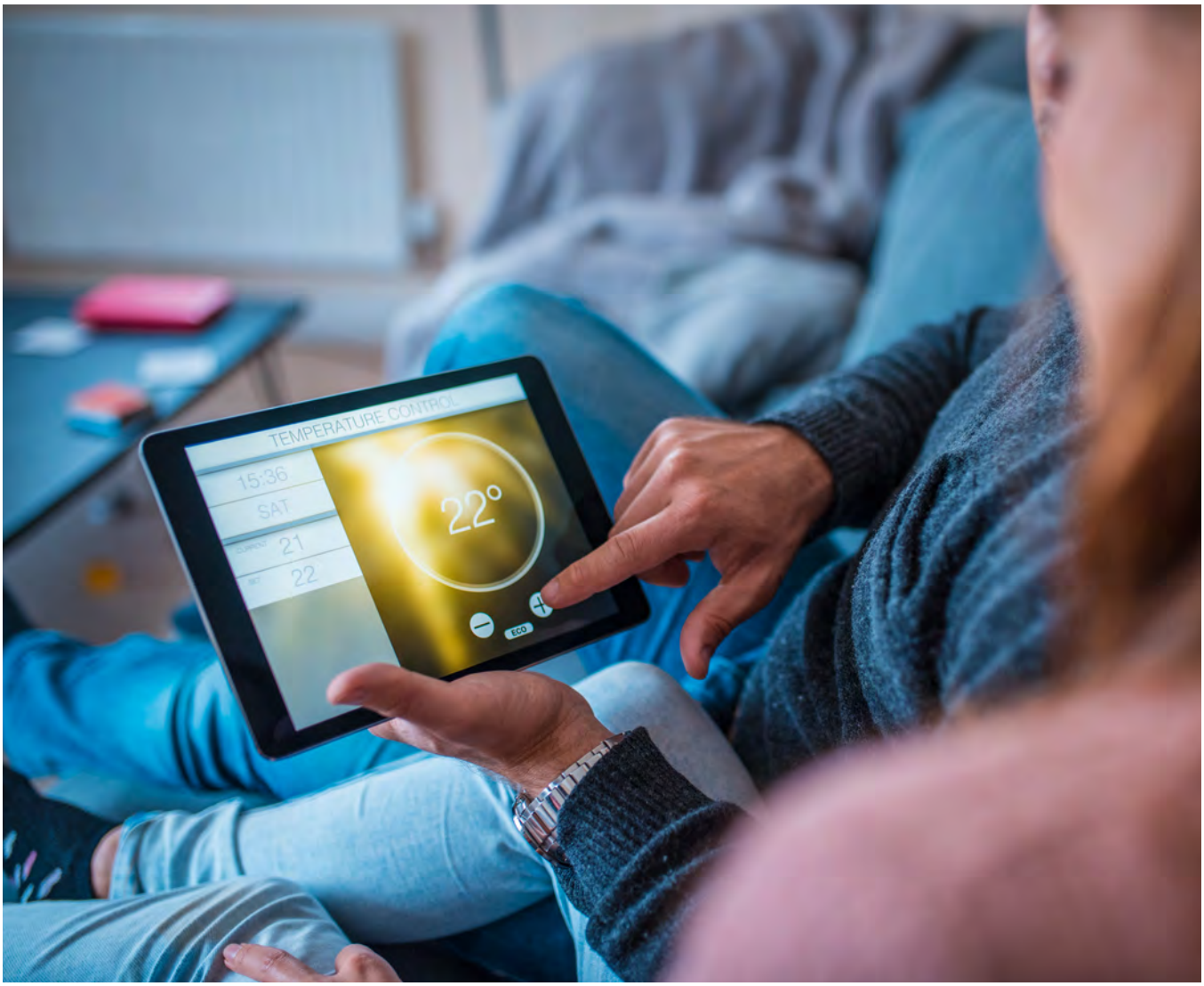
16. Our *Transport Decarbonisation Plan* outlines how we will explore the feasibility of a travel reward scheme that uses peer-driven motivation and encourages individuals to switch to, or continue to use, sustainable modes of travel.

17. We are providing tailored advice and support to homeowners on what they can do to improve their homes. Our Simple Energy Advice service has already had over 1.5 million users, providing homeowners with personal, tailored advice for improving and decarbonising their homes and links to local, accredited, trusted installers. Homeowners can also find out about government schemes

for which they may be eligible. We will enhance the digitally led service and are considering options to support tailored retrofit advice in local areas, supported by tailored local advice. This includes moving our Simple Energy Advice service to gov.uk, which will improve user experience, and supporting local advice provision.

18. We are also reviewing other existing digital information and advice services related to net zero and exploring how to improve wider existing public-facing net zero content and advice on gov.uk

19. We know that technologies can also improve public understanding of energy use and energy efficiency. In-Home Displays for smart meters give accurate information about energy consumption to help households easily understand how to use less energy and save money on their bills. Building on this, the Smart Energy Savings initiative is trialling how innovative products and services can use smart meter data to provide consumers with advice on how to manage their energy use. At the end of June 2021, there were 25.2 million smart and advanced meters in homes and small businesses across Great Britain.[51]



Principle 5: Motivate & build public acceptability for major changes

20. Achieving our net zero target must be a shared endeavour. It is therefore vital that we listen to the publics views on how to reach net zero. We already regularly invite the public to shape policies on net zero through consultations and deliberative dialogues. Since 2019, we have run, funded, or are still running deliberative dialogues on a range of net zero issues, such as green choices, homes, heating, transport decarbonisation, green savings, hydrogen, food, Carbon Capture Use and Storage (CCUS) and Advanced Nuclear Technologies (ANT).

21. To ensure that the transition to net zero is fair and affordable, and does not negatively impact disadvantaged groups, we are committed to assessing the impact of our net zero policies. We consult on policy changes and we will continue to make it easier for people and businesses, including those who are most marginalised, to feed into key policy decisions on net zero.

22. The Devolved Administrations have a range of initiatives aimed at engaging and motivating the public around net zero and climate action:

a. The Scottish Government launched a draft *Public Engagement Strategy for Climate Change* in December 2020, and the final report of Scotland's Climate Assembly was laid in Scottish Parliament in June 2021.

b. The *Welsh Government Engagement Approach for Low Carbon Delivery Plan 2* was published in June 2021, encouraging collective action on climate change through four Calls to Action.

c. In March 2021, the Northern Ireland Executive unveiled a new digital climate action campaign, delivered by MyNI in the run up to the COP26 conference. It aims to raise climate awareness, encourage change, enable action, and exemplify climate leadership.

Principle 6: Present a clear vision of how we will get to net zero and what the role of people and business will be

The role of business in delivering net zero

Businesses have significant power to drive change towards achieving our domestic net zero goal. Our approach to supporting businesses to deliver this change will need to be differentiated by business size and sector, as these factors will influence the ease with which a net zero target and other relevant actions can be adopted. We have seen significant numbers of companies signing up to science based targets alongside sector-specific ambition being put forward already. For example, Water UK has launched the world's first sector-wide plan to deliver net zero carbon emissions by 2030.

We know that businesses account for 18% of UK territorial emissions and so encouraging them to take action to reduce their emissions is important.[52] But just as vital is the role businesses are playing in designing the ground-breaking new technologies, world leading products and innovative approaches that we need to develop the low carbon economy and enable others to reach net zero. Collaboration across sectors and value chains will enable us to innovate faster, create stronger incentives for investment and drive down costs for low carbon alternatives through the global mechanisms laid out in the Paris Agreement.

To underline the importance of this area, the Prime Minister appointed a net zero Business Champion, Andrew Griffith MP, to spearhead business engagement nationwide in the year to COP26. Already over half of the FTSE100 companies have committed to Science-Based Targets by joining the global Race to Zero campaign. Alongside engaging large corporates, the Net Zero Business Champion has led a campaign targeting small and micro businesses across the UK. Over 1,900 have joined the Race to Zero to date by visiting the Business Climate Hub, developed in partnership with a global business coalition led by the International Chambers of commerce. Companies, particularly large businesses, once they have joined the Race to Zero, should work with others to drive breakthroughs in their sectors, regions, and support SMEs in their value chains to take action. We're encouraging Business Representative Organisations (BROs) to become Race to Zero Accelerators by recruiting members into the Race to Zero. To be recognised officially as an Accelerator, businesses must recruit at least 20% of members not already in Race to Zero by COP26.

Many businesses across the UK have said they want to tackle climate change, but that they don't know where to start[53]. Through the small business campaign, government has taken an important step towards making net zero relevant to SMEs by helping them access the support they need. Beyond COP26 we will continue to support UK businesses to meet their net zero commitments, including exploring a government-led digital advice service that consolidates and simplifies advice, funding, and other support on net zero.

For larger businesses, we want to ensure businesses are aware of their energy and carbon use so they can take action towards reaching net zero. Climate risks must be assessed and disclosed through the Task Force on Climate-related Finance Disclosures (TCFD). This is complemented by Streamlined Energy and Carbon Reporting, which requires energy and emissions reporting in all UK large businesses to improve awareness of energy costs. We also require large businesses and their corporate groups to carry out a broader assessment of their energy use from buildings, transport and industrial processes every 4 years under the Energy Savings Opportunity Scheme (ESOS), which is designed to identify practicable and cost-effective energy saving opportunities. In the future building users and decision makers will be able to compare the performance of their buildings to other similar buildings using a performance-based energy rating to support targeted investments.

Government will work in partnership not just with businesses themselves, BROs, sector-based trade associations, business groups in the Devolved Administrations and local and regional organisations to translate the pathways within this strategy into business specific plans to reach net zero.

23. Supporting people to make green choices will be a collective effort between government, businesses, voluntary sector, social enterprise and community groups, local authorities, media organisations and others. However, we know that others look to Government to set the narrative on how we should get to net zero and what people's role will be.

24. We will build on government communications and engagement on net zero to increase awareness of how we plan to deliver the net zero target in the UK. Building on the momentum of COP26, the Together for our Planet campaign is showcasing how people across the UK are going "One Step Greener" to tackle climate change - from the engineers working on the offshore wind farms now powering our homes and businesses, to local initiatives encouraging children and parents to walk to school. The campaign demonstrates that taking a single step can have a positive impact on the environment, using the inspiring stories of 26 One Step Greener Ambassadors who are playing their part for the planet - be it by walking to work, repairing their clothes, or reducing their food waste - to encourage others to join them. The 'One Step Greener' Ambassadors come from all walks of life in their pursuit of a greener future and demonstrate how going one green step can culminate in a large collective impact in helping to make the UK a more sustainable place.

25. We will build on the success of Together for Our Planet, through which the UK business community is demonstrating global leadership in efforts to combat climate change, with over 1,900 SMEs signed up to reach net zero by 2050. Up and down the country, local high street shops are proudly displaying their climate leadership by sharing their net zero journey on social media. Examples include Caribe Coffee, a family run coffee business in Northumbria, John Sankey, a sustainable furniture maker in Derbyshire, and SilverHare, a jewellery maker in West Cornwall. In doing so, they are acting as changemakers in their local communities. The focus of the campaign in the run-up to COP26 has been on encouraging business to make net zero pledges. After COP26, we commit to continuing to support businesses to meet their commitments whilst developing their climate resilience.

4vii. International Leadership and Collaboration

Accelerating the global transition to a resilient net zero future

Our Key Commitments

- Increase global climate action through our push for global net zero, including our COP26 Presidency objective to keep 1.5°C within reach. As part of this, strengthen international collaboration in key sectors including by working with others to accelerate the innovation and deployment of clean technology and continue to convene the Zero Emission Vehicle Transition Council, the Energy Transition Council, the FACT dialogue, and other flagship initiatives that will be announced at COP26.
- Deliver against net zero on a trajectory in line with the Paris Agreement, decreasing UK emissions by at least 68% by 2030 as set out in our Nationally Determined Contribution,[54] 78% by 2035 compared to 1990 levels in line with our Sixth Carbon Budget.
- Double our International Climate Finance to at least £11.6 billion between 2021 and 2025 to support net zero support adaptation and build resilience internationally. Within this, invest at least £3 billion in solutions that protect and restore nature, and £200 million at a minimum to help countries access technical exprtise to limit emissions and build back greener.
- Drive international innovation in key low carbon technologies through Mission Innovation, including co-leading the Green Powered Future and Clean Hydrogen Missions.
- Lead by example internationally on inclusive climate policies, Action for Climate Empowerment and support for the UNFCCC Gender Action Plan.
- Set out a clear vision and priorities to guide UK international climate and nature action in the coming decade through a 2030 Strategic Framework, and publish a refreshed Export Strategy outlining HMG support for exporters in the low carbon economy.

The challenge

1. Meeting our shared objective of avoiding dangerous climate change requires a dramatic, global acceleration of progress towards net zero CO_2 emissions by mid-century and net zero greenhouse gas emissions (GHG) by around 2070.[55] Over 2020-21 there has been considerable progress, with all G7 countries, over half of the G20, and around 75% of global emissions now covered by net zero targets. However, the world is still not on track to reach the Paris Agreement temperature goal, which aims to limit global warming to well below 2°C and pursue efforts to limit warming to 1.5°C, compared to pre-industrial levels. More must be done to turn these targets into immediate action.

2. UK emissions account for about 1% of the global total.[56] To accelerate progress towards a resilient net zero future, we need to play a prominent role in promoting collective global action, working together to ensure the transition is quicker, cheaper, and easier for all building on a strong foundation of domestic action.

3. The transition to net zero must be supported by a joined-up approach to halting biodiversity loss. The two are inextricably linked: the greatest drivers of biodiversity loss, land use change and agriculture are also responsible for approximately one fifth of global GHG emissions. Simultaneously, climate change itself is a direct driver of biodiversity loss, and terrestrial and marine ecosystems act as carbon sinks for human-driven CO_2 emissions.[57]

Our goal

4. As set out in the *Integrated Review of Security, Defence, Development and Foreign Policy* (the Integrated Review), tackling climate change and biodiversity loss is the number one international priority for the UK for the coming decade.[58]

5. As the world recovers from the COVID-19 pandemic our actions must be aligned with the Paris Agreement to ensure a fair and inclusive ransition to net zero. This includes enhancing adaptive capacity, strengthening resilience, and reducing vulnerability to climate change.

6. The international emissions reductions required to keep 1.5 degrees warming within reach are only achievable if the international community works together. And by working together, we can create stronger incentives for investment, we can innovate faster, we can achieve economies of scale more quickly and we can create level playing fields. This international collaboration will make the transition to net zero cheaper, faster, and more accessible for all countries. This is not a matter of shouldering a burden between us, but of sharing an opportunity. It will support the UK's own transition and stimulate UK jobs and prosperity.[59] Over the past decade alone, we have seen over an 80% drop in the costs of clean energy technologies thanks to technology innovation, learning-by-doing, and greater deployment at scale domestically and globally.[60]

7. Collaboration across borders and society is a key aim for our COP26 and G7 Presidencies. Beyond these, we will continue to advocate for enhanced international collaboration, and coordinate action across science, innovation, finance, and trade.

Delivering our Paris Agreement commitments

Mitigation

8. Parties to the Paris Agreement shall communicate ambitious short-term targets to reduce greenhouse gas (GHG) emissions through Nationally Determined Contributions (NDCs) and should strive to underpin these targets with credible pathways set out in Long Term Strategies (LTSs).

9. The UK's NDC commits us to reducing our economy-wide GHG emissions by at least 68% by 2030, compared to 1990 levels.[61] This strategy sets out the UK's plans to deliver on the NDC and reach net zero by 2050 and will be submitted to the UNFCCC as our revised LTS under the Paris Agreement.

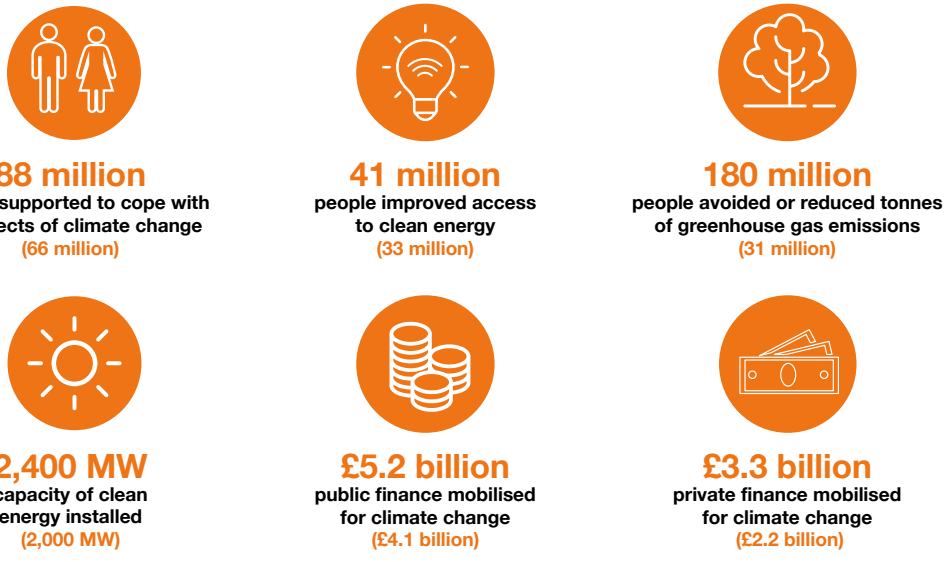
International Climate Finance (ICF)

10. The UK's ICF helps over 100 developing countries mitigate and adapt to the impacts of climate change. This includes supporting countries' resilience to the damaging effects of climate change, accelerating the clean energy transition, supporting low carbon infrastructure, and investing in climate change solutions that protect and restore nature and biodiversity.

11. The UK has committed to doubling our ICF to at least £11.6 billion between 2021-2025, including at least £3 billion for nature and biodiversity.[62] This forms part of an ambition by developed countries to mobilise $100 billion in climate finance annually. We have also committed to aligning all UK Official Development Assistance (ODA) with the Paris Agreement and ensuring that all new UK bilateral aid spending does no harm to nature. This delivers on our Integrated Review objective of investing in a nature-positive economy.

2021 cumulative UK ICF Achieved results

(2011-2021, last year's in brackets)



Source: BEIS analysis (2021)

12. UK ICF is stimulating a shift in private finance mobilisation for climate action from the billions to the trillions. Between 2011 and 2021, UK ICF mobilised £3.3 billion of private finance for climate change purposes in developing countries.[63] We target investment in dveloping economies with the highest potential to accelerate the global transition to net zero, ensuring that everyone can share the opportunities of clean growth sooner.

13. We support the work of key multilateral funds and have significant bilateral programming drawing on UK experience and expertise, enabled by the diplomatic work of our climate, energy and environment attaché network embedded in UK Embassies and High Commissions. UK Partnering for Accelerated Climate Transitions (UK PACT) is supporting developing countries with potential for high emissions reductions to build the knowledge and expertise required to both develop and implement the ambitious plans needed to limit emissions and realise the opportunities of clean growth.

14. For all new and existing International Climate Finance programmes, we will ask delivery and monitoring partners to include analysis of the impacts of programmes on certain groups of people to manage any negative impacts.[64]

Case study: UK-Colombia Partnership for Sustainable Growth

Through our Partnership for Sustainable Growth, the UK is working with Colombia to help drive real world emissions reductions and global climate ambition. The partnership and UK programmes are supporting Colombia to reduce deforestation, accelerate the energy transition, and conserve biodiversity. For example, UK technical assistance helped deliver Colombia's first renewable energy auction in 2020 – which will increase solar and wind capacity in the country from 50 MW to nearly 2,500 MW – as well as the development of the country's strategic planning for a low carbon energy sector through skill-shares with UK experts. Our strong climate partnership has also supported increased ambition in line with the goals of the Paris Agreement and a net-zero future, with Colombia committing in 2020 to cut 51% of greenhouse gas emissions by 2030, compared to a projected scenario.

15. Climate change disproportionately affects the world's poorest and can exacerbate economic and social disparities. However, local communities and indigenous knowledge systems can also play a key role in solutions.

16. As part of our incoming COP26 Presidency, the UK has developed a framework that aims to guide investment towards a global net zero transition that also supports the UN's Sustainable Development Goals. The framework will indicate how support for developing countries and emerging economies can accelerate climate ambition and enable a global green recovery in an inclusive way. This is the first time donor countries will have set out how they will support this transition, including through financial flows for quality local jobs in the most vulnerable communities.

17. Low carbon transitions should be fair and affordable and not negatively impact disadvantaged groups.[65] We are committed to monitoring the impacts of our climate and clean energy policies, and any disparities which arise, to assess the need for targeted support for disproportionately impacted groups, in line with the UNFCCC Gender Action Plan and domestic law.

Influencing global action

COP26 Presidency

18. The four goals of our COP26 Presidency are: (1) mitigation to secure global net zero by mid-century to keep 1.5°C within reach; (2) adapting to protect communities and natural habitats; (3) mobilising finance and (4) collaboration: working together to deliver, finalising the Paris Rulebook and accelerate action to tackle the climate crisis through collaboration between governments, businesses, and civil society.

19. There will also be a renewed focus on accelerating near-term action in the top priority areas of coal phase out, zero-emission vehicles, climate finance and halting deforestation. We will ask countries to sign up to initiatives under each goal:

- **Coal:** to push for an immediate end to new unabated coal power and international coal financing, and the scaling up of low carbon power to rapidly move away from existing coal.
- **Trees:** to halt natural forest loss by 2030 and restoring millions of hectares of degraded landscapes and forestlands. This is alongside improving governance and increasing forest finance.
- **Cash:** developed countries to make good on their promise to mobilise at least $100 billion in climate finance per year through to 2025.
- **Cars:** to accelerate the shift to zero emission vehicles (ZEVs), pushing for all new car sales in leading markets to be ZEV by 2035.

20. Our COP26 Presidency has defined five areas vital to a zero-carbon future: energy transitions, clean transport, nature-based solutions, adaptation and resilience, and, tying it all together, finance. We are working with those affected by climate change and with wider civil society to harness innovation and commitment in these areas and will continue this work throughout our COP26 Presidency year up to November 2022.

Case study: 2020 Climate Ambition Summit

A major milestone ahead of COP26 was the 2020 Climate Ambition Summit, co-convened by the UK, UN, and France, in partnership with Chile and Italy. This landmark event demonstrated how we can help drive collective ambition by combining major domestic commitments with diplomatic engagement, working closely with multilateral organisations and international partners.

Achievements included more ambitious Nationally Determined Contributions (NDCs) from 45 leaders. We also saw 24 countries announce new commitments, plans or strategies to reach net zero, and a UK announcement on ending direct government support the for fossil fuel energy sector overseas. When the UK was confirmed as host of COP26, less than 30% of global GDP was signed up to net zero or carbon neutrality commitments. Again, thanks in part to UK leadership, that figure is now over 80% - and rising.

We will continue to encourage all countries to set targets to get to net zero by 2050, and more ambitious 2030 emissions reduction targets to get us there. We are also encouraging countries to publish Adaptation Communications or National Adaptation Plans. We will use COP26 and our Presidency year to turn these commitments into action to make the next ten years the decade of delivery.

G7 Presidency and G20

21. Under our 2021 G7 Presidency, members committed to becoming 'a net zero G7 by 2050 at the latest'; ensuring a green recovery from COVID-19 that is sustainable, resilient, and inclusive; phasing out new direct government support for international fossil fuel energy, and pursuing commitments to support those most vulnerable to the impacts of climate change and environmental degradation. These have helped to lay the foundation for COP26.

22. As inclusivity was at the heart of the UK's G7 Presidency, these commitments are underpinned by pledges to support affected workers and sectors so that no person, group, or geographic region is left behind.

23. As part of our G7 Presidency, the UK hosted several follow-up workshops including on Net Zero Sectors and the Industrial Decarbonisation Agenda (IDA). G7 members supported the idea of using the IDA to unlock market potential through high-level G7 government coordination and collaboration on ambitious industrial decarbonisation initiatives. Driving international cooperation on decarbonisation will help to diffuse 'first mover' risks and address carbon leakage risks at the outset. The IDA is due to be integrated into the rotating G7 Presidency with Germany taking ownership in 2022. During the rest of our G7 Presidency, we will work with our partners to consider how best to coordinate efforts on the pricing of carbon to mitigate emissions, and to explore international solutions to prevent carbon leakage, helping us deliver the transformational change required by the Paris Agreement.

Key G7 climate commitments

- Submitting net zero-aligned NDCs to 2030 and LTSs to 2050 ahead of COP26;
- Reaffirming the collective developed country goal to jointly mobilise $100 billion per year through to 2025;
- Increasing adaptation finance, including a commitment to submit adaptation communications ahead of COP26;
- Accelerating the transition away from unabated coal capacity and to an overwhelmingly decarbonised power system in the 2030s;
- Ending new direct government support for unabated international thermal coal power generation by the end of 2021, alongside phasing out new direct government support for international fossil fuel energy as soon as possible;
- Increasing the pace of the global decarbonisation of the road transport sector throughout the 2020s and beyond;
- Decarbonising hard-to-abate sectors, including through a new UK-US-led Industrial Decarbonisation Agenda;
- Launching a new partnership to modernise development finance tools to build back better for the world, including for resilient infrastructure and technologies to address the impacts of climate change;
- Pledging cooperation on the risk of carbon leakage and to aligning trading practices with the Paris Agreement; and
- Recognising the potential of carbon pricing to foster emission reductions, while ensuring environmental and social considerations are accounted for.

24. The G20 includes both developed and developing nations. Its members are jointly responsible for approximately 80% of global emissions[66] and more than 80% of global GDP[67]: it must play a leading role in global efforts to tackle climate change. In July 2021, UK Climate and Energy Ministers met with their G20 counterparts in Naples to agree to accelerate action in the 2020s, to submit ambitious 2030 targets by COP26, and to urge each other to develop long term strategies in line with keeping the 1.5°C temperature goal within reach. The UK will advocate for further action from the G20 to meet the commitments of the Paris Agreement. The Leaders' Summit in Rome in October, on the eve of COP26, will be a crucial moment to build consensus for urgent and ambitious action on climate change and the clean energy transition.

Facilitating a global transition

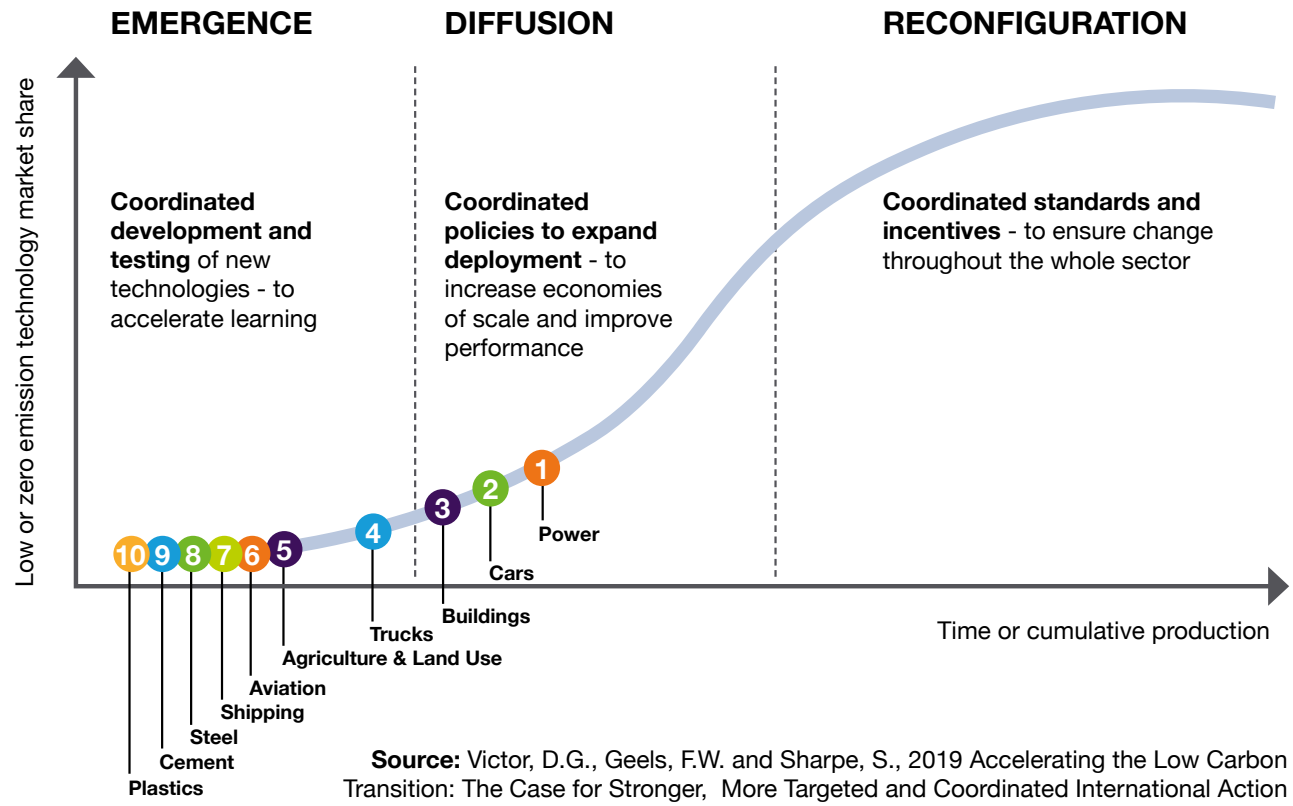
25. The global move to a green and net zero economy will require accelerated transitions across all major emitting sectors – including power, transport, buildings, industry and agriculture, forests and land-use. All countries, including the UK, can benefit from greater collaboration to help achieve their net zero targets more quickly and more cheaply.

26. Across the global economy, different sectors are experiencing the transition at different speeds (see infographic below for one interpretation of the progress by sector). International collaboration focused at the sector level can accelerate action towards our global goals, which is why it is a key focus for the UK. This includes delivering faster innovation through coordinating on research, development, and demonstration of clean technologies, as well as faster deployment of technologies, by coordinating on policy, finance, and trade measures to create new demand, economies of scale, and supply chains for clean technologies.

27. Collaborative action also sends clearer market signals to businesses and consumers about the global direction of travel. This confidence in a credible global net zero pathway is especially important for the harder to abate sectors, such as heavy industry, where we know that the pace of emissions reduction will progress more slowly up to 2030. However, action is needed in these sectors now to lay the significant groundwork required to set the path for future emission reductions.

28. We will therefore continue to work with countries to accelerate sectoral technologies at COP26 and beyond – including continuing to convene the Zero Emission Vehicle Transition Council, the FACT Dialogue, and the Energy Transition Council – as well as working with partners to set a common vision for the next decade of clean technology innovation and deployment at COP26.

Figure 30: The sectoral S-curve



Source: Victor, D.G., Geels, F.W. and Sharpe, S., 2019 Accelerating the Low Carbon Transition: The Case for Stronger, More Targeted and Coordinated International Action

Case study: COP26 Energy Transition Campaign

Our COP26 Energy Transition Campaign will help accelerate the global transition from coal to renewables, enabling the energy sector to achieve net zero. The UK is working through the Powering Past Coal Alliance (PPCA) and the Energy Transition Council (ETC) up to, and beyond, COP26. This will strengthen the coalition of countries, sub-national governments, and businesses phasing out unabated coal power and reduce international coal finance.

Solar and wind power are now cheaper than new coal and gas power plants in two-thirds of the world.[68] The Energy Campaign will bring together countries, development banks, investors and civil society to strengthen low carbon power investment and assistance so that it is viable for every country.

The UK has also worked with the IEA to launch a COP26 Product Efficiency Call to Action, to double the efficiency of four key products (air conditioners, refrigerators, industrial motors, and lighting) by 2030. These four products combined currently account for more than a third of global electricity consumption. Global action to improve product efficiency will lead to a significant reduction in the energy sector's carbon emissions.

The UK driving inclusive climate action

29. We will drive forward our commitment under the 'Equal by 30 Campaign' to work towards equal pay, leadership, and opportunities for women in the global clean energy sector by 2030, and champion increased gender representation across the UK's international organisations.

30. The UK remains committed to strengthening the evidence base and understanding of differentiated impacts of climate change on men and women, the role of women as agents of change and on equal opportunities for women. We continue to support amongst other things, increasing the proportion of women and girls in decision-making and leadership positions, supporting their access to finance, education, building their resilience to climate change, and improving data on gender and inclusion.

Science and innovation

31. Science and innovation are essential to achieve global climate goals. The UK will continue to work closely with countries to drive innovation, research, and aligned policy to ensure that clean technologies become cheaper and more readily available. The UK will also continue to promote the vital role of the Intergovernmental Panel on Climate Change (IPCC) and other scientific research, ensuring the best available science is accessible and understood by all, enabling informed decision-making across the world.

32. The UK will continue to use its world-leading position in climate-related science and innovation to build global multidisciplinary networks and facilitate knowledge exchange to support effective global climate action through initiatives such as Mission Innovation, the Adaptation Research Alliance, and the Visions for a Net-Zero Future project.

Case study: Mission Innovation

The UK has played a leading role in Mission Innovation (MI) since it launched at COP21 as the primary intergovernmental forum focused on clean energy innovation essential to achieving net zero. We have more than doubled our MI baseline clean energy innovation spend over the past five years, exceeding our MI commitment.

The second phase of Mission Innovation (MI 2.0) was launched in June 2021, bringing together countries responsible for more than 90% of global R&D clean energy investment and committed to a decade of action and investment in innovation for clean energy solutions. Commitments included developing National Innovation Pathways describing enhanced ambition to pioneer clean energy technologies and sectors.

The UK is co-leading two of the three Missions. Launched as part of MI 2.0, The Green Powered Future Mission is bringing together governments and businesses to enable the transition to variable renewable power. The Clean Hydrogen Mission aims to make clean hydrogen cost competitive. The UK is also participating in the Zero-Emission Shipping Mission which aims for ships capable of running on zero-emission fuels to comprise at least 5% of the global deep sea fleet by 2030.

Trade

33. The whole system shift that will be required for the UK to reach net zero will also mean changes to how and what we trade. Taking a leading role in the global shift to net zero presents a significant economic opportunity for the UK. Estimates suggest the UK's low carbon economy could deliver up to £170 billion of export sales of goods and services by 2030.[69] The UK will seek to improve market access for green goods and services through our trade policy, our growing array of free trade agreements (FTAs) and our seat at the World Trade Organization (WTO). For example, when we exited the EU, we unilaterally removed tariffs on over 100 additional products used in renewable energy generation, energy efficiency, carbon capture, and the circular economy as part of the UK's Global Tariff.[70]

34. We will seek to reaffirm our commitment to the Paris Agreement in all UK trade agreements and will ensure that they preserve our regulatory autonomy to pursue our climate targets including our Carbon Budgets, enhanced 2030 NDC and 2050 net zero commitment. We will use our multilateral fora to galvanise international partners to adopt climate-ambitious trade policy, and to promote global trade rules that are aligned to net zero and the Paris Agreement, for example through the WTO committees and the new Trade and Environmental Sustainability Structured Discussions.

35. While there are significant opportunities for UK trade to support our climate and nature ambitions as we transition to net zero, it is important we ensure that our policy interventions support global emissions reductions. The UK is at the forefront of measuring and publishing statistics of emissions generated overseas in the production of goods and services consumed by UK residents. We recognise there is much more to do on consumption emissions globally which is why we are urging and supporting other countries to raise ambition on climate change, including on effectively pricing carbon, as well as considering this issue as we negotiate new FTAs.

36. Decisions on the liberalisation of partners goods must account for their environmental and climate impact. Where there is evidence that liberalisation could lead to significant carbon leakage the case for maintaining tariffs or pursuing conditional market access, through clauses on standards or eco/carbon intensity, should be carefully considered.

37. We will publish a refreshed Export Strategy by the end of 2021. The Strategy will help deliver jobs and growth and maximise export opportunities for green UK technologies and innovation. It will also support our transition to net zero, enabling the UK to take advantage of the window to boost UK competitiveness in key low carbon technologies, services and systems. The Strategy will also help developing countries mitigate and adapt to climate change and nature loss by reducing trade barriers to help them benefit from the green transition.

38. UK Export Finance is also expanding its suite of green products and published the UK Export Finance Climate Change Strategy in September 2021. The UK is also one of the founding signatories of the Export Finance for Future initiative, a coalition of countries which endorsed a statement of principles to better integrate climate in export finance.

Finance

39. At COP26 the UK is working to achieve the finance goal, agreed in Article 2.1.c of the Paris Agreement, to make finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development. The UK Presidency published our Priorities for Public Finance earlier in 2021, and Priorities for Private Finance in 2020.[71]

40. Following COP26, the UK will continue to strive for greater ambition on finance. Achieving the global transition requires renewed action from all stakeholders to support the needs of developing countries. From the global to the local level, we need to put in place the conditions for a sustainable recovery and climate action, creating the right investment environments and aligning national budgets and planning processes with the goals of the Paris Agreement and 2030 Sustainable Development Agenda.

41. However, international public finance alone will never be enough to achieve the trillions of investment needed and put the world on a sustainable footing; the private sector will be key. Achieving net zero and our finance goals requires changes from the whole economy – we need every company, bank, insurer, and investor to adjust their business models, develop credible plans for the transition and implement them.

UK global climate action beyond COP26

42. Beyond our COP26 and G7 Presidencies, and the commitments outlined in this chapter, the UK will continue championing the fight against climate change and biodiversity loss internationally and at home in the decade to come.

43. The UK COP26 Presidency will formally begin at the Summit in November 2021 and run until COP27 in November 2022. Throughout our Presidency year, we will build on the outcomes from COP26 and the COP26 campaigns, including further strengthening the architecture for collaboration in key sectors, and work with international partners to keep the 1.5°C temperature goal alive. This entails continuing to advocate for our four Presidency goals with a focus on progress against our agreed targets in critical sectors and building the conditions for further ambition and a successful Global Stocktake in 2023.

44. Building on our COP26 Presidency, we are developing a 2030 Strategic Framework due to be published in 2022. The Framework will provide a coordinated approach to deliver against the climate and biodiversity commitments set out in the Integrated Review. It will also establish a common vision and clear priorities to guide UK international climate and nature action over the next decade. The UK will continue to play a leadership role in delivering the change needed by capitalising on our areas of strengths including diplomacy, finance, science, technology and innovation, trade, and domestic leadership.

45. On top of the 2030 Strategic Framework, we will aim to mobilise greater finance for nature, tackle the key drivers of biodiversity loss, and deliver against the targets contained in the post-2020 Global Biodiversity Framework.

46. The upcoming International Climate Finance Strategy will set out how we will use our £11.6 billion ICF to deliver transformational programmes in support of mitigation and adaptation action in developing countries across the four themes of clean energy, nature, resilience, and infrastructure.

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9 This diagram is not an entirely accurate representation of the stages of development at which these institutions and funds intervene and it is simplification of the varied programmes and impacts they have on different sectors, businesses and technologies. However, it demonstrates roughly where these government interventions have greatest impact and have a key role to play in delivering economy-wide net zero solutions.

10 Mark Carney and the COP26 Private Finance Hub – in partnership with the UNFCCC Climate Actions Champions and the Race to Zero campaign and the COP26 Presidency- have launched a coalition that combines existing and new net zero finance initiatives into a wider strategic forum: The Glasgow Financial Alliance for Net Zero (GFANZ). GFANZ aims to raise ambition in the financial sector by allowing firms to demonstrate collective commitment to net zero.

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Technical Annex

Technical Annex

UK carbon budgets and international emissions targets

Climate Change Act

1. Parliament passed the Climate Change Act[1] (the Act) in 2008, establishing the UK's 2050 target and the supporting framework of carbon budgets. The Act also established the Committee on Climate Change, now the Climate Change Committee (CCC), an independent statutory body, to advise the Government and the Devolved Administrations on setting and meeting carbon budgets. The CCC advises on the level of each budget, the respective contributions that different sectors could make and the extent to which carbon budgets could be met through the use of permitted "flexibilities" (such as surpluses from previous carbon budgets or the purchase of good quality international carbon credits).

2. Under the Act, the UK was legally required to reduce greenhouse gas emissions by at least 80 per cent by 2050 on 1990 levels. In 2019, on advice of the CCC[2], the UK committed to reaching net zero emissions by 2050 and consequently the target reduction in the Act was increased to at least 100%.

3. To keep the UK on a pathway to achieving the 2050 target, the Government is obliged to set legally binding, five-year caps on emissions – carbon budgets – twelve years in advance and then to publish a report setting out policies and proposals for meeting that budget and those budgets previously set.

4. The Net Zero Strategy is the means by which we satisfy the requirements of the Act in relation to policies and proposals for meeting the current carbon budgets.[3]

Legislated carbon budgets

5. Six carbon budgets have been set to date, covering 2008 to 2037. The sixth carbon budget, the first to be decided under the UK's new net zero target, was set in June 2021. The UK has already met, and overachieved, its first (2008-2012) and second (2013-2017) carbon budgets, and is on track to meet its current third (2018-2022) carbon budget.[4]

6. To show how we will meet our climate targets, including legislated carbon budgets up to and including the sixth carbon budget, the Net Zero Strategy contains both an indicative delivery pathway and illustrative 2050 net zero scenarios. The pathway, which stretches to the end of the Sixth Carbon Budget period in 2037, provides an indicative trajectory of emissions reductions which we aim to achieve through the Strategy and through delivery of the policies and proposals outlined. It therefore indicates the timescales over which we expect those policies and proposals to take effect to deliver our targets. The pathway is designed to be broadly consistent with all three of the illustrative 2050 scenarios set out in the Journey to Net Zero chapter of the *Net Zero Strategy*. There is uncertainty associated with our decarbonisation pathway through to 2037 and the 2050 scenarios – the exact path we take to meet our climate targets is likely to differ and must respond flexibly to changes that arise over time.

International emissions targets

7. The 2015 Paris Agreement[5] under the UN established the goal of keeping the global mean temperature rise to well below 2°C, whilst pursuing efforts to limit the rise to under 1.5°C. Under the Kigali amendment to the Montreal Protocol, the UK has also committed to reducing F-gas emissions by 85% on 2011-2013 levels by 2036.

8. Under the Paris Agreement, the UK announced its Nationally Determined Contribution (NDC) in December 2020, which commits the UK to reduce net greenhouse gas (GHG) emissions by at least 68% by 2030 compared to 1990 reference year levels.[6] This represents an increase of ambition on the fifth carbon budget, which covers the years 2028-2032.

9. The UK will therefore need to overachieve on the fifth carbon budget to meet its international climate targets and stay on track for the sixth carbon budget. Accordingly, the policies and proposals, delivery pathway, deployment assumptions and any other analysis presented in the Net Zero Strategy for the fifth carbon budget period are consistent with the action required to meet the UK's 2030 NDC.

10. The Net Zero Strategy also constitutes the UK's updated Long-Term Low Greenhouse Gas Emission Development Strategy for the purposes of the Paris Agreement.

Accounting for UK emissions

The UK greenhouse gas inventory

11. The UK's performance against its 2050 target and carbon budgets is assessed through the UK's net carbon account,[7] measured in tonnes of carbon dioxide equivalent (tCO_2e). The net carbon account comprises GHG emissions from the UK net of emissions which are captured and stored from land use, land-use change and forestry (LULUCF). The UK greenhouse gas inventory[8] is the basis for calculating the UK's domestic greenhouse gas emissions. Performance against a carbon budget is assessed against the earliest GHG inventory that covers the whole of the carbon budget period, which is published two years after the carbon budget period in question ends. For example, the sixth carbon budget will be assessed in 2039 based on the 1990-2037 GHG inventory.

12. The net carbon account also includes the UK's net purchases/sales of international carbon units, if any. Carbon units include allowances issued under cap-and-trade systems, and international carbon credits issued under international schemes. While the UK intends to meet its climate targets for each of carbon budgets 3 to 6 through reducing emissions domestically and the proposals and policies set out in this Strategy have been prepared on that basis, it reserves the right to use such voluntary cooperation under Article 6 of the Paris Agreement. This could occur through linking the UK ETS to another emissions trading system, or through the use of international emissions reductions or removals units.

13. The net carbon account for each budget is calculated according to rules set in Carbon Accounting Regulations.[9] The accounting regulations that apply to each of the carbon budgets may not be in place until after the carbon budget periods are over, so assumptions are required on what accounting rules will apply. Some key assumptions are outlined in the remainder of this section.

14. The international science behind measuring emissions is continually evolving and the assumptions made here do not preclude future decisions on emissions accounting at both the domestic and international level. If future accounting decisions turn out to differ from the assumptions made here, this would not automatically lead to a change in the budget levels. The Climate Change Act allows for legislated carbon budget levels to be amended if the government believes that, since the budget level was originally set, there have been significant changes affecting the basis on which the previous decision was made. Where such changes happen but no reset occurs, significant policy changes may be needed to meet the carbon budget.

Peatland emissions

15. Emissions from peatlands were only partially captured in the UK GHG inventory when the first five carbon budgets were set. A major revision to the inventory was implemented in February 2021 for the 1990-2019 inventory[10] to represent these emissions with methodologies consistent with the IPCC Wetlands Supplement[11], which will count towards all current and future carbon budgets. All analysis in this document includes peatland emissions in line with the updated inventory. This revision increased estimated emissions in 2019 by approximately 16 $MtCO_2e$ relative to the methods used in the previous inventory.

International aviation and shipping

16. The sixth carbon budget is the first that will include international aviation and shipping (IAS) emissions. Previous budgets have not included IAS emissions but were set such that headroom for IAS emissions was left. We have used bunker fuel sales to calculate IAS emissions for the sixth carbon budget. Under this method, IAS emissions are estimated from the amount of refuelling from bunkers at UK airports and ports, whether by UK or non-UK operators, for onward international journeys.

Global warming potentials

17. Emissions of each greenhouse gas (carbon dioxide, methane, nitrous oxide, fluorinated gases) are expressed in terms of carbon dioxide equivalent (CO_2e), recognising the different global warming potentials (GWP) of the different gases.

18. The UK greenhouse gas inventory currently uses 100-year GWPs published in the IPCC's Fourth Assessment Report (AR4).[12] However, it was agreed by the international community that GHG emissions would be reported under the Paris Agreement transparency framework using an updated set of 100-year GWPs from the IPCC's Fifth Assessment Report (AR5).[13, 14] Two sets of values for 100-year AR5 GWPs were published (with and without climate-carbon feedbacks, which reflect more indirect effects of GHG emissions on the climate system - included in their methodologies) and it is not yet clear which will be used. Therefore, to ensure that carbon budgets can still be met under either methodology, emissions pathways in the main body of the Net Zero Strategy are based on the higher AR5 GWPs with feedback methodology (consistent with the approach taken in setting the sixth carbon budget). However, this does not preclude any future decisions on which methodology will be used, and emissions pathways based on AR5 GWPs without feedback are also presented in this technical annex.

19. The use of AR5 GWPs without feedback results in a lower CO_2-equivalent value for UK GHG emissions compared to AR5 GWPs with feedback, meaning that less abatement would be required to meet the same carbon budget. As a result, it may appear that the policies and proposals in this strategy overachieve on our carbon budgets when based on AR5 GWPs without feedback. However, these provide additional headroom with which the Government could seek to manage uncertainty in emissions projections. We would review the cost effectiveness of maintaining this headroom as the necessary policies and proposals are implemented. Conversely, since the 2030 NDC is a percentage-based target and the base year to which that percentage relates comprises disproportionately high non-CO_2 emissions, slightly more abatement is actually required to meet the NDC under the lower AR5 GWPs without feedback compared to AR5 GWPs with feedback.

20. The Working Group I Contribution to the IPCC's Sixth Assessment Report (AR6)[15] was published in August 2021, which included updated estimates of 100-year AR6 GWPs. However, it is not yet certain if or when these will be used for GHG emissions reporting under the UNFCCC or Paris Agreement. UK GHG emissions based on AR6 GWPs would be closer to UK emissions based on AR5 GWPs without feedback than based on AR5 GWPs with feedback.

The UK Emissions Trading Scheme (ETS)

21. Calculations of carbon emissions by HMG historically followed a net accounting framework[16] that constructed the total carbon budget as a sum of two individual components: i) emissions covered by the EU Emissions Trading System (ETS), known as traded sector emissions (around one third of all UK emissions); and ii) emissions outside the EU ETS known as non-traded sector emissions. When the UK was part of the EU ETS, the UK share of EU ETS allowances was used to calculate traded sector emissions, and emissions in the non-traded sector were measured as actually emitted. The sum of these was the net carbon account.

22. Now that the UK is no longer participating in the EU ETS, UK operators are not trading emissions allowances with operators outside the UK. The new UK ETS came into operation on 1 January 2021, and it is only currently necessary to count emissions within the UK territory towards carbon budgets. We assume that all years from 2021 onwards will be accounted on this basis. If the UK ETS were later linked with another ETS it may be decided that an adjustment needs to be made to account for any trading of allowances.[17]

The UK's 2030 Nationally Determined Contribution

23. Accounting for the UK's nationally determined contribution is different from that for carbon budgets. In particular, the NDC is a fixed percentage-based target. This means that any changes to the inventory in the baseline year will change the level of effort required to meet the NDC, while the carbon budgets are fixed targets in $MtCO_2e$.

Accounting for UK climate targets

24. The above assumptions are summarised in Table 1, alongside the coverage and level of the UK's climate targets.

Table 1: Accounting basis of UK climate targets

	Carbon Budget 3	Carbon Budget 4	Carbon Budget 5	NDC	Carbon Budget 6
Years	2018-2022	2023-2027	2028-2032	2030	2033-2037
$MtCO_2e$ limit (annual equivalent)	2,544 (509)	1,950 (390)	1,725 (345)	% based target (estimated 262-275*)	965 (193)
Accounting basis	Traded/ non-traded split for 2018-2020 Territorial for 2021-22	Territorial UK emissions	Territorial UK emissions	Territorial UK emissions	Territorial UK emissions
International Aviation and Shipping (IAS)	Excluded	Excluded	Excluded	Excluded	Included
Base year (1990) emissions**	859.6	859.6	859.6	TBC*** (859.6)	883.3****
Percentage reduction on 1990 (implied for carbon budgets)***	41%	55%	60%	68%	78%

*The range of emissions required to meet the NDC reflects uncertainty over whether AR5 with or without feedback GWPs are used. Uncertainty over baseline emissions in the 1990-2030 GHG inventory means the actual limit may lie outside this range.

**Base year emissions are calculated as emissions of CO_2, N_2O and CH_4 in 1990, and fluorinated gases in 1995.

***The baseline for the NDC will be determined by the GHG inventory 1990-2030, meaning that the abatement required to meet the NDC is dependent on future estimates of baseline emissions. Our estimate of that abatement is based on the UK 1990-2019 GHG inventory.

****The baseline for the sixth carbon budget includes 23.7 $MtCO_2e$ for IAS, based on bunker fuel sales.

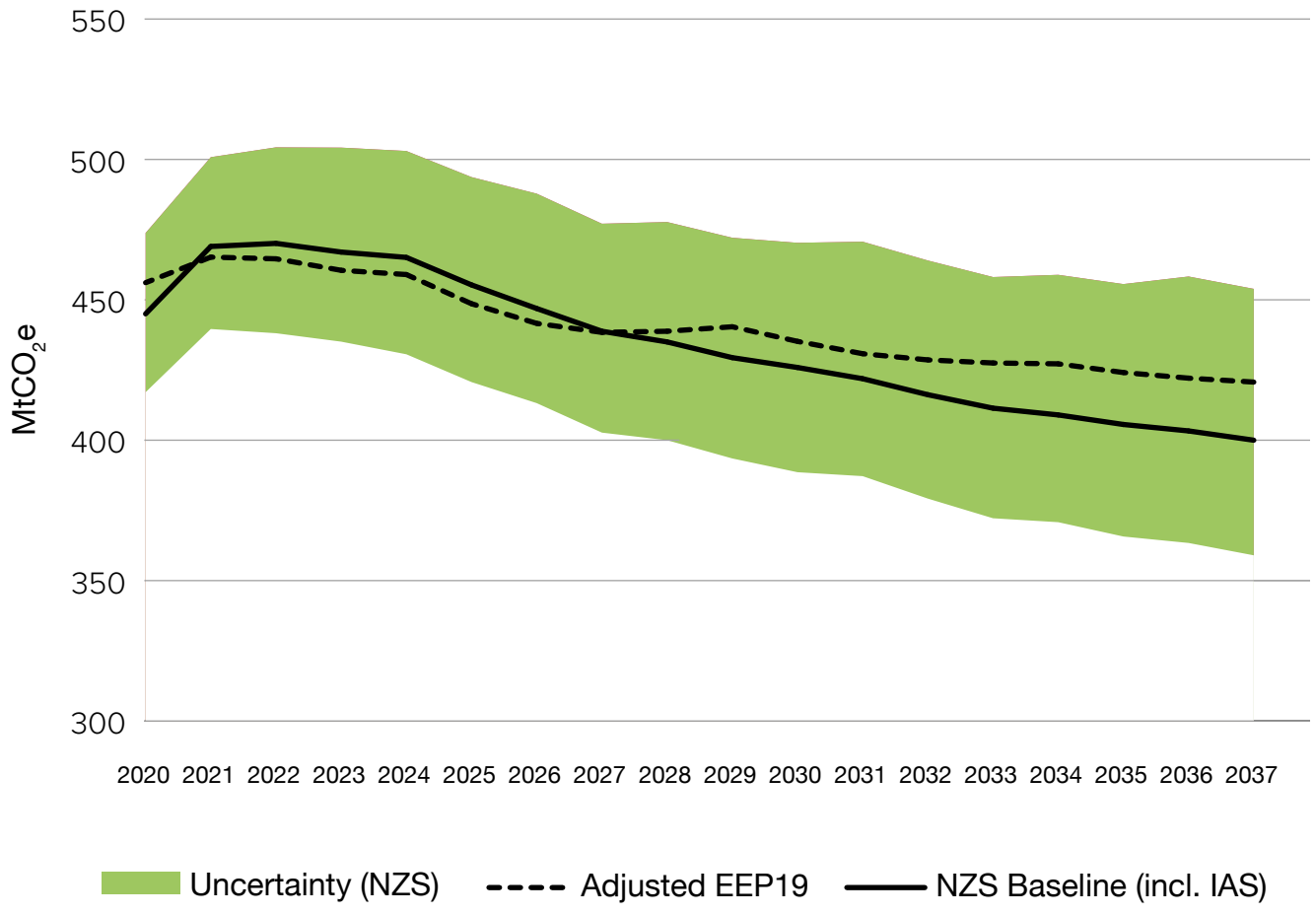
*****Estimates of historic UK GHG emissions are revised annually to incorporate methodological improvements, updated data and changes to international guidelines. The percentage reductions implied by CB levels are therefore subject to change.

Baseline emissions projections

25. While the GHG inventory is the source for historical emissions data, a combination of sector modelling and the BEIS Energy and Emissions Projections (EEP)[18] are used to project future emissions. This section sets out the assumptions about the baseline used for the purpose of this analysis. These projections determine baseline emissions for the indicative delivery pathway, based on policies implemented, adopted, or planned as of August 2019, and thus the further total emissions savings required to meet the carbon budgets. The baseline does not include policies announced in the Ten Point Plan, Energy White Paper, Transport Decarbonisation Plan, or the Industrial Decarbonisation Strategy.

26. In some sectors, adjustments to the EEP 2019 reference case,[19] published in October 2020, have been made to reflect developments in the evidence base since publication and to tailor it to ensure it is suitable as a baseline for the Net Zero Strategy. The adjusted EEP, referred to as the "baseline", incorporates the Office for Budget Responsibility's (OBR) central forecast of economic growth available in July 2020.[20] The baseline also includes some planned methodological improvements and corrections brought forward from the forthcoming EEP 2020, but no updates to policies beyond those included in EEP 2019. Table 2 provides details of these changes, and Figure 1 compares the differences across the series. The uncertainty range is explained further in paragraphs 45-48.[21]

Figure 1: Net Zero Strategy baseline compared to EEP 2019[22]



27. In accordance with the accounting rules represented in Table 1, all baselines are adjusted where relevant to be consistent with accounting assumptions for the relevant carbon budget.

Table 2: Differences between Net Zero Strategy baseline and EEP 2019 reference case

Sector	Change between EEP 2019 and Net Zero Strategy baseline	Impact on total CB6 emissions, 2033-37 ($MtCO_2e$)
All	Update of economic growth projections to the latest available OBR forecasts as of July 2020.	-42
All	Conversion of GHGs to CO_2e using Global Warming Potentials from AR5 with feedback compared to AR4 in EEP 2019.	+75
Buildings	Improvement of energy demand projections for domestic buildings. EEP 2019 did not fully account for technology improvements in new build dwellings beyond those directly attributable to Building Regulations.	-35
Buildings, Industry and Agriculture	Improvement to the methodology for alignment with UK Greenhouse Gas Inventory estimates for mobile machinery and other oil emissions. This results in lower emissions in agriculture and buildings, and higher emissions in industry.	Negligible net impact.
Buildings	Inclusion of estimates of short-term behaviour change in 2020 on energy demand in public buildings.	Impact limited to 2020-2021.
Buildings	Inclusion of estimates of short-term behaviour change in 2020 on energy demand in domestic buildings.	Impact limited to 2020-2021.
Industry	Improvement of energy demand projection methodology for chemicals and construction industry subsectors.	+38
Industry	Alignment of projections of emissions from refineries with the Net Zero Industrial Pathways model to reflect the impact of UK and global decarbonisation under a net zero consistent world scenario.	-22
Fuel supply	Alignment of projections for offshore oil and gas with projections from the Oil and Gas Authority (OGA).	-42
Power	Power sector evidence base has been updated to latest data available. This includes a revision to Energy from Waste (EfW) emissions where EEP2019 underestimated these due to an error in the percentage of EfW that is renewable. In addition, some policies included in EEP2019 have been removed as these are considered to be pre-Energy White Paper, in particular further Nuclear beyond HPC, and building one Gas CCS plant. Offshore Wind capacity is 15 GW higher in 2035 than in EEP2019 as further CfD auctions and planning means more capacity is on track to be built. There is also more large solar capacity building due to lower costs for this technology in up to date evidence.	-9

Sector	Change between EEP 2019 and Net Zero Strategy baseline	Impact on total CB6 emissions, 2033-37 ($MtCO_2e$)
Transport	Inclusion of estimates of short-term behaviour change in 2020 in road transport and domestic aviation.	Impact limited to 2020-2021.
Transport	Correction of a calibration error in EEP 2019 which led to an underestimation of the amount of oil in the historic fuel mix for transport.	+14
Transport	Closer alignment of national navigation and fishing emissions estimates with research commissioned by the Department for Transport.	+<5
International Aviation and Shipping	Inclusion of estimates of short-term behaviour change in 2020 on international aviation.	Impact limited to 2020-2021.
International Aviation and Shipping	Closer alignment of international shipping estimates with research commissioned by the Department for Transport.	+7

28. There is ongoing uncertainty over how the COVID-19 pandemic will affect emissions in the long term. In 2020, emissions fell,[23] but it is not yet clear what the effect will be on future emissions. We have assumed that there is no long-term behavioural change due to the pandemic. However, as stated above, the baseline is adjusted for the reduction in economic growth and the short-term behaviour changes occurring due to the COVID-19 pandemic. [24]

Sector definitions

29. The precise definition of the sectors used by the Net Zero Strategy, marked against IPCC categories, is published separately to this document.[25] A summary of the coverage of each sector is shown in Table 3. Where sector chapters cover more than one of these sectors, the below table shows which sectors are covered by which chapter.

Table 3: Net Zero Strategy sector definitions

NZS Sector	Sector chapter	Sector definition
Power	Power	Emissions from power stations (Major Power Producers only), including those generating energy from waste.
Fuel Supply	Fuel Supply and Hydrogen	Emissions from the extraction, processing, and production of fuels (chiefly oil, coal, gas and hydrogen).
Industry	Industry	Emissions from industrial processes, manufacturing, and production, including fuel combustion and product use in industrial buildings, as well as emissions from refineries and construction machinery. Includes emissions from non-Major Power Producers auto-generation and Combined Heat and Power.
Heat and Buildings	Heat and Buildings	Emissions from public, commercial, and residential buildings, including domestic product use such as garden machinery and composting.
Domestic Transport	Transport	Emissions from all forms of road and rail transport, domestic aviation and domestic shipping (including fishing vessels).
International Aviation and Shipping		Emissions from fuel used in international aviation and international shipping, as measured by UK bunker fuel.
Agriculture	Natural Resources, Waste and F- Gases	Covers emissions from livestock, crop soils and agricultural machinery.
Forestry and Other Land Use		Emissions and removals from land use change, forestry, peatlands and other carbon stock change from land use (e.g. in the biomass pool).
Resources and Waste		Emissions from the treatment and disposal of solid and liquid waste and landfill, including emissions from incineration not used to generate energy (e.g. incineration of chemical waste).
Fluorinated Gases (F-gases)		Fluorinated gas emissions, primarily from refrigeration, air-conditioning, heat pumps, aerosols, and high voltage switchgear.
Greenhouse Gas Removals	Greenhouse Gas Removals	Negative emissions from engineered removal technologies, including direct air and bio-energy carbon capture and storage.

Illustrative 2050 net zero scenarios

30. The Net Zero Strategy explores three possible net zero scenarios in 2050 in chapter 2, building on the pathways developed for the sixth carbon budget Impact Assessment. These have been deliberately selected to illustrate a wide range of outcomes for the economy that are possible by 2050. However, different outcomes within this range or beyond this range are also possible.

31. This analysis has primarily two objectives:

a. First, to examine three different scenarios of economy-wide decarbonisation to understand the range of possible long-term outcomes and therefore inform the short-term delivery pathways. Through previous modelling and research, BEIS has identified three areas of technology and resource uncertainty likely to have a substantial impact on the 2050 energy system.[26] The scenarios have been developed in consultation with internal experts to illustrate feasible avenues to achieving net zero emissions based on:

- The relative role of electrification and hydrogen in fuel switching;
- The role of land-use and bioenergy to produce negative emissions; and
- The role of further innovations to address the hardest to abate sectors of the economy.

b. Second, it confirms that all three scenarios are consistent with the policies and proposals set out in the Strategy to meet the sixth carbon budget.

32. This section explains the methodology that was used for this analysis and summarises the differences between the three scenarios. It also shows illustrative sectoral emissions in 2050 and accompanying deployment characteristics.

Overview of the methodology used to develop the 2050 scenarios

33. The net zero scenario modelling primarily uses the UK TIMES Model (UKTM), a least-cost, optimisation model covering all UK emissions (including land use) and the UK energy system over the period 2010 to 2060.[27] The model includes assumptions about technology costs, availability, performance, and build rates.[28] It also includes assumptions for future fossil fuel prices and energy services demand by end-use sector. These inputs are pre-determined for each model run and do not vary with deployment. Based on the input assumptions, the model identifies the least-cost way of meeting a given GHG reduction trajectory while also meeting assumed end-use demand for energy services. Further information on the methodology and assumptions used in the UK TIMES model can be found in Annex A.2 of the sixth carbon budget impact assessment.[29]

34. An extensive exercise has been undertaken to ensure UKTM is aligned with the latest evidence base and assumptions used across government. Where this was not possible, off-model adjustments have been made to the net zero scenarios.

35. A particular advantage of UKTM is that it identifies the least-cost technology pathway for a given set of assumptions, taking account of interactions across energy supply and end-use sectors over time. The model is therefore useful for identifying which technologies could be essential or important in the long run for achieving a low cost, net zero consistent energy system. It also helps identify the appropriate sequencing of abatement opportunities.

36. However, there are a number of limitations to the modelling:

- The model does not directly take account of uncertainty of any kind over future technology costs and availability. Uncertainty is only displayed through the range of outputs given by the different scenarios.
- Technology cost reductions over time are based on fixed assumptions and do not directly account for cost reductions through widescale deployment in the model. i.e. costs are not a function of deployment.
- No additional barriers beside cost and technical build rates are considered, no potential industrial benefits from developing and deploying new low-carbon technologies are considered. Modelling does not consider any upside or downside risks to the economy arising from the transition.
- Behavioural or other practical considerations that might make certain pathways more or less expensive to achieve are not accounted for (other than where they are reflected in costs or build rates).
- The model varies in detail by sector. In some areas only high-level representations are provided and the model is not spatially disaggregated.

37. The three scenarios are summarised below:

- **High electrification:** explores the impact of using widespread electrification to support transport, heating, and industry decarbonisation coupled with deep decarbonisation of electricity supply.
- **High resource:** explores the impact of using low-carbon hydrogen more extensively, particularly for decarbonising buildings and heavy vehicles. It assumes higher levels of tree-planting are achievable, increasing the 'negative emissions' available from land-use sinks.
- **High innovation:** explores a world in which successful innovations, such as synthetic fuels and zero emission aircraft, enable lower residual emissions to be reached sooner in aviation. Higher capture rates – above baseline assumptions – increase the impact of carbon capture technologies, particularly higher deployment of direct air capture.

38. The scenarios were constructed in the UKTM by varying input assumptions for:

- The extent to which technologies can be rolled out. For example, in the high electrification scenario 100% of buildings are set to be heated by electricity in 2050, whereas in the high resource scenario heat pump deployment is constrained and this figure drops to 40%.
- Availability of resources and technologies. For example, in the high resource scenario, we assume 50kha afforestation per annum by 2050 (compared to 30kha in the other scenarios). Higher efficiency capture technologies are only available in the high innovation scenarios (for example CCUS capture rates of 99% compared to 95% in most cases in the other scenarios).
- For sectors such as industry and aviation, where the UKTM does not represent the full range of known abatement options, supplementary adjustments to emissions, energy demand, and key deployment requirements have been made. These have been taken into account in the optimisation of other sectors via the specification of the emission targets.

39. Other assumptions were kept the same across the scenarios. For instance, projections of final demand for end-use sectors are consistent with those used in the central 2037 delivery pathway and are the same for each of the modelled 2050 scenarios. Technology and resource cost assumptions, including fossil fuel prices, are also the same across each scenario. Sensitivity analysis conducted as part of the sixth carbon budget Impact Assessment showed that the impact of economic growth and fossil fuel prices on the technology mix in 2050 is relatively small, therefore these effects were not considered further.[30] Finally, sector emissions to 2037 were aligned to those in the delivery pathway described in the Strategy. For further key assumptions by sector see the evidence base section of this annex.

40. Table 4 shows the level of emissions in 2050 implied by each of the three illustrative scenarios. All scenarios meet net zero in 2050, with removals technologies compensating for any residual emissions.

Table 4: Illustrative total territorial emissions under the different scenarios

Sectors	2019 emissions ($MtCO_2e$)	2050 illustrative emissions ($MtCO_2e$)		
		High electrification	High resource	High innovation
Power	58	3	2	1
Industry	78	3	3	10
Fuel Supply	26	0	5	8
Heat and Buildings	88	0	0	2
Domestic Transport	122	3	4	5
International Aviation and Shipping	45	35	35	21
Agriculture and LULUCF	63	20	14	21
Waste and F-gases	40	12	13	13
Greenhouse Gas Removals	0	-75	-76	-81
Total emissions	**520**	**0**	**0**	**0**

41. Given the long-term scientific uncertainty and to err on the side of caution, the analysis above assumes AR5 with feedback GWPs. On the basis of AR5 without feedback GWPs the scenarios would reach c.-9 $MtCO_2e$ in 2050 as a result of primarily lower emissions from methane. This uncertainty represents less than 2% of the overall abatement requirement. Because of this, detailed sensitivity analysis on GWPs has not been carried out for the purposes of this strategy. However, lower GWPs could allow less reliance on removals in 2050 thereby lowering the requirements for sustainable biomass, or alternatively slightly higher end-use sector emissions.

Characteristics of the 2050 scenarios

42. To illustrate the assumptions underpinning the 2050 scenarios, Table 5 shows deployment characteristics for each sector. These are illustrative of the levels of deployment required for each of the three scenarios. Not all technology deployment required to meet net zero is represented.

Table 5: Illustrative characteristics in 2050

Sector	Deployment assumptions	Unit	2019	2050 illustrative range
Power	Electricity generation	TWh	320	610-690
	Low carbon GB generation as a percentage of total projected generation	%	56%	99-100%
Industry	Low carbon fuel switching*	TWh	110	190-210
	Resource and energy efficiency savings	$MtCO_2e$	0	13
	Industry demand for industrial CCUS (not including BECCS)	$MtCO_2e$	0	6-9
Fuel Supply	Low carbon hydrogen production	TWh	0	240-500
	Steam methane reformation with CCS (as a percentage of total hydrogen generation)	%	0	0-75%
	Electrolysis as a percentage of total hydrogen generation	%	0	15-75%
	Biomass gassification with CCS as a percentage of total hydrogen generation	%	0	0-20%
Heat and Buildings	Cumulative heat pumps installed domestically	Million installations	0.2	12-28
	Cumulative homes converted to 100% hydrogen	Million homes	0	0-14
	Demand reduction as a result of energy efficiency measures	%	0	15-20%
	Low carbon fuels* consumption as a percentage of total fuel consumption in commercial buildings	%	62%	90-100%
	Heat supplied via heat networks	TWh	14	70
	Biomethane injected into gird	TWh	3	0-20
Agriculture and LULUCF	Total area of peatland under restoration	kha	n/a	380
	Yearly area of afforestation UK	kha	13.6	30-50
	Yearly area of perennial energy crop and short rotation forestry planted	kha	0	53
	Farmers engaging with low carbon farming practices as a percentage of total farmers	%	60%	100%
Waste and F-gases	Level of HFC consumption relative to a 2015 baseline level	%	63%	15%

Sector	Deployment assumptions	Unit	2019	2050 illustrative range
Greenhouse Gas Removals	BECCS (all technologies)	$MtCO_2e$	0	52-58
	DACCS	$MtCO_2e$	0	18-29
Transport and IAS	ZEVs as a percentage of total car fleet	%	0.3%	96-97%
	ZEVs as a percentage of total van fleet	%	0.2%	88-90%
	ZEVs as a percentage of total HGV fleet	%	0%	95-97%
	ZEVs as a percentage of total bus and coach fleet	%	0.3%	91-95%
	Low carbon fuels* use in road transport as a percentage of total fuel use (in litres)	%	5%	30-60%
	SAF use in domestic and international aviation as a percentage of total fuel use (in tonnes)	%	0%	5-30%
	Low carbon fuels use in domestic and international shipping as a percentage of total fuel use (in TWh)	%	0%	97%
Overall	GDP carbon intensity	tCO_2e/ GDP £m2020	194	0
	GDP energy intensity	MWh/ GDP £m2020	700	270-310

*The table includes several deployment assumptions covering relevant low carbon fuels in different sectors. The low carbon fuels included are the following: electricity, biofuels, solid biomass, hydrogen, ammonia, and methanol. All these deployment assumptions include electricity and hydrogen both in the numerator and denominator, with the exception of low carbon fuels used in road transport (from which electricity and hydrogen are completely excluded).

Meeting the carbon budgets

43. This section sets out historic performance against carbon budgets and future performance implied by the delivery pathway, including emissions broken down by sector for each future carbon budget. Deployment assumptions that illustrate some of the real-world changes required to meet carbon budgets are also presented.

44. The UK has overperformed on its carbon budgets so far, by 37 Mt CO_2e for the first carbon budget and 384 Mt CO_2e for the second carbon budget. Table 6 shows the current baseline projections for future carbon budgets (reflecting policies as of August 2019),[31] and also the overall pathway for emissions as set out in the *Net Zero Strategy*.

Table 6: Projected emissions implied by pathway against current and future carbon budgets

	CB3	CB4	CB5	CB6 (incl. IAS)
Years covered	2018-2022	2023-2027	2028-2032	2033-2037
Baseline	2,499	2,052	1,889	2,029
Budget limit	2,544	1,950	1,725	965
NZS emissions pathway	2,499	1,854	1,312	962
Performance against carbon budget	-45	-96	-413	-3

Uncertainty over future emissions

45. Table 7 shows an indicative annual range over the sixth carbon budget period.[32] The lower and upper ranges are based on Monte Carlo analysis of the EEP, conducted in 2018 and assessed to represent the best evidence of the uncertainty in the projections for the sixth carbon budget period.[33] The analysis reflects a 95% confidence interval around the baseline to reflect uncertainty in future macro trends (such as GDP, and population size), uncertainty in the impacts of certain existing policies on emissions and uncertainty in the current evidence base on emissions (such as land use emissions). It also uses regression residuals to account for structural modelling uncertainty in the EEP. The analysis does not capture uncertainty in the policies and proposals brought forward under the Strategy.

46. Due to accounting changes, further emissions have recently come in scope of the sixth carbon budget period. The Monte Carlo analysis has therefore been augmented to include these emissions. The range around historical emissions for international aviation and shipping is estimated based on statistical volatility in historical emissions. Emissions added following the adoption of the Wetlands Supplement assume the uncertainty is proportional to the overall uncertainty in the LULUCF sector.[34]

47. The pathway is highly ambitious meaning there are downside risks to the estimated policy savings (for example, delays to delivery), as well as upside risks (for example, no long-run behavioural impacts are assumed as a result of the COVID-19 pandemic). Government will monitor progress against the pathway as set out in the Embedding net zero in Government chapter, and will prepare further proposals and policies to enable the carbon budgets to be met as necessary.

Table 7: Provisional indicative range of the carbon account over the sixth carbon budget

	2033	2034	2035	2036	2037
Upper	279	265	240	226	207
Central	232	215	190	171	153
Lower	193	177	150	131	112

48. Emissions across the period prior to the sixth carbon budget are also uncertain: the Government will provide further analysis in future Energy and Emissions Projections.

Sectoral emissions over the carbon budgets

49. Table 8 shows an indicative emissions pathway, broken down by sector across the fourth, fifth and sixth carbon budgets. The fifth carbon budget figures are aligned with the UK's NDC, and 2030 values have been used for this column. To reflect uncertainty from macroeconomic trends and in underlying baseline emissions, emissions for each sector are shown as a range. These ranges are calibrated to the uncertainty range set out in the economy wide EEP Monte Carlo analysis.[35]

50. Whilst the ranges below represent our current assessment of the right trajectory to meet our carbon budgets, developments in climate science, accounting regulations, baseline emissions, technological progress and/or policy impacts may alter the expected impact of policies set out in the strategy, or the optimal distribution of policy effort across sectors. Future climate strategies will update this sectoral emissions pathway where necessary using the latest evidence.

Table 8: Sectoral emissions across the carbon budgets: $MtCO_2e$ per year (using AR5 with feedback GWPs)

Sector	Current (2019)	CB4 (average 2023-27)	NDC (2030)	CB6 (average 2033-37)
Agriculture and LULUCF	63	51 to 57	44 to 52	38 to 48
Buildings	88	73 to 82	55 to 66	34 to 47
Domestic Transport	122	100 to 111	67 to 80	29 to 43
Fuel Supply	26	18 to 20	14 to 16	10 to 12
Industry	78	58 to 65	36 to 45	19 to 29
Power	58	28 to 31	14 to 17	9 to 11
Waste and F-gases	40	24 to 27	17 to 20	12 to 15
Greenhouse Gas Removals	0	0 to 0	-12 to -1	-33 to -11
Intl Aviation and Shipping*	45	(42 to 46)	(44 to 50)	39 to 46
Total (incl. IAS)	**520**			**192**
Total (excl. IAS)	**476**	**371**	**262**	

*Figures in parentheses indicate that IAS is not counted towards that target

51. As set out above, there is some uncertainty which set of Global Warming Potentials the UK will adopt. We have therefore also translated these pathways using alternative AR5 without feedback GWPs, assuming it were optimal in cost- and non-cost terms to implement the same set of policies and proposals modelled in the AR5 with feedback pathways.

Table 9: Sectoral emissions across the carbon budgets: $MtCO_2e$ per year (using AR5 without feedback GWPs)

Sector	Current (2019)	CB4 (average 2023-27)	NDC (average 2030)	CB6 (average 2033-37)
Agriculture and LULUCF	54	43 to 48	37 to 44	31 to 39
Buildings	88	73 to 82	55 to 66	34 to 47
Domestic Transport	122	100 to 111	67 to 80	29 to 43
Fuel Supply	25	18 to 20	13 to 16	10 to 11
Industry	78	58 to 65	36 to 45	19 to 29
Power	58	28 to 31	14 to 17	9 to 11
Waste and F-gases	34	21 to 23	14 to 17	10 to 13
Greenhouse Gas Removals	0	-1 to 0	-12 to -1	-33 to -11
Intl Aviation and Shipping*	44	(42 to 46)	(44 to 50)	39 to 46
Total incl. IAS	**503**			**182**
Total excl. IAS	**458**	**359**	**251**	

* Figures in parentheses indicate that IAS is not counted towards that target[36]

Illustrative deployment assumptions to meet the carbon budgets

52. To illustrate some of the deployment assumptions underpinning the emissions pathway, Table 10 below shows real-world deployment assumptions for each sector. Not all of the policies and proposals underlying the delivery pathway are represented by these assumptions. Ranges indicate where values differ between the electrification and hydrogen pathways set out in the strategy for the heat and buildings sector. In some cases, these assumptions represent early-stage assessments based on maximum technical potential. Given ongoing uncertainties, the policy mix that will meet carbon budgets, and related deployment assumptions, are subject to change; these are illustrative and should not be interpreted as government targets.

Table 10: Deployment assumptions underpinning pathway

Sector	Deployment assumptions	Unit	2019	2025	2030	2035
Power	Electricity generation	TWh	320	315	370	460*-510
	Low carbon GB generation as a percentage of total projected generation required in 2035	%	29%-33%*	38%-42%*	62%-69%*	99%
Industry	Low carbon fuel switching[a]	TWh	110	115	125	157
	Resource and energy efficiency savings	$MtCO_2e$	0	1	10	11
	Industry demand for Industrial CCUS (not including BECCS)[b]	$MtCO_2e$	0	2	5	7
Fuel Supply	Low carbon hydrogen production	TWh	0	10**	40	80-140*
	Electrical power demand from offshore oil and gas installations as a percentage of their total power demand	%	0%	0%	31%	43%
Heat and Buildings	Cumulative heat pumps installed domestically	Million installations	0.2	1.1	4*- 4.3	6.9* - 11.3
	Cumulative homes converted to 100% hydrogen for heat	Million homes	0	0	0-0.2*	0-4*
	Yearly homes treated by new domestic energy efficiency measures	Million homes	0	0.5	1	0.5
	Low carbon fuels[a] consumption as a percentage of total fuel consumption in commercial buildings (excluding heat networks)	%	62%	63%	67%	78%-81%*
	Yearly heat supplied via heat networks	TWh	14	16	22	29
	Yearly biomethane injected into the grid	TWh	3	8	12	12

Sector	Deployment assumptions	Unit	2019	2025	2030	2035
Agriculture and LULUCF	Yearly area of peatland under restoration in England	Ha	2,000-5,000***	7,000	10,290	10,290
	Yearly area of afforestation in the UK	Ha	13,600	30,000	40,000	50,000
	Yearly area of perennial energy crop and short rotation forestry planted	Ha	0	7,440	21,275	26,350
	Farmers engaging with low carbon farming practices as a percentage of total farmers	%	60%	70%	75%	85%
Waste and F-gases	Level of HFC consumption relative to a 2015 baseline level	%	63%	31%	21%	15%
Greenhouse Gas Removals	BECCS and DACCS	$MtCO_2e$	0	0	6	23
Domestic transport	ZEVs as a percentage of total car fleet	%	0.3%	6%	24%	53%
	ZEVs as a percentage of total van fleet	%	0.2%	2%	14%	40%
	ZEVs as a percentage of total HGV fleet	%	0%	0%	9%	37%
	ZEVs as a percentage of total bus and coach fleet	%	0.3%	9%	25%	48%
	Single track kilometres electrified per year	Km	0	350	650	650
	Low carbon fuels[a] use in road transport as a percentage of total fuel use (in litres)	%	5%	7%	8%	8%
	Journeys in towns and cities that are cycled and walk as a percentage of total journeys in towns and cities	%	42%	46%	50%	55%
	SAF use in domestic aviation as a percentage of total fuel use (in tonnes)	%	0%	1%	3%	6%
	Low carbon fuels use[a] in domestic shipping as a percentage of total fuel use (in TWh)	%	0%	0%	1%	42%

Sector	Deployment assumptions	Unit	2019	2025	2030	2035
International Aviation and Shipping (IAS)	SAF use in international aviation as a percentage of total fuel use (in tonnes)	%	0%	1%	3%	6%
	Low carbon fuels*** use in international shipping as a percentage of total fuel use (in TWh)	%	0%	0%	1%	28%
Overall	GDP carbon intensity	tCO_2e/ GDP £m2020	194	144	93	62
	GDP energy intensity	MWh/ GDP £m2020	700	600	480	380-400*

* Reflects deployment in hydrogen pathway.

** Figure reflects hydrogen demand in the mid-2020s (rather than 2025 specifically).

*** The 2019 range for peat reflects different estimates of peat restoration in England, including both public and externally funded work.

[a] The table includes several deployment assumptions covering relevant low carbon fuels in different sectors. The low-carbon fuels included are the following: electricity, biofuels, solid biomass, hydrogen, ammonia and methanol. All of these deployment assumptions include electricity and hydrogen both in the numerator and denominator, with the exception of low-carbon fuels used in road transport (from which electricity and hydrogen are completely excluded).

[b] Industrial carbon capture deployment starts in the mid-2020s, reaching a total of 6Mt in 2030 and 9Mt in 2035 including carbon capture from biomass use.

Costs and economic impacts of the transition

Costs of the transition

53. Table 11 shows the additional investment costs for the indicative delivery pathway in each of the future carbon budgets relative to a baseline of existing policies. These represent in-year capital expenditure requirements, excluding financing costs, and do not cover operational costs or savings, or policy costs. Costs are expressed in real 2020 prices as average annual values over the carbon budget periods. The costs of the delivery pathway remain highly uncertain and will depend on factors such as technology costs and fuel prices. Ranges, where given, represent the implication of higher or lower demand from end-use sectors consistent with the electrification and hydrogen scenarios.

Table 11: Estimates of additional investment requirements for Net Zero Strategy pathway (£bn pa, undiscounted, 2020 prices)

Sector	Carbon Budget 3 (average 2020-2022)	Carbon Budget 4 (average 2023-2027)	Carbon Budget 5 (average 2028-2032)	Carbon Budget 6 (average 2033-2037)
Power*	1	7-8	11-22	12-23
Fuel Supply	0.3	2.0	1.3-2.3	0.6-1.9
Industry	0.0	0.9	1.1	0.9
Heat and Buildings**	2	12	12	14
Transport	2	8	17	18
Natural Resources, Waste, and F-Gases[37]	0.6	1.2	1.7	2.6
Greenhouse Gas Removals	0.0	0.7	1.6	1.7
CCUS (T&S Infrastructure)	0.0	0.6	1.2-1.4	0.8-1.0
Total	5-6	32-33	48-59	52-61

*Figures exclude additional Transmission and Distribution Network investment requirements.

**Costs represent a scenario where heat is predominantly decarbonised via electrification through heat pumps.

54. Table 11 excludes operating costs to avoid double counting (e.g. where CAPEX in an energy supply sector is OPEX in an end-use sector). Over the same period, we could see additional resource savings of around £180 billion as a result of our reduced use of oil/petroleum products and natural gas. This has been calculated by multiplying the change in energy demand (relative to the baseline) by the corresponding long-run variable cost of energy supply (LRVCs) from The Green Book. This is based on the central price and the savings could be higher or lower, depending on how future prices evolve.

Other economic and fiscal considerations

Economic considerations

55. There are many economic impacts of the transition to net zero to consider. As shown above, there are significant capital investment requirements, and although the exact requirements are uncertain it is clear that patterns of investment will have to change. New jobs will also be created, and these jobs may require different skills and education. Consumption and production behaviours will shift towards greener choices, and different places and sectors in the UK could face different economic opportunities and challenges.

56. Previous cost benefit analysis of the sixth carbon budget showed that there are significant co-benefits to the transition to net zero.[38] As well as the benefits from reduced greenhouse gas emissions, improvements to air quality were valued at £35 billion to 2050, fuel savings at £123 billion and other benefits to natural capital at £5 billion. The net present value of meeting the sixth carbon budget and net zero target, compared to no further action, was estimated as a net benefit of £266 billion.[39] This calculation does not include many other potential co-benefits, such as reduced noise pollution from cars, improved health from walking and cycling and warmer homes from energy efficiency measures, nor indirect costs from macroeconomic impacts.

57. In terms of the macroeconomic impact of the transition to net zero, the Office for Budget Responsibility (OBR) finds that the costs of failing to get climate change under control, which relies on global effort, would be much larger than those of bringing emissions down to net zero.[40] In terms of transition costs, the OBR has presented scenarios in which the level of UK GDP changes relative to the baseline by between -4.6% and +1.6% by 2050, with a central estimate of -1.4% for early action on climate change compared to -4.6% for late action. These changes are small when set against expected growth of over 50% in real GDP to 2050 compared to today's levels. Further information on the economic impacts of the transition to net zero are set out in the HMT ***Net Zero Review***.[41]

Competitiveness

58. The transition to net zero can stimulate innovation that increases domestic competitiveness and global comparative advantage for some UK industries, providing potential export opportunities. Updated internal analysis based on the Energy Innovation Needs Assessment estimates that just over half of the £60 billion GVA potential from sectoral decarbonisation in 2050 comes from export related opportunities.[42] However, there will also be risks to sectors and industries susceptible to competitiveness impacts, particularly those that are trade-exposed and/or carbon intensive. Where UK firms lose market share to international firms with lower environmental standards, there is a risk of carbon leakage. There is little empirical evidence of this occurring in the UK to date, but risks could increase as further policy is implemented.

59. Historically, the UK's approach to mitigating competitiveness impacts and carbon leakage risk has been through issuing free allowances under the EU ETS.[43] This approach has been carried over to the UK ETS, and possible changes to free allowances are currently under review.[44] BEIS also provides compensation to certain energy intensive industries for the indirect emission cost due to the UK ETS and some sectors receive a reduction in energy consumption tax via Climate Change Agreements. The eventual impact of decarbonisation on firms at risk will depend on future policy development, particularly relating to the UK ETS.

60. The magnitude of competitiveness effects in international markets is dependent on global climate ambition as well as domestic policy. If other countries, particularly the UK's trading partners, increase their industrial decarbonisation ambition in line with the UK's, and face similar transition impacts, then competitiveness effects will be smaller. Similarly, where the UK's path to net zero creates export opportunities for UK businesses, the size of these will depend on the actions of the rest of the world. High global climate ambition will result in a large market for decarbonisation technologies and services but may also result in more global competition in those markets.

Fiscal considerations

61. The overall fiscal impacts of the transition to net zero will depend on many as yet unknown factors, including the financing mechanisms used to fund the policies and proposals set out in the Net Zero Strategy, and the macroeconomic impacts of the transition, for example through changes in GDP growth or inflation. There are some known fiscal impacts, such as the erosion of direct tax receipts like fuel duty that depend on carbon intensive activity, and increased tax receipts from other policies, such as revenue from the UK ETS.

62. HMT's *Net Zero Review*[45] and the OBR's recent fiscal risks report[46] provide a more detailed overview of the channels through which the net zero transition can impact the UK's fiscal position, and the factors which will determine the overall magnitude of this impact. While noting uncertainties, the OBR concluded that there could be significant fiscal benefits from transitioning to net zero sooner rather than later. However, governments public spending will be dependent on the economic, fiscal and decarbonisation context of the time.

Jobs

63. The policies and sectoral ambitions across the *Net Zero Strategy* are estimated to support up to 190,000 jobs in low carbon and green sectors by the middle of the 2020s, and up to 440,000 by 2030. The breakdown of jobs by chapter is as follows. Information on the methodology used to calculate these numbers can be found in the evidence base section of this annex.

Table 12: Estimate of jobs supported in Net Zero Strategy pathways, by sector and date

Sector	Jobs supported by 2024/5	Jobs supported in 2030
Power	59,000	120,000
Fuel Supply	N/A	10,000
Industry	5,000	54,000
Heat and buildings	100,000	175,000
Transport	22,000	74,000
Natural resources, waste and F-gases (forestry only)	2,000	2,000
Greenhouse Gas Removals	N/A	N/A
Total	190,000	440,000

64. *The Ten Point Plan for a Green industrial Revolution*[47] published in November 2019 set out plans to support up to 250,000 jobs by 2030, which was based on specific sectors included within the *Ten Point Plan*. The figures in this *Net Zero Strategy* include areas not covered by the *Ten Point Plan*, such as solar and onshore wind. In several cases, most notably around Heat and Buildings and Transport, figures have been updated since the *Ten Point Plan* was announced.

65. Government has also set out its ambition to pivot towards a green economy supporting up to 2 million green jobs by 2030. This is a wider ambition which includes areas of economic activity not included in the Net Zero Strategy but which support other environmental goals, such as climate adaptation and the circular economy.

Wider impacts of the transition to net zero

66. Section 10 of the Climate Change Act lists various factors that must be taken into consideration by all decisions relating to carbon budgets, while Section 13 requires that the policies and proposals set out in the *Net Zero Strategy* as a whole contribute to sustainable development. These factors have been taken into account in relation to proposals and policies that will enable the UK to meet its carbon budgets, as set out throughout this annex and in the main body of the Strategy.

Table 13: Summary of wider considerations

Factor	Consideration in Net Zero Strategy	Conclusions
Scientific knowledge	See Climate Science Annex	The scientific case for strong action on climate change remains definitive.
Technology	See Journey to Net Zero, sector chapters, Technical Annex	The latest evidence on relevant climate technologies has been used for all analysis across the strategy.
Economic	See Technical Annex, Why Net Zero, Green Jobs, Skills, and Industries, Investment, Innovation, Green Choices and Local Climate Action chapters	There are many economic and competitiveness impacts of the transition, some of which are positive and some negative. We make no overall conclusion.
Fiscal	See Technical Annex	The full fiscal impact of the transition is not yet known and will depend on varied policy decisions and economic outcomes.
Sustainable development	See Reducing Emissions across the Economy chapters, Technical Annex, Embedding Net Zero chapter	There are both positive and negative natural capital impacts associated with emissions reduction policies but the overall contribution to sustainable development is likely positive. Other aspects of sustainable development are addressed in the economic, fiscal and social sections.
Energy policy	See Journey to Net Zero and Power chapters, and Technical Annex	Delivering our carbon budgets has the potential to reduce demand for gas, coal, oil and transport fuels which could improve security of supply by diversifying away from primarily imported fossil fuels. Other measures will mean increases in electrification and the simultaneous deep decarbonisation of electricity supply, which carries security of supply risks. Estimations of the future energy and carbon intensity of the economy are presented in Table 10 of the Technical Annex.
Social	See Technical Annex, Green Choices, and Buildings chapters	Price and bill impacts will depend on electricity market developments and consumption patterns. Policies that improve energy efficiency of homes will reduce bills and benefit fuel poor households.
IAS	See Technical Annex, Transport chapter	IAS emissions will be included from the sixth carbon budget onwards and will use the bunker fuel sales method to calculate emissions. Projected IAS emissions are set out in Table 8.
International and European	See International climate leadership and Why Net Zero chapters	The UK has world leading ambition on climate change and is committed to advancing global climate action. The UK has now left the EU and is no longer bound by EU climate policies.

Factor	Consideration in Net Zero Strategy	Conclusions
Devolved circumstances	See sector chapters and Technical Annex	The NZS pathway analysis includes modelling of the scope to reduce emissions in each nation, considering their differing circumstances. These assumptions are broadly in line with the CCC's distributions of abatement by nation. Key assumptions are outlined in the evidence base section below.

67. The following section considers two of these impacts in more detail: sustainable development, which is considered through analysis of the effects of policies and proposals on natural capital; and social considerations, including the potential impacts on energy bills and fuel poverty.

Sustainable development and natural capital

68. Sustainable development concerns the stability and prosperity of society, and its capacity to provide for future generations. Sustainable development also incorporates social, economic, and environmental dimensions of sustainability. The Act requires carbon budget proposals and policies as a whole to contribute to sustainable development. The main outcomes of the policies and proposals in this Strategy will have a positive impact on the UK's contribution to the global Sustainable Development Goals, in particular goal 7, targeting affordable and clean energy, and goal 13, targeting climate action.

69. In this section, we assess the sustainability implications of the net zero transition in terms of its impact on the continuation and improvement of environmental functions, and stability and renewal of natural assets. This is most relevant to the Sustainable Development Goals 6, 14 and 15, which target protection of water and life on land and marine habitats.

70. In line with HM Treasury Green Book, a natural capital perspective is taken to analyse these implications, whereby the impact of policies and proposals on the natural assets on which the economy depends is assessed.[48] It is not yet possible to provide a complete assessment of the delivery implications of policies and proposals, as many are still subject to designs and implementations upon which the impacts are dependent. The extent that the natural capital impacts are mitigated will be dependent on the options considered in policy specific delivery analysis.

71. To assess the potential natural capital impacts of a policy, a series of screening questions are used.[49] Following this, the main benefits and risks associated with net zero policies are listed for different natural capital stocks. This is an indicative assessment of the natural capital impacts due to the limitations described above. As such, the large majority of measures in this strategy require further natural capital assessment. All policies will be assessed for natural capital benefits and risks in their impact assessments and business cases according to Green Book guidance. This includes considering the implications of policies for natural assets and any associated effects on wider economic welfare. More information on the natural capital approach can be found in the Green Book supplementary guidance and the Enabling a Natural Capital Approach guidance.[50]

72. Delivery of net zero policies and proposals will need to consider the UK's other legally binding environmental commitments (for example, new legally binding targets stemming from the Environment Bill), and any trade-offs against these acknowledged and mitigated through careful planning policies and actions can be designed that deliver multiple outcomes in support of the UK's net zero and 25 Year Environment Plan ambitions. For instance, the planting of broadleaf trees and restoration of peatland or grassland can deliver carbon sequestration as well as environmental benefits including improved biodiversity and water quality, if done in the right way. Conversely, certain interventions such as planting of maize for biomass or food may risk soil health and water quality. It will be important to assess the wider impacts of proposed net zero actions and seek synergies with environmental ambitions wherever possible, so that the twin challenges of biodiversity loss and climate change are tackled in an efficient way.

73. The independent Natural Capital Committee defined natural capital as 'those elements of the natural environment which provide valuable goods and services to people'.[51] Nature underpins the UK's economy and society: the energy, food, and water we consume; the air we breathe; our access to green space; and biodiversity, which is crucial in underpinning all our ecosystem and abiotic services, and in maintaining ecological function.[52] Nature is a major economic sector in its own right – as a productive asset it provides market and non-market services of £25 billion each year.[53]

74. The policies and proposals taken together within the Net Zero Strategy are expected to have a significant net benefit to natural capital and thus sustainable development. Moving away from i) fossil fuels towards a greater share of renewable energy, ii) petrol and diesel cars towards green alternatives such as electric vehicles iii) gas boilers to lower carbon heating sources and iv) high carbon land uses towards afforestation and other land-based carbon dioxide removals, are just a few examples that will provide significant benefits.

75. However, some negative impacts to some natural capital stocks are likely to arise from realising climate targets; impacts will likely be specific and localised. For example, the development of BECCS technology could lead to a rise in PM2.5 released in these areas. The direction of impact from the significant land use change required to meet net zero will depend on how and where this change is enacted, with a systemic and spatial approach more likely to deliver on net zero while providing natural capital benefits. Further in-depth exploration of the natural capital impacts of specific policies and policy mixes will need to be undertaken through the normal channels of Impact Assessments and Business Cases, to ensure trade-offs are managed and impacts mitigated.

76. Air Quality: As climate change and air pollution have many of the same contributing emission sources, the decarbonisation of the UK economy offers major opportunities to significantly reduce air pollution and therefore improve human health and reduce the impact of some air pollutants on ecosystems. This is primarily driven through the reduction of petrol and diesel cars towards green alternatives, as well as the continual shift away from fossil fuels in heat and power generation. However, some policies and proposals could result in significant negative air quality impacts at both regional and local scales, for example emissions of fine particulate matter from biomass combustion, ammonia from the use of anaerobic digestion, and NOx emissions

from hydrogen combustion in domestic or industrial settings. These are likely to impact our ability to reach statutory national emissions ceilings, increase exposure to harmful pollutants and cause some uneven health burdens. Furthermore, the impacts of air pollution can also impact the delivery of net zero. For example, all of England's forests and peatlands continue to be damaged by harmful emissions – particularly ammonia – which impact their ability to provide the ecosystem services required to meet net zero, including carbon sequestration and flood mitigation. Historic pollution loading across all habitats may also need to be ameliorated to maximise the potential of restoring them to meet the biodiversity targets in the Environment Bill. Further work will be undertaken to assess this and provide advice on tailoring our pathway to minimise these impacts. Continuous improvements in emission requirements and innovation in abatement technologies will also be necessary to deliver a pathway to net zero that maximises environmental benefits.

77. **Recreation:** Achieving climate targets could have positive impacts for recreation and the provision of landscape amenity, with a transition to a low carbon economy providing spaces to enjoy nature. This will primarily be driven by new woodland creation for recreation and forestry more widely (where access permitted), woodland management and restoring peatlands. Green transport will also provide the opportunity to regularly access green spaces, parks and woodlands. Some policies may cause landscape issues for example, solar and onshore wind generation.

78. **Biodiversity:** In the long-term, net zero policies, for example, afforestation and peatland restoration, can be positive for biodiversity, preservation, connectivity, resilience and reducing ecological stress caused by climate change. However, biodiversity and habitats are spatially explicit, meaning locations and extent of future policies must seek to minimise any negative impacts, including displacement, air and noise pollution, and habitat loss, for example through housing or industry development. This could be minimised through further work on net gain principles which would seek to leave the environment in a better position. Other risks include ensuring land use changes (i.e. afforestation, biomass feedstocks, settlement expansion) do not lead to biodiversity loss. Mitigating actions and trade-offs will be considered when designing policies for reaching climate targets, including for low carbon technologies, greenhouse gas removals, marine policies, land management, and agricultural intensification.

79. **Floods:** Global temperature rise is leading to increased precipitation levels within the UK. There are a number of nature-based solutions such as the creation of new woodlands, planting of biomass crops such as willow, increased levels of upland peatland restoration, and strategically located natural flood management measures which can have positive impacts on flood risk management. For example, increased upland water storage improves the capacity of the UK's waterbodies to prevent floods downstream. This will have varied benefits through reducing damages from floods to property, agricultural land and health, and reduced carbon emissions from floods. Conversely, rewetting lowland peatlands may reduce the water storage capacity of those landscapes with possible impacts on local flood risk.

80. Water availability and quality: Whilst many policies have positive impacts on water availability and quality, for example through upland peatland restoration and strategic planting of trees, some low carbon technologies are water-intensive and large-scale implementation could result in pressures on water demand. For example, nuclear power and hydrogen production require high levels of water input for cooling and electrolysis, respectively and certain biomass crops (for use in BECCS) have high water demand. This is set against a backdrop of increasing global water scarcity in a changing climate. The UK is no exception, with increasing likelihood of warmer, drier summers. Therefore, water demand both regionally and nationally should be considered at a systems level, to ensure sustainable demand.

81. Raw materials: Resource efficiency policies will have a net benefit to pressures on raw material availability, reducing raw material demand and consumption. Reduced resource extraction and processing will also benefit other natural capital assets. For example, 90% of global biodiversity loss and water stress is caused by resource extraction and processing.[54] Moving towards a circular economy, where priority is placed on extending the lifetime and lifecycle of a product through sharing, reusing, repairing, redesign and recycling, is likely to have a positive impact on a number of natural capital stocks, primarily water quality and availability, air quality and reducing pressures on land use.

82. Rare metals: Materials are finite. Some low carbon technologies are dependent on critical raw materials, many of which are rare, found in unique locations and in high demand globally, for example cobalt, lithium and nickel. Many of these rare metals are sourced internationally and extraction of them may place pressure on the natural capital stock in the country of origin. There are risks associated with overreliance on specific technologies where raw material scarcity may grow and geopolitics may determine access, for example, rare earth elements such as neodymium for use in magnets. These risks will be assessed in relevant policy delivery analysis.

83. Land Use: Land is finite. Meeting climate targets will require significant and competing demands from land, for example, for food, shelter, goods and service production, ecosystem services and greenhouse gas abatement. This will result in large changes to land use and management. The pathway in the Net Zero Strategy is reliant on land use change linked to tree planting, peat restoration and growing perennial energy crops or short rotation forestry for use as biomass. This change will impact on the extent and condition of natural capital assets and the ecosystem services they provide. The direction of impact (positive or negative) and its magnitude will depend on how and where land conversion happens. A systemic and spatial approach to land use, that considers net zero, socio-environmental objectives, and various socio-economic factors such as population and economic growth, is necessary to enact land use changes that delivers net zero as well as environmental outcomes in line with the 25 Year Environment Plan. Such an approach enables trade-offs to be managed among different objectives while facilitating win-win outcomes- for instance with flood protection and recreation.

Social considerations

84. Over the last decade there have been changes in the underlying costs of energy bills, which have been mitigated through energy efficiency measures, helping consumers to use less energy. Electricity prices have trended upwards due to rising network costs and support for low carbon infrastructure and vulnerable households. Gas prices have fluctuated due to international wholesale gas prices, which in recent months have been particularly volatile.

85. Government energy saving schemes have been targeted towards low-income or vulnerable households, and the retail energy price cap has helped protect those customers on default energy tariffs. Steps have also been taken to protect industries most exposed to the UK's relatively higher industrial electricity prices.

86. The policies set out in the *Net Zero Strategy* will help insulate consumers from the over-reliance on fossil fuels which they face today, and help to shield households, business, and the wider economy from the destabilising effects of this reliance.

87. How electricity and gas bills will change on the path to net zero depends on factors such as technology costs, patterns of consumer energy use and the government's gradual approach to rebalancing where social and policy costs fall. The nature of costs in a smart, clean energy system will be different. The largest part of the electricity bill is currently the cost to energy suppliers from buying power. This cost has traditionally been determined by the underlying price of gas or coal, but this is changing. Gas will continue to play a role in setting the electricity price for some years to come but, over time, will do so less frequently, as more and more low carbon generation (such as wind and solar) connect to the electricity system - consistent with the commitment to a fully decarbonised power system by 2035. This will help put downward pressured on wholesale electricity prices.

88. Patterns of energy consumption will also change. Most households and businesses are likely to increase their use of electricity, but reduce gas and petrol/diesel consumption, as they shift to low carbon forms of transport and heating (such as electric vehicles and heat pumps). It is essential to ensure that price incentives are fair and help support this transition away from relying on fossil fuel prices.

89. It will remain the case that households and businesses who install energy saving measures will reap significant savings.

90. As we progress towards net zero, the Government is committed to ensuring the costs of decarbonising the energy system are fair and affordable for all energy users. We are considering both the benefits and the costs of different pathways holistically across the economy and will work with industry and consumers to keep costs down.

91. The impact of decarbonisation on progress in tackling fuel poverty will be determined by changes in electricity and fuel prices, and higher energy efficiency in the housing stock. In particular, policies to improve energy efficiency in homes - such as the Social Housing Decarbonisation Fund, Home Upgrade Grant, Energy Company Obligation and proposals on Minimum Energy Efficiency Standards - will help to improve the building performance for the homes of those in or at risk of fuel poverty. The Warm Homes Discount will support fuel poor homes through reduced bill costs. Fuel poverty is a devolved matter. In England we are committed to our target for fuel poor households, as far as reasonably practicable, to be living in a home rated EPC Band C or better by 2030. Scotland, Wales and Northern Ireland have their own fuel poverty targets and are also working to improve the energy efficiency of their building stock.

Evidence base

Sectoral evidence

Power

BEIS' Dynamic Dispatch Model (DDM) has been used to generate technically feasible pathways that are consistent with achieving the NDC in 2030, the sixth carbon budget in 2033-37 and net zero in 2050.[55] This model was developed by BEIS and is used for all power sector analysis within the department. This includes the Modelling 2050 – Electricity System Analysis report that was published with the *Energy White Paper* and the Energy and Emissions projections.[56] It was also used for the power sector analysis in the CCC's *Sixth Carbon Budget* report although the CCC used their own assumptions and off-model adjustments for this.[57] Assumptions for the Northern Ireland power sector demand and emission pathway are based on the CCC's Sixth Carbon Budget advice.

The DDM relies on many exogenous assumptions and inputs, and results can be sensitive to changes in these assumptions. This includes using electricity demand from UKTM and other sectors analysis and evidence on different technologies costs and characteristics from BEIS' generation costs report.[58] Both full pathway runs and single year analysis is used to underpin the strategy set out in the power sector chapter.

Distribution Network outcomes are modelled in the Distributions Networks Model (DNM). The DNM conducts electricity power flow analysis across 10 representative regional networks to estimate future distribution network constraints (thermal violations and voltage imbalances). The results of the constraint analysis are then fed into a separate investment model to calculate reinforcement costs up to 2050.

Investment costs for power plant generation capacity and flexible assets are calculated from the DDM based on technological costs assumptions. Transmission and Distribution Network costs have been calculated separately. The costs for networks provided are in Allowed Revenues terms. Allowed Revenue estimates are the costs that network operators will be allowed to recover annually – as decided by Ofgem as part of their RIIO price control process. These are therefore the network costs that will be passed through each year. They do not represent the total value of investment in assets.

The 2050 illustrative scenarios represent the power sector at a less granular level than DDM. Supplementary adjustments and results were validated by DDM but should not be read as predictive of the optimal technology mix in 2050. For a detailed assessment of potential scenarios for the 2050 electricity system please consult the *Modelling 2050: electricity system analysis* published alongside the *Energy White Paper*.[59] The high electrification scenario assumes no hydrogen availability for power to illustrate an alternative power sector trajectory.

Fuel Supply and Hydrogen

Hydrogen: The hydrogen demand needed to meet the sixth carbon budget in industry, power, buildings and transport was estimated as set out in the evidence base sections for those sectors. The hydrogen production capacity needed to meet this demand has been calculated assuming hydrogen production plants run at a 95% load factor. Evidence on hydrogen supply and demand has also been drawn from the *Hydrogen Strategy*: further detail can be found in the *Hydrogen Strategy* analytical annex.[60, 61] Estimates of hydrogen production costs are based on the evidence set out in the hydrogen production cost report.[62]

Upstream Oil and Gas: The pathway for upstream oil and gas was developed using the OGA's projected abatement from offshore electrification and flaring.

Estimates of potential abatement from offshore electrification (scope 1 emissions only) were developed using the best available data provided to the OGA by industry as of August 2021, and assumes that there will be a mixture of some installations being partially electrified and some being fully electrified (the list of these installations was provided by industry). Fully electrified installations were estimated, in line with industry representatives' assessment, to have 70% of power demand provided by electrification, while partially electrified ones have 43%. Additionally, it is assumed that project phasing is one year and that electrification of the installation would not affect previously reported economic cessation of production dates.

The estimate of GHG emissions abatement via flaring reduction from offshore oil and gas infrastructure was developed assuming that zero routine flaring will be in place across all UKCS assets in 2030. Routine flaring is assumed to be broadly consistent with category 1 flaring (now defined by the OGA as category A flaring). Future expected flare volumes were calculated by subtracting the routine element of flaring from total anticipated flaring per facility after 2030, with data taken from the *UK Stewardship Survey*. Flared gas values, in both mass and volume units, have been converted to CO2 emissions using emission factors observed in published datasets (e.g. EEMS).[63]

Capex assumptions for Upstream Oil and Gas abatement measures have been sourced from the CCC's *Sixth Carbon Budget advice*. The overall cost profile has been calculated by BEIS and is aligned to the deployment trajectory underpinning the sector's illustrative emissions pathway. This is an early analysis with significant uncertainties. Through discussion with the OGA BEIS is confident that these estimates are in the right order of magnitude, however actual costs might end up being higher.

Hydrogen and other fuel supply assumptions for 2050 are aligned with those used in the *Sixth Carbon Budget Impact Assessment*. The level of curtailment available for electrolysis was taken directly from the power sector modelling.

Industry

A model of the UK industrial sector called Net Zero Industrial Pathways (NZIP) has been used to generate a technically feasible pathway to achieve a net zero industry sector by 2050. The model was developed by Element Energy for BEIS and the Climate Change Committee (CCC)[64] and was used to underpin the manufacturing and construction sector analysis in the CCC's *Sixth Carbon Budget report*[65] and the Government's *Industrial Decarbonisation Strategy* (IDS),[66] published in March 2021. The industry pathway required to reach net zero is based on the IDS National Networks scenario but achieves a faster trajectory through earlier decarbonisation of the Iron and Steel sector and increased CCS ambition by 2030. The model calculates the least cost pathway for a range of technologies, assessed on their capital and operating costs, along with cost reductions over time due to technology learning, and a number of key constraints impacting their deployment (e.g. technology readiness level, hydrogen and CO_2 transport and storage availability, supply chain capacity).

The 2050 scenario analysis includes supplementary adjustments to align the UKTM emissions, energy demands and CCS requirements with the evidence base in NZIP IDS 2050 scenarios. In the high electrification and high resource scenarios these align with the National Networks scenario, whilst the high innovation scenario is more representative of the Cluster Networks scenario.

Heat and Buildings

Both heat and buildings scenarios are developed to be consistent with completely decarbonising buildings by 2050 to meet a net zero target. With the assumption that a typical heating appliance has a lifetime of 15 years, this implies that no new fossil fuel heating systems can be installed after 2035. The high electrification scenario assumes that hydrogen is not available as an option for heating buildings, so the level of heat pump deployment grows from its current level of around 35,000 in 2020 to be able to meet the turnover of fossil fuel systems in 2035. In scenarios involving hydrogen, heat pump deployment meets the common ambition of 600,000 heat pumps by 2028, and further growth is dependent on the level of hydrogen deployment to generate the same level of carbon savings between scenarios. Installation of energy efficiency measures and deployment of low carbon heat networks is assumed to be same in all scenarios.

Domestic Energy Efficiency: The domestic energy efficiency modelling was carried out using the National Household Model.[67] This model estimates the impact of installing different measures in different properties by applying the Standard Assessment Procedure[68] to a representative sample of the housing stock based on the English Housing Survey.[69] Further adjustments are made to modelled savings to account for factors such as the real-life performance of measures and people heating their homes to a more comfortable temperature when their energy bills are reduced. Cost data for different measures comes from a variety of published sources, as well as some internal data.[70, 71, 72] The deployment profile for measures was estimated based on current and planned policies and proposals.

Non-Domestic Buildings - Commercial and public: The sixth carbon budget pathway for commercial and public sector buildings was created using BEIS Non-Domestic Buildings Model (NDBM). This models the deployment of low carbon heating and energy efficiency measures in non-domestic buildings. The NDBM uses building stock characteristics and potential energy efficiency information from the Building Energy Efficiency Survey (BEES) dataset.[73] Data on energy consumption and emissions come from the Digest of UK Energy Statistics, Energy and Emissions Projections, and ECUK.[74, 75, 76] The model has been supplemented with updated information on off-gas grid buildings from the Non-domestic National Energy Efficiency Data-Framework (ND-NEED); and updated cost and efficiency assumptions for Heating Ventilation and Cooling (HVAC) technologies in non-domestic buildings.[77] Modelling assumptions for public sector buildings have been further refined through monitoring the on-going rollout of phase 1 and 2 of the Public Sector Decarbonisation Scheme.

Products Policy: For products policies, as well as the sources listed above, additional data is taken from the ONS, consultation with trade associations and research provided by external contractors to develop the evidence base. The average energy consumption of products in the pathway are compared to the market average to calculate energy savings, taking into account product lifetime, usage and different technology types. Costs associated with products price increases, staff labour and training and installation costs are also taken into account, as well as interaction with EU and international trade and product regulations.

Domestic Heat Pumps: Deployment of domestic heat pumps is based on simple analysis of the residential stock, segmenting homes by heating fuel, and considering natural replacement cycles. The trajectory of heat pumps is based on estimates of deployment from current and planned policies, supply chain growth required to meet phasing out of new fossil fuel heating systems, and use of the natural replacement cycle to remove all fossil fuel heating in homes by 2050. Assumptions on appliance costs and performance, and on potential supply chain growth, are based on published research.[78, 79, 80] Assumptions on the current building stock and heat demand are from the NHM and domestic NEED.[81, 82] Assumptions on new build homes are based on DHLUC's 2019 FHS Consultation stage Impact Assessment - these were produced externally by consultants and an independent consortium.[83] These are for appraisal purposes only, and are not an official forecast of housing supply.

Hydrogen: Deployment of hydrogen for heat in buildings up to the sixth carbon budget has been modelled using a spatial analysis approach considering the metered gas demand from residential, commercial and public buildings within an expanding radius around potential industrial cluster sites producing hydrogen. Spatial gas demand has been derived from NEED data and assumptions on rollout rate have been taken from the CCC's residential heat decarbonisation scenarios from their Sixth Carbon Budget advice.[84, 85, 86] Additional assumptions on overall demand for scaling are from DUKES.[87]

Heat Networks: Deployment of heat networks has been derived from the expected impact of capital support and regulation, informed by the heat network opportunity areas.[88] The analysis appraises the impact of low-carbon heat network policies, and on fuel demand relative to a predominately gas-fired counterfactual, to estimate carbon savings. The costs technical assumption come from a AECOM report, but a number of assumptions have been updated since using learning from the Heat Network Investment Projects (HNIP).[89, 90]

Biomethane: Plant deployment scenarios are based on a combination of historic deployment under the Renewable Heat Incentive (RHI), and commercial intelligence. Heat generated is estimated from plant deployment scenarios and using estimates for biomethane injection as proportion of capacity.[91] The internal BEIS Biomass Heat Pathways Tool provides assumptions on biogeneration emissions, feedstock costs, capex and opex costs.[92] These capex and opex costs have also been verified against cost information collected through market intelligence, the Non-Domestic RHI Evaluation, and a review of AD plant costs commissioned by BEIS and awarded to the National Non-Food Crops Centre (NNFCC). Rothamsted Research has provided assumptions on upstream carbon savings, linked to diverting feedstocks from counterfactual uses to AD, and ammonia impacts.[93] Downstream carbon savings, linked to the displacement of natural gas with biomethane, are estimated using emissions factors provided in the HMT Green Book supplementary guidance.[94] Fertiliser savings are valued using the average of fertiliser prices published by the Agriculture and Horticulture Development Board across multiple years.[95] Full methodology and assumptions can be found in the final stage impact assessment for the Green Gas Support Scheme.[96]

The 2050 UKTM scenarios represent the housing stock at a less granular level but have been calibrated to the sectoral evidence base. The high electrification scenario assumes no availability of hydrogen for heating, the high resource scenario limits the deployment of electric heating, whilst the high innovation scenario is left to optimise outcomes.

Transport

Domestic Transport: The pathway for domestic transport covers road transport, rail, domestic shipping and domestic aviation. The *Net Zero Strategy* pathway for road transport, rail and domestic aviation was developed using projections from the recently published *Transport Decarbonisation Plan* (TDP).[97] These projections were produced using a range of models and analysis, including the National Transport Model (road transport), Traction Decarbonisation Network Strategy (rail), and the Aviation model, adjusted for decarbonising transport measures.[98] The forecasts presented in the TDP considered a number of scenarios. The *Net Zero Strategy* pathway for road transport, rail and domestic aviation assumes an ambitious policy package within the range of policy outcomes explored in the TDP. These emissions savings are applied to a central demand scenario. The Net Zero Strategy pathway for domestic shipping is based on research commissioned by the Department for Transport (DfT) – see below for further details.

International Aviation and Shipping: The *Net Zero Strategy* pathway for international aviation was developed using projections from the TDP and the *Jet Zero Consultation*.[99] This uses the same Aviation model and assumptions as used for the domestic aviation projections. The DfT's Aviation model is an established suite of interrelated components used to produce forecasts for aviation demand at the national level, and the associated passenger numbers, aircrafts and CO_2 emissions from flights departing from UK airports.[100] Three abatement measures are considered within the modelling; system efficiencies, sustainable aviation fuels (SAF), and zero emission aircraft.

As with the *Net Zero Strategy* pathway for domestic shipping, the pathway for international shipping is based on research commissioned by the Department for Transport (DfT).[101] For both pathways, the estimates from this research have been adjusted to align them with the latest UK greenhouse gas emissions national statistics.[102] Therefore, the pathways for domestic shipping and international shipping are consistent with the definitions of domestic shipping and international shipping used in these national statistics.[103] Given the emerging nature of zero emission shipping fuels, the NZS pathways for domestic shipping and international shipping should be interpreted as a possible scenario for meeting the government's commitment to achieving net zero in maritime rather than estimates of the impact of specific policies.

The illustrative 2050 scenarios rely on the same evidence base for transport as the Sixth Carbon Budget Impact Assessment with the exception of the high innovation scenarios, where modelling updates on aviation to reflect DfT's Jet Zero consultation high ambition scenario, and the scenarios for shipping which have been aligned with the NZS pathways described above. To support the sustainable fuel production requirements additional assumptions have been taken from the Advanced Gasification Technology review.[104]

Natural Resources and Waste

Agriculture: The agriculture emissions trajectory is based on estimates of maximum technical GHG mitigation potential (MTP) for each technology from the Clean Growth through Sustainable Intensification (CGSI) Project and building upon previous work by the CCC. MTP quantifies the impact if all farms which could technically adopt a measure do so, whilst considering any current uptake to avoid double counting.[105] MTP was derived from expert review of published literature and modelling to scale experimental data to national level. These estimates have been independently peer reviewed. CGSI used the MTP values to derive the trajectory based on ambitious but feasible deployment rates. The trajectory was informed by academic, industry and policy experts to reflect barriers, technology readiness and R&D lead in times.

Additional stretch options were modelled through Defra analysis using CGSI and CCC data, generally through adjustments to implementation rates. Additional modelling addressing agricultural mobile machinery aligned to CCC analysis in its *Sixth Carbon Budget* Report. England only data was scaled to a UK basis using the relative emission share between England and the Devolved Administrations as an estimator of Devolved Administration potential, pending publication of the Devolved Administrations pathways.

The UKTM modelling for the 2050 scenarios uses the same evidence base as the agriculture emissions trajectory. A set of crop and livestock measures are characterised by their cost and maximum technical potential to reduce emissions, and these assumptions are the same across the three scenarios.

Biomass: The biomass analysis is an indicative technical assessment of potential carbon abatement assuming optimal species/site/climate matching and a relatively simplistic approach to modelling carbon removals. Five biomass crop categories were modelled, deployed in fixed proportions: exotic SRF (14%); conifer SRF (23%); broadleaf SRF (poplar, aspen) (12%); SRC willow (27%); miscanthus (25%). A high-level analysis of land availability has been undertaken, indicating that the *Net Zero Strategy* pathway deployment profile is feasible. To calculate carbon stocks, a simple linear approach to yield modelling has been adopted which could overestimate initial growth and thus abatement. For all crops, appropriate biomass expansion coefficients were applied to account for branches and/or roots, as appropriate. All biomass was converted to carbon, assuming carbon comprises 50% of biomass. Emissions savings are modelled as the time-averaged increase in biomass carbon stocks resulting from planting of the crop, assuming the land use change is permanent.

In addition, the 2050 scenarios assume a maximum technical potential of 53 kha domestic bioenergy crop planting rate by 2050. Bioresource import assumptions in 2050 do not exceed current levels of imports.

Forestry: Emissions/removals are estimated using output from Forest Research's CSORT model, an off-line version of Carbine, the greenhouse gas accounting model used to calculate the forestry contribution to the UK LULUCF GHG inventory.[106, 107] Three indicative woodland types are represented in the model: productive conifer, productive broadleaf, and unmanaged. The modelled abatement is for England only and adjusted to a UK basis to be broadly aligned to the CCC share of afforestation by country in the "Balanced Net Zero pathway" scenario.[108] Linear expansion of deployment is assumed between 2025 and 2035. Non-market benefits are calculated using various research, compatible with the Enabling a Natural Capital Approach services data book.[109]

The 2050 scenarios vary the maximum afforestation/tree planting rate assumptions between 30 kha (in the high electrification/innovation scenario) and 50 kha pa (in the high resource scenario).

Peatland: The peatland trajectory covers restoration as well as technical potential modelling covering abatement from responsible management and the ending of peat extraction. Emissions savings from peatland restoration are based on upland, lowland cropland and lowland grassland emissions factors, which are applied to the peatland restoration deployment profile, delivered via the Nature for Climate Fund and Blended finance up to 2050.[110] The technical potential modelling covering responsible management measures (management activity that does not seek to re-establish peat habitats, but which significantly reduces the impact of using peatland for its current purpose) assumes abatement to be 1/3 of respective cropland/grassland restoration abatement. Biodiversity and water quality benefits are monetized using central values, whilst upfront restoration costs are estimated using 2017 Defra grant scheme data.[111, 112] The peatland modelling from Defra is England only, including an early stage assessment of how emissions factors from wasted peat may be revised in future inventories. Abatement potential in DAs is assumed to be in line with CCC analysis.

Peatland assumptions are the same across the three 2050 scenarios and there are two separate evidence bases – one that covers England, and one that covers Scotland. Both evidence bases consist of a set of restoration measures characterised by cost and maximum technical potential to reduce emissions. Assumptions for England come from Defra but for Scotland, data comes from the Scottish TIMES model and are uplifted to account for Wales and Northern Ireland.

Resources and Waste: For municipal wastewater, water companies use the Carbon Accounting Workbook developed by UK Water Industry Research to estimate operational GHG emissions across the industry. The workbook has been in place since 2004 and is updated annually to reflect the needs of the industry, including changes in carbon accounting practices with updated emission factors to align with the latest UK and international data. There are no internal models for private or industrial emissions and there are still significant gaps in our understanding of the magnitude and main sources of these. The Water UK Routemap to 2030 sets out industry plans to achieve net zero by 2030.[113] This routemap has been used as the basis for Defra to develop net zero consistent policies, for example, using assumptions from industry on cost and feasibility of policy deployment.

For landfill emissions estimation, the Landfill Environmental and Financial (LEAF) model has been used. This was developed by Resource and Waste Solutions, and more detail can be found in their report.[114] This is a high-level and strategic model of non-hazardous waste flows in England. LEAF allows the different scenarios to be described numerically and their effects on landfill emissions and costs of landfill to be calculated. The model considers the impacts of changes on landfill gas, leachate and void space consumption. The model is England only, but to provide an indication of Devolved Administration potential, emission savings are scaled to a UK level using relative emissions shares between England and the Devolved Administrations. It is assumed that there is a linear increase in diversion from landfill after 2021.

F-Gases: The *Net Zero Strategy* pathway for F-gas Emissions was estimated primarily using the UK-Level HFC Outlook Model developed by Gluckman Consulting. Non-HFC F-gas emissions are estimated using the BEIS Energy and Emissions Projections. The level of ambition for metered dose inhalers is derived from the ambition within the NHS report 'Delivering a 'Net Zero' National Health Service'.[115] Costs were developed using the CCC report 'Assessment of the potential to reduce UK F-gas emissions beyond the ambition of the F-gas Regulation and Kigali Amendment'.[116] Uplift of HFC GWPs to AR5 with Carbon Cycle Feedback values was taken from BEIS Methodology.

Assumptions on maximum technical potential for resources, waste, and F-gases in the 2050 scenarios are aligned with the sectoral evidence base for the pathway analysis.

Greenhouse Gas Removals

The engineered removals include the following technologies: Power Bionenergy with Carbon Capture and Storage (Power BECCS), Industry BECCS, Direct Air Carbon Capture and Storage (DACCS), and BECCS applications based on advanced gasification technologies (Hydrogen generation with waste, Hydrogen generation with biomass, Biofuels, Biogas, and Biomethane generation with CCS). Other engineered removals solutions, such as enhanced weathering, carbon-negative cements, ocean carbon sequestration and biochar have not been included in the modelling at this stage given the underlying uncertainty and need for further development.

The pathway was developed through a combination of bottom-up sectoral modelling, as well as UKTM whole-system modelling. The pathway analysis (including build rates, energy demand, and costs) relied on assumptions from published sources on BECCS and DACCS, alongside a benchmarking study commissioned by BEIS.[117, 118, 119, 120, 121] The study presented evidence based on an original review of the published literature, feedback received through the GGR Call for Evidence and additional stakeholder engagement.[122]

An investment lead-in time of four years is assumed for power BECCS, and five years for hydrogen BECCS and DACCS. Costs for power BECCS and hydrogen BECCS represent both the cost of generation (electricity/hydrogen) and of CO_2 removal. Power and hydrogen generation with BECCS are assumed to operate at baseload. DACCS is assumed to rely on low carbon energy inputs.

UKTM modelling for the 2050 scenarios uses the same technology assumptions as the pathway analysis where possible. In addition to the benchmarking study, assumptions on maximum technical potential and technology performance have been sourced from the sectoral models such as NZIP and from the Advanced Gasification Technology review.

Supporting the transition across the economy

Green Jobs, Skills and Industries

Skills evidence presented in the *Net Zero Strategy* is largely drawn from the work carried out by the Green Jobs Taskforce and found in the published Green Jobs Taskforce report.[123] The joint BEIS and DfE Ministerially led independent Taskforce included representatives from across business, trade unions and the skills/education sector and it was supported by a secretariat comprised of civil servants from BEIS and the DfE. The secretariat facilitated the drawing together of its evidence review and supported the Green Jobs Taskforce reviewing over 200 reports published by industry, academia, and government to form a robust evidence base upon which to build recommendations. The Annex published alongside the Green Jobs Taskforce brings together a wide range of information about how certain sectors, occupations, skills requirements and qualification levels (L)1 will change as the UK transitions to a net zero economy gathered by the secretariat.

Green Investment

Research referenced in the Green Investment chapter is drawn from external sources. This includes the Climate Change Committee's *The Road to Net Zero Finance*, which was a report prepared by the Advisory Group on Finance to critically assess the UK financial systems ability to deliver net zero.[124] This report provides an estimate for the total amount of capital investment needed in technologies to achieve net zero and therefore does not deliver a full picture of investment needs given the exclusion of operational costs.

Innovation for Net Zero

The published Energy Innovation Needs Assessments (EINAs) are the main source of evidence base underlying the innovation chapter.[125] It is a whole system analysis used in understanding the sectors and innovations of highest potential benefit to the UK energy system. The analysis is based on cost optimisation modelling carried with the Energy System Modelling Environment (ESME), and extensive engagement with industry to shape input assumptions and guide technical specifications. The EINAs are split into twelve reports, each covering a group of similar technologies and exploring their potential impacts and current barriers to their innovation and deployment. Overall, the EINAs aid understanding of where innovation can help achieve the largest energy system cost reductions and business opportunities when on a net zero trajectory.

GVA figures used in this publication have been updated internally by BEIS using the same EINA methodology to reflect increased net zero ambition, as original EINA publications were on the basis of the previous 80% greenhouse gas reduction target.

Local Climate Action

Analysis of local based decarbonisation policies is based on the Local Net Zero Model. The model takes assumptions from the ELENA programme, an EU fund which leverages public money for local based decarbonisation projects.[126] These assumptions include the expected level of private funding leveraged, energy savings of projects and additionality. The model estimates the public costs, private costs, carbon savings and energy savings of expected projects resulting from the programme.

Empowering the Public and Businesses to Make Green Choices

Much of the research contributing towards this chapter was part of BEIS' Net Zero Societal Change Research Programme 2020-21. Components of the research programme that have fed into this chapter include: 'Climate change and net zero: public awareness and perceptions' (an online survey of circa 7,000 members of the UK public on public perceptions of climate change and net zero); 'Net zero public dialogue' (online workshops with the public exploring their understanding and perceptions of net zero); 'Net Zero Societal Change Analysis Project' (analysis carried out by Energy Systems Catapult exploring the potential impact of different societal changes in reaching net zero); and a research note entitled 'Net zero public engagement and participation'.[127, 128, 129, 130]

Within the chapter, the 'Principles underpinning green public and business choices' section is drawn from 'Net zero: principles for successful behaviour change initiatives', a report BEIS commissioned from the Behavioural Insights Team.[131] The chapter also uses findings from BEIS' Public Attitudes Tracker surveys regarding people's concern about climate change.[132]

Cross-cutting assumptions

Fuel prices: Fossil fuel price assumptions are based on the BEIS Fossil Fuel Prices Assumptions 2020, with the exception of UKTIMES analysis which uses the BEIS Fossil Fuel Prices Assumptions 2016.[133]

Carbon values: Carbon values apply a monetary value to emissions in policy appraisal and are based on a target-consistent approach. The latest 2021 HMG carbon values are consistent with the UK's national and international climate commitments and represent an increase on previous values.[134] Where cost benefit analysis of the sixth carbon budget from the Impact Assessment is quoted, the 2018 carbon values were used. These are consistent with the previous 80% emissions reduction target. To compensate for subsequent increased climate ambition, the high rather than central 2018 carbon values were used in the cost benefit analysis.[135]

Economic growth and demography: The baseline for economic growth used for all analysis is consistent with the July 2020 OBR long term projections of economic growth.[136] When calculating the GDP carbon intensity and GDP energy intensity deployment assumptions, projections from the March 2021 Economic and fiscal outlook were used, for both short and long-term GDP forecasts.[137]

Air quality: Where air quality impacts have been quantified, they have been monetised in line with the national values of the most recent air quality damage costs.[138]

Discount rates: Discount rates are used in line with Green Book guidance.[139] For appraisal periods up to 2050 the discount rate is 3.5%. A 2% cumulative annual health uplift is applied to air quality benefits prior to discounting, effectively reducing the discount rate to 1.5%.

Estimating jobs: The estimate of jobs delivered since the *Ten Point Plan* announcement is based on internal HMG analysis of employment impacts across a range of policies and programmes within the 10 Points of the Plan. The method for estimating the number of jobs supported by *Net Zero Strategy* policies and proposals in 2025 and 2030 is as follows. This varies by sector and in some cases by the period of analysis.

Power: Analysis aggregates projected employment across Power Networks, Offshore wind, Onshore wind, Solar, and Storage and demand side flexibility, all based on BEIS analysis using the EINA methodology and the technology deployment levels implied by the indicative delivery pathway (see Table 11). The 2030 figure also includes 10,000 jobs (peak employment) from the construction of a large nuclear plant. These estimates are based on the number employed directly in the power sector technologies, with the exception of offshore wind, which also includes indirect (supply chain) jobs based on a multiplier of 1 direct job to 1 indirect job.

Fuel supply: The 2025 analysis is an estimate of potential employment by that year in a UK industry in Sustainable Aviation Fuels (SAF) (based on DfT analysis). The 2030 figure is an aggregation of anticipated employment by that year in SAF (based on DfT analysis), along with an estimate of potential employment in a UK hydrogen economy as set out in the Hydrogen Strategy.[140] This is based on BEIS analysis of an updated model from the Energy Innovation Needs Assessment.

Industry: Analysis relates to estimated employment in the UK in Carbon Capture Utilisation and Storage (CCUS), calculated using the Energy Innovation Needs Assessments approach and pro-rated for 2025 based on the anticipated trajectory for the level of carbon captured through CCUS over the decade. These are high-level estimates and actual outturn of employment will depend on several factors, although the jobs estimate is considered broadly consistent with stated government policy for the development of the technology. These estimates cover both power CCUS and CCUS for industrial purposes, but are included in the Industry chapter as the estimates do not directly overlap with any estimates included in the Power chapter.

Heat and Buildings: Analysis aggregates anticipated employment impacts from the decarbonisation of heating (calculated using an update of the *Energy Innovation Needs Assessments* applied to the deployment levels set out in Table 11) and total public and private spending on energy efficiency measures (based on BEIS analysis using a jobs/capex multiplier). These estimates are based on broad assumptions of the policy mix driving carbon savings from domestic buildings over the 2020s. As some of these policies are still not confirmed, there is large uncertainty over the exact timing and job numbers supported by them.

Transport: Both numbers are based on an aggregation of anticipated employment impacts from the Automotive Transformation Fund and the Advanced Propulsion Centre, along with anticipated levels of employment in active travel (cycling and walking), and rail decarbonisation. The active travel and rail decarbonisation estimates are based on DfT analysis of what policy ambitions for active travel and rail decarbonisation are likely to imply for employment in their respective sectors in these years.

Natural Resources, Waste and F-gases: These numbers relate exclusively to direct employment in the UK forestry sector and are based on Defra analysis. These estimates exclude indirect jobs, such as those supported in tourism, the wider forestry supply chain or local farming. Employment in forestry will be supported by policies such as the Nature for Climate Fund. This number does not include potential employment in other areas covered in the chapter such as peat restoration, sustainable agriculture or waste recycling.

Public and private investment estimates

Public investment figures in the strategy refer to sums of government spend committed to a relevant Budgets and Spending Reviews, unless otherwise stated. Private investment estimates are derived through analysis of how much private sector spend is likely to be leveraged from this public spend. Further public and private investment will be delivered as proposals are developed into firm policies. Analysis of the potential GVA generated by decarbonisation has been conducted for a subset of sectors: power, renewables, heat and buildings, industry, CCUS, hydrogen, smart systems and road transport. The analysis follows the methodology developed by Vivid Economics for the Energy Innovation Needs Assessment in 2019.[141] Where possible, it uses whole energy systems modelling to estimate domestic economic opportunities from achieving net zero in the UK in 2050 and, while export opportunities rely on a global scenario limiting global warming to two degrees Celsius above pre-industrial levels.

Endnotes

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Climate Science Annex

Climate Science Annex

Why we must act

Science is clear that the world is warming, that this is occurring because of human activity, and that left unchecked, continued warming would be deeply harmful, not just to the natural world, but also to human security and wellbeing. Global average temperatures have already risen by around 1.1°C[1] and 2020 concluded the earth's warmest 10-year period on record.[2] Without action to reduce the level of greenhouse gas (GHG) emissions emitted globally down to net zero, climate change is set to continue with increasing temperatures across the world.[3]

We are already seeing the impacts of climate change across all parts of the world, with many types of extreme weather becoming more frequent and more intense – causing droughts, wildfires and flooding.[4] The North American heatwave in June 2021, which broke temperature records by over 4°C and reached 49.6°C in Canada, would have been virtually impossible without climate change.[5] The melting of glaciers and ice sheets is accelerating, with sea levels currently rising at 3.7mm annually.[6] In the UK we can see a trend towards warmer and wetter winters, along with hotter summers.[7]

These changes are damaging the land and oceans that support human society and the natural environment. As a result, many species are being driven closer to extinction,[8] food supplies are being disrupted,[9] and the health and livelihood of people across the world are being affected.[10] Climate change disproportionally affects poor and disadvantaged people, with rural, coastal, and indigenous communities facing greater risks from impacts such as rising sea levels, drought, and food shortages.[11]

There is still uncertainty over the responsiveness of global temperatures to GHG emissions; the Intergovernmental Panel on Climate Change (IPCC) estimate that a doubling of pre-industrial CO_2 levels would result in warming in a range of 2.5°C – 4°C.[12] The higher that temperatures rise, the greater the risk of seeing dangerous low-likelihood, high-impact outcomes. These could include abrupt responses and tipping points such as dieback of the Amazon Rainforest, melting of the polar ice sheets, and the collapse of key ocean currents controlling global weather, which cannot be ruled out.[13, 14] To avoid these risks, strong and decisive action is needed to reduce GHG emissions. Limiting further warming decreases the likelihood of more severe and potentially irreversible impacts on people and ecosystems. Action would also provide other co-benefits, such as limiting the rate of ocean acidification and improving air quality. Every additional fraction of a degree of global warming counts – with every 0.5°C of warming there are clearly discernible increases in the intensity of and frequency of impacts.[15] This is why we should aim to reduce global emissions to net zero as quickly as is practically possible.[16]

Global temperature goals and emissions pathways

Rapid and deep cuts to emissions are essential to avoid the most dangerous impacts of climate change.[17] Greenhouse gas concentrations and global temperatures will continue to rise until we reduce GHG emissions to net zero.[18] In 2015 the Paris Agreement was signed, where 196 parties committed to hold "the increase in the global average temperature to well below two degrees above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels, recognising that this would significantly reduce the risks and impacts of climate change". The Agreement recognised that, to achieve this goal, global emissions of greenhouse gases would need to peak as soon as possible, reduce rapidly thereafter, and reach a net zero level in the second half of this century.

As part of the Paris Agreement, countries also committed to reduce or limit their greenhouse gas emissions. These commitments are contained in their Nationally Determined Contributions (NDCs). A number of studies have assessed how close these commitments bring us to staying below two degrees.

It is worth noting that these assessments use different assumptions regarding both the extent to which countries will meet their NDCs and, crucially, the actions that will be taken by countries to reduce their emissions after 2030. The latter will be a key determinant of whether the world will meet the long-term global temperature goal.

The Climate Action Tracker (CAT)[19] estimates that if there were a continuation of the currently implemented global policies these set us on course for a global average temperature rise of 2.1°C to 3.9°C by the end of the century. But if currently pledged ambitions (i.e. those not yet implemented into tangible policies) are implemented this range decreases to 1.9°C to 3.0°C, with a mid-range estimate of 2.4°C. These estimates are also consistent with projections in the UN Environment Programme's 2020 Emissions Gap Report.[20] Whilst these assessments show that current NDCs can have a significant impact on projected temperature rises, greater action is still needed if we are to limit global temperature increases to well below two degrees.

Adaptation in the UK

Responding to the complexity of climate change demands a multifaceted approach. Regardless of global success in reducing GHG emissions, some future temperature rises are already locked in by historical emissions up to the present day. Even the most optimistic, ambitious emission reduction scenarios suggest approximately 0.5°C of further warming by mid-century compared to the present day.[21] Furthermore, future global emissions pathways are highly uncertain, so it is essential that the UK's adaptive capacity is rapidly developed to prepare for, and bolster our resilience to, the inevitable near-term and potential future impacts of climate change.

To prepare for these eventualities, the UK is already considering climate risks and what actions will be required through its five-yearly policy cycle of a Climate Change Risk Assessment followed by a National Adaptation Programme (NAP). The Government's Third Climate Change Risk Assessment will be published in January 2022 and will outline Government views on the key risks and opportunities the UK will face from climate change. The Climate Change Committee's 2021 Independent Assessment of UK Climate

Risk identified eight risk areas that will require the most urgent attention in the next two years.[22] These are applicable even if global warming is limited to 1.5°C.

- Risks to the viability and diversity of terrestrial and freshwater habitats and species from multiple hazards
- Risks to soil health from increased flooding and drought
- Risks to natural carbon stores and sequestration from multiple hazards leading to increased emissions
- Risks to crops, livestock and commercial trees from multiple hazards
- Risks to supply of food, good and vital services due to climate-related collapse of supply chains and distribution networks
- Risks to people and the economy from climate-related failure of the power system
- Risks to human health, wellbeing and productivity from increased exposure to heat in homes and other buildings
- Multiple risks to the UK from climate change impacts overseas

The NAP is a cross-department collaboration, bringing together government's policies on managing climate risks in one place. The second NAP sets out how we will address climate risks for the period 2018 to 2023, including risks to terrestrial, coastal, marine, and freshwater ecosystems, soils and biodiversity; and flooding and coastal change risks to communities, businesses and infrastructure.

Future developments in climate science

In recent years the debate and focus of scientific research has shifted from whether climate change is happening and/or is being caused by human activity, to the range of the expected impacts and the level of action required to address climate change through a combination of adaptation and mitigation. We need to better understand the nature, magnitude and rate of climate change. Preparing for unavoidable changes to the climate will require more local analysis and more information on how global warming relates to local-scale changes in weather and climate extremes. Further research is also needed around stronger mitigation actions to inform climate policy that can get us to net zero.

Our knowledge has increased significantly but many key research priorities remain, including deepening our understanding around the four questions Government posed to the Met Office this year.[23]

- What current weather and climate risks and impacts are expected globally and in the UK?
- What are the future risks and impacts from weather and climate that we need to avoid or need to adapt to?
- What are the carbon budget and mitigation scenarios that will avoid the most dangerous impacts of global climate change?
- What impacts and opportunities from mitigation and adaptation actions are needed to proceed towards a resilient and net zero future?

The UK has also recently committed £1.2 billion of funding to develop a new state-of-the-art supercomputer for the Met Office. This will help ensure government, industry and communities are better prepared for the impacts from a changing climate through increased amounts of data. Examples include the provision of very detailed localised climate information to improve city planning and public transport infrastructure.

Climate science continues to rapidly improve and develop. This year saw the publication of the Working Group I (WGI) contribution to the IPCC's Sixth Assessment Report (AR6). The report addresses the most up-to-date physical understanding of the climate system and climate change, bringing together the latest advances in climate science. WGII and WGIII contributions to AR6 will be published in 2022 and respectively cover the impacts of climate change on people and nature, and the options for reducing GHG emissions and removing GHG from the atmosphere.

The main conclusions of WGI are a reinforcement of the consensus on climate science: that there is absolutely no doubt that human activities have warmed the planet and are causing widespread and rapid changes to the climate. Without immediate and drastic action, the impacts will be more severe and frequent. It shows that we are already feeling the effects of climate change and know that some changes to the planet are already irreversible on timescales of centuries to millennia. However, with immediate, concerted action to reduce emissions now, the worst impacts can still be averted. Technologies to remove CO_2 directly from the atmosphere or ocean can also help, but to adhere to the temperature goal of the Paris Agreement ambitious action on emission reductions is still required, and is needed today.

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978-1-5286-2938-6