

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 MtCO₂e 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

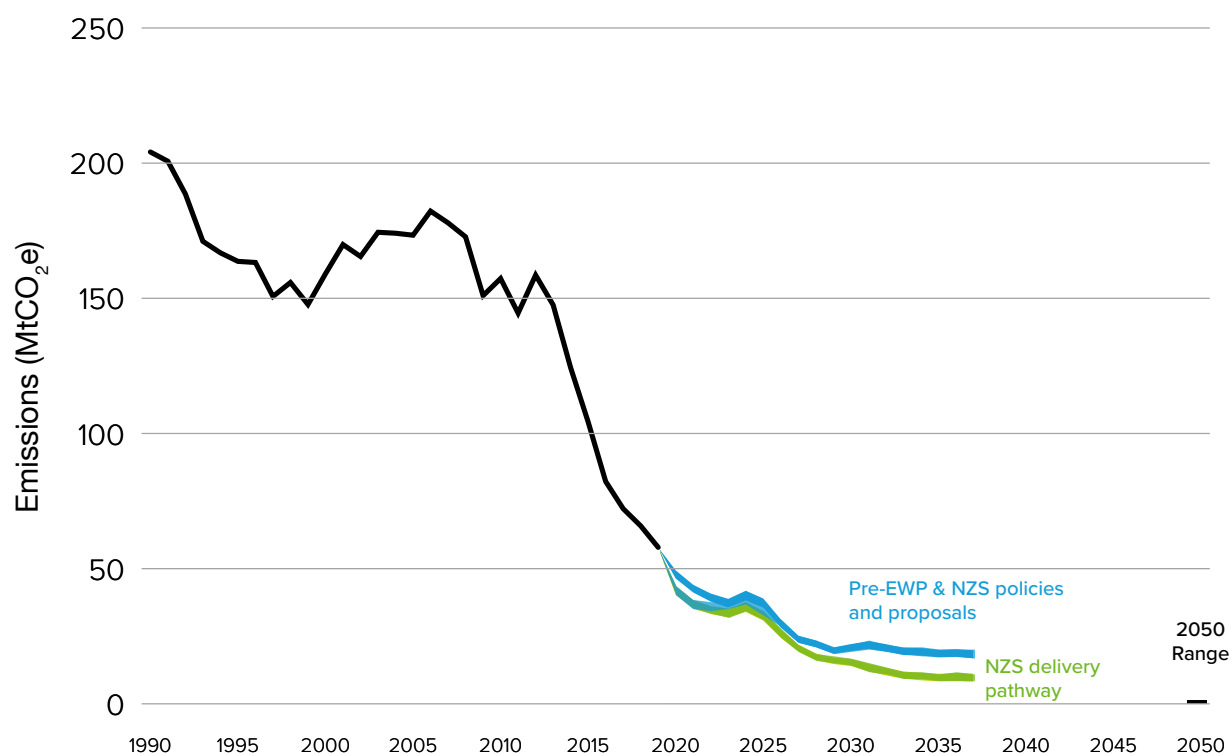
Our 2050 vision and how we get there

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 MtCO₂e. 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 MtCO₂e 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

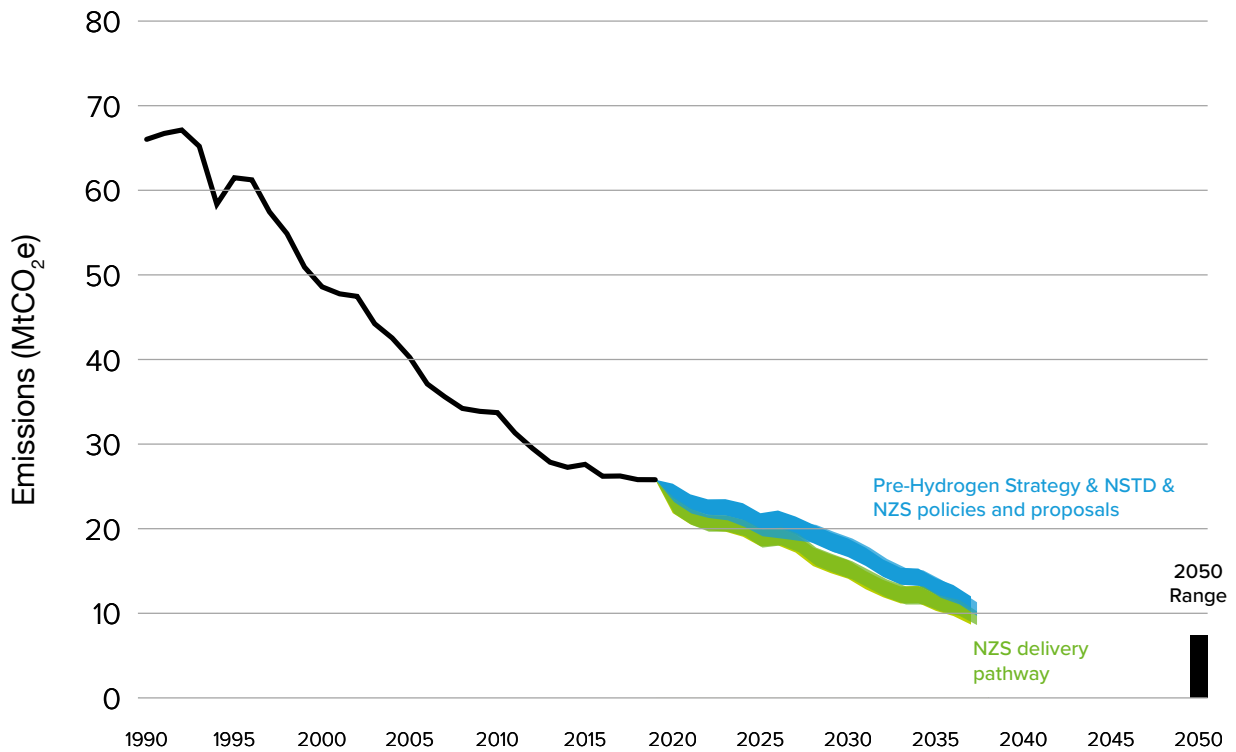
Our 2050 vision and how we get there

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 MtCO₂e. 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 MtCO₂e 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 CO₂' 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 industrial ‘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 MtCO₂/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 OGA 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 MtCO₂e. 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 MtCO₂e 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 model²⁵ 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 consultation²⁷ 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 MtCO₂ per year of industrial CCUS by 2030, and 9 MtCO₂ 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 MtCO₂e worth of savings by 2035, including up to 3 MtCO₂e 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 GDP³⁰ and provides 2.5 million direct jobs across the country³¹ as well as over 5 million across the value chain.³²
- 2.** However, industry³³ is also a major source of CO₂ emissions, producing 15% (78 MtCO₂e)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.

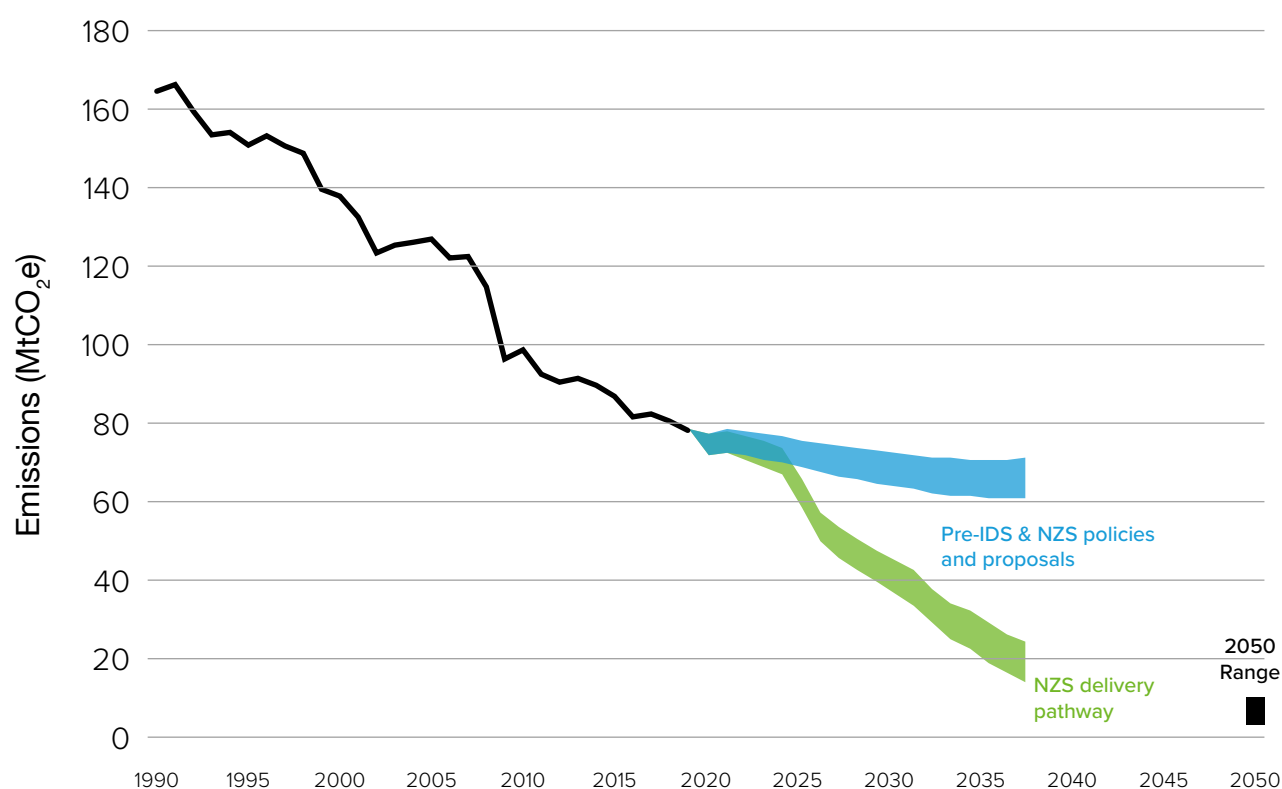
Net zero transition and economic opportunities

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 MtCO₂e. 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 MtCO₂ per year to 6 MtCO₂ by 2030, and 9 MtCO₂ 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 MtCO₂e worth of savings by 2035, including up to 3 MtCO₂e 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 2030³⁵, 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 areas. 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 as 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 MtCO₂ per year by 2030. Our delivery pathway for Carbon Budget 6 requires an increased ambition of 6 MtCO₂ per year by 2030 and 9 MtCO₂ 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 CO₂ 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 contracts 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 MtCO₂e and 12 MtCO₂e of industry emissions per year by 2050. Electrification will play a more significant role (12 MtCO₂e) 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 MtCO₂e per year. Industrial NRMM accounts for around 6 MtCO₂e,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 MtCO₂e 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 MtCO₂e 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 MtCO₂e 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 sites⁴³ account for approximately half of the UK's industrial emissions⁴⁴, 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 integrated 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 buildings⁴⁶ 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 m² 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 conditions⁶⁵. 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

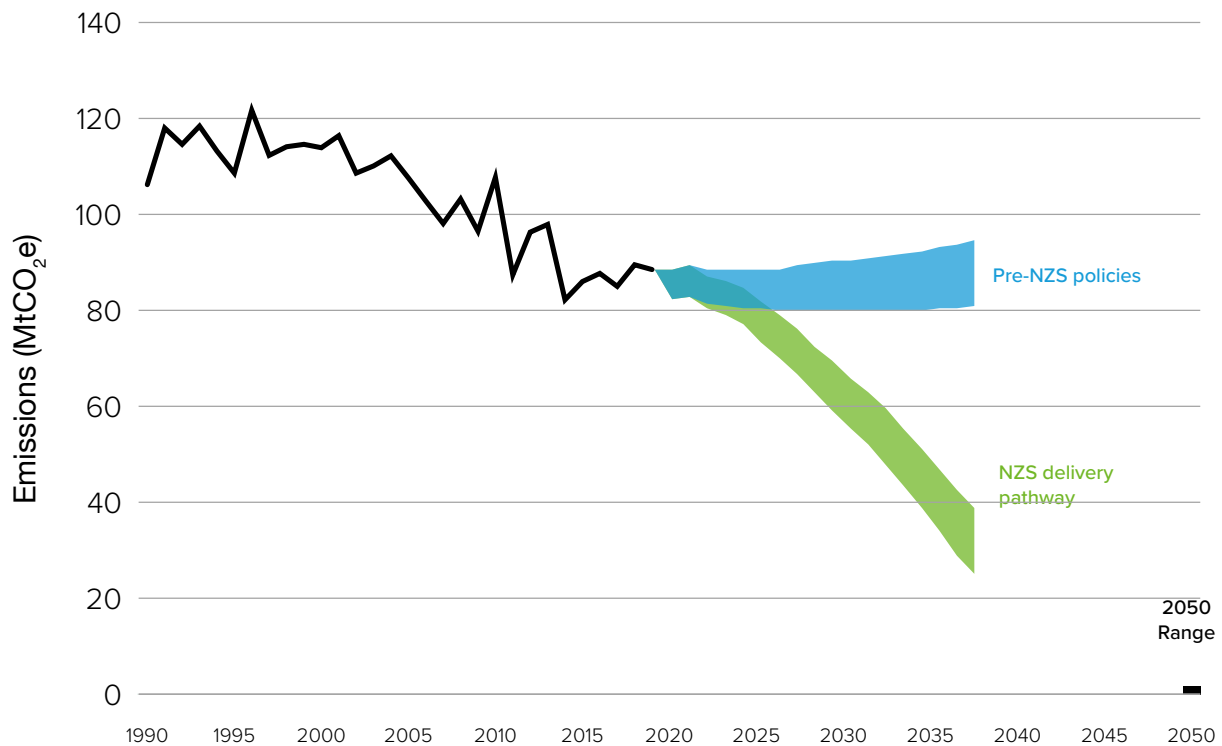
Our 2050 vision and how we get there

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 MtCO₂e. 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 our 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 CO₂ 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 (SBEEES) 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 MtCO₂e. This is followed by heavy goods vehicles and light goods vehicles contributing 19 MtCO₂e (16%) and 19 MtCO₂e (16%) respectively. The remaining emissions in domestic shipping, road transport, rail, and domestic aviation contribute a combined further 16 MtCO₂e (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.

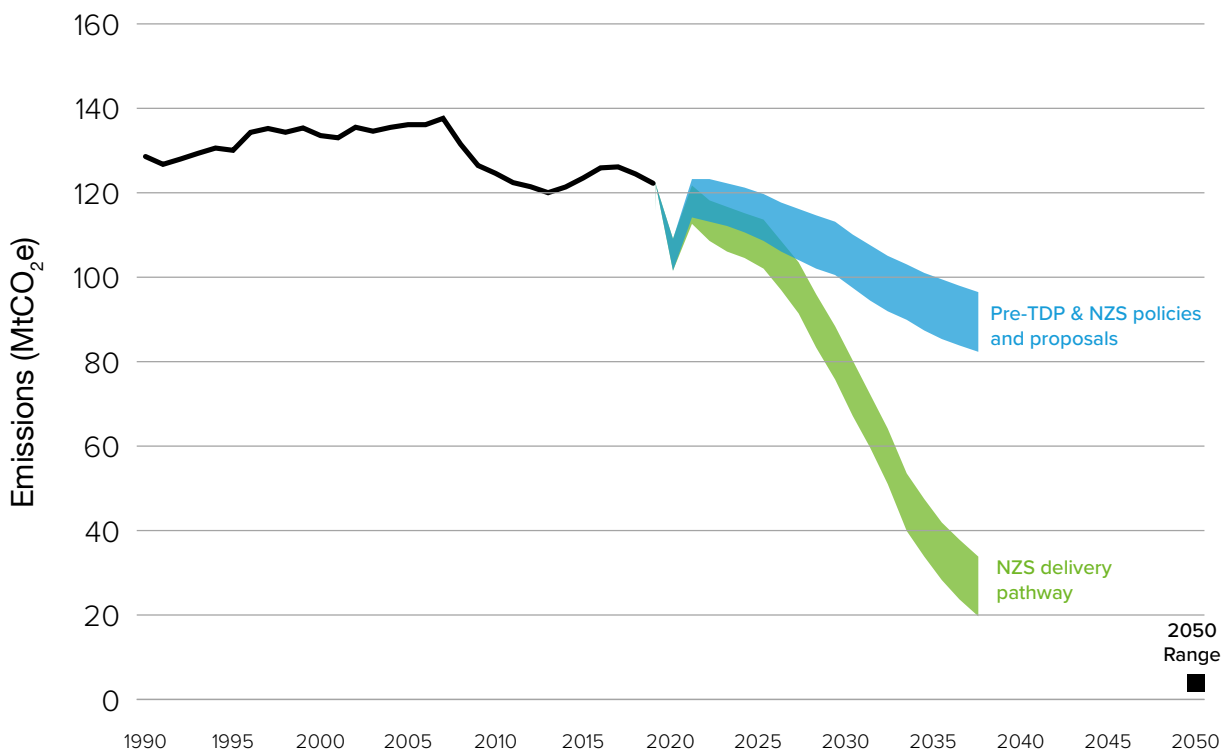
Net zero transition and economic opportunities

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.

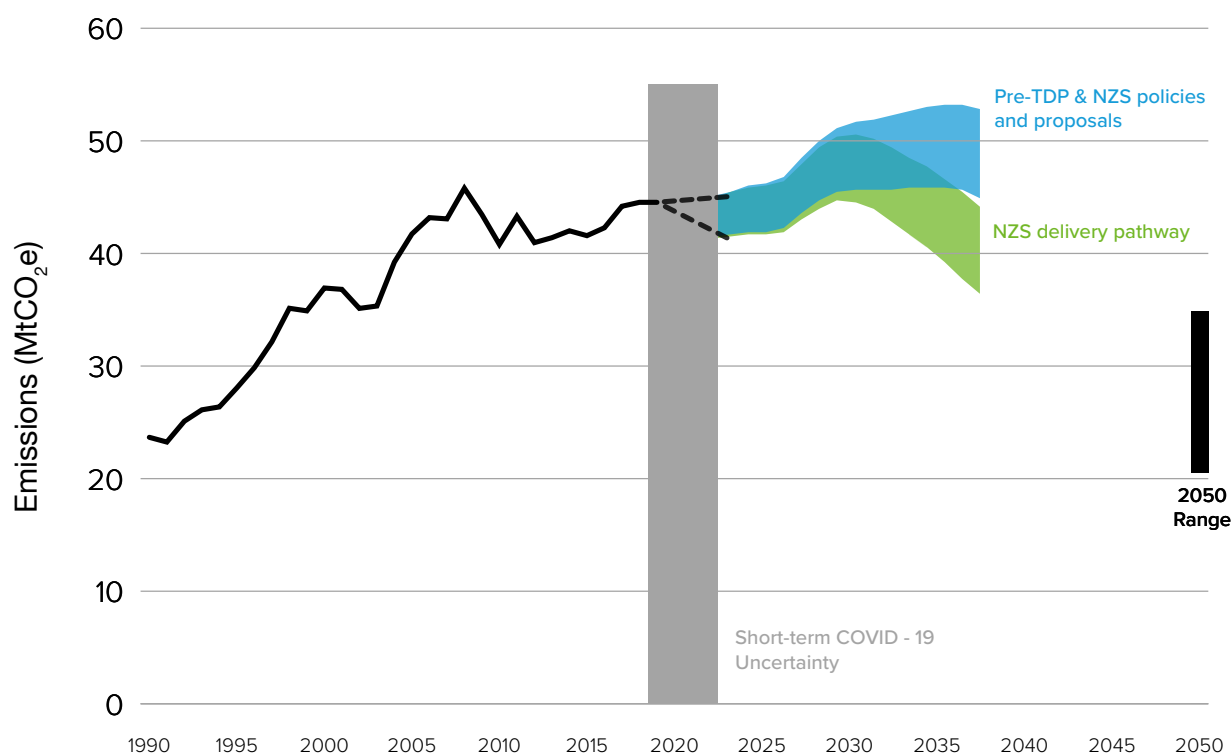
6. Based on our whole system modelling, by 2050, total transport emissions, including international aviation and shipping, could need to drop by 76-86% compared to 2019, down to 23-40MtCO₂e. In the interim, to meet our NDC and CB6 targets,⁷² we expect they could fall by 22-33% by 2030 and 46-59% by 2035, 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 may 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 MtCO₂e 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 England 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 MtCO₂e 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 MtCO₂e (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 MtCO₂e (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 MtCO₂e (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 MtCO₂e (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

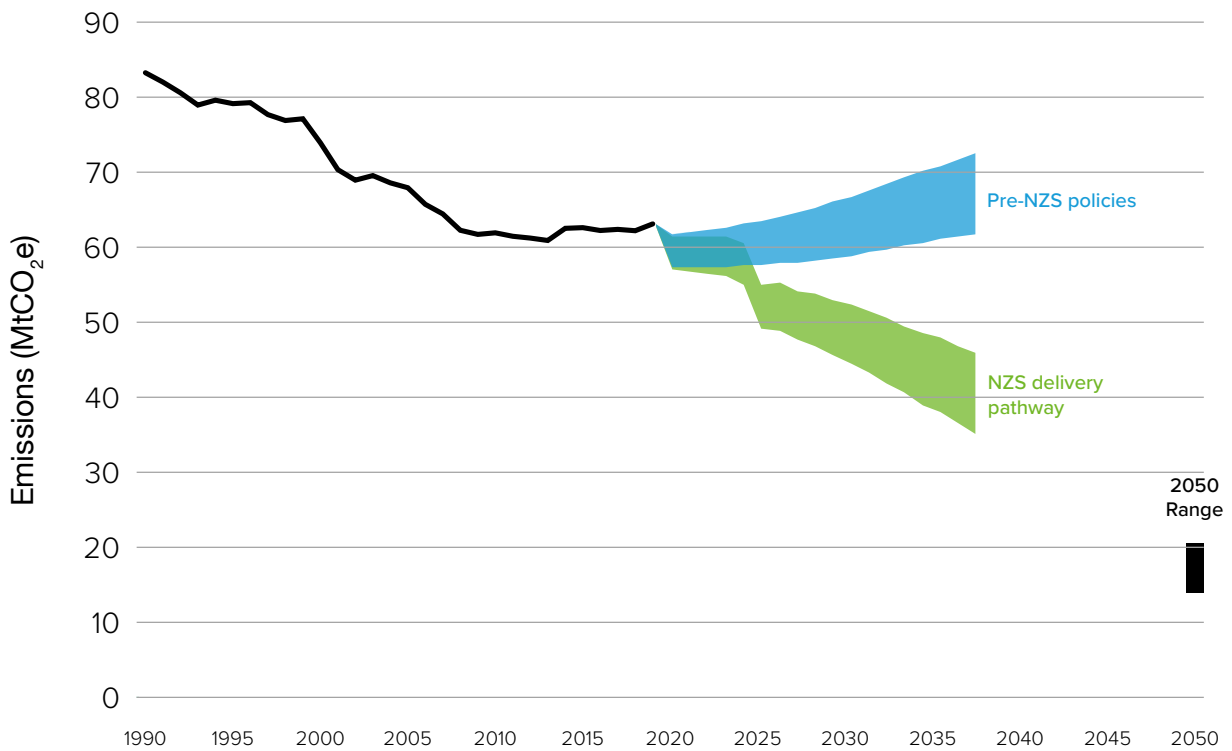
9. A systemic transformation across the UK economy, including NRWF sectors, is required to achieve net zero by 2050. While we will significantly reduce emissions across the NRWF sectors, some residual emissions from agriculture, waste, and F-gases will remain. These will need to be compensated for by 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 MtCO₂e. 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 NRWF 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

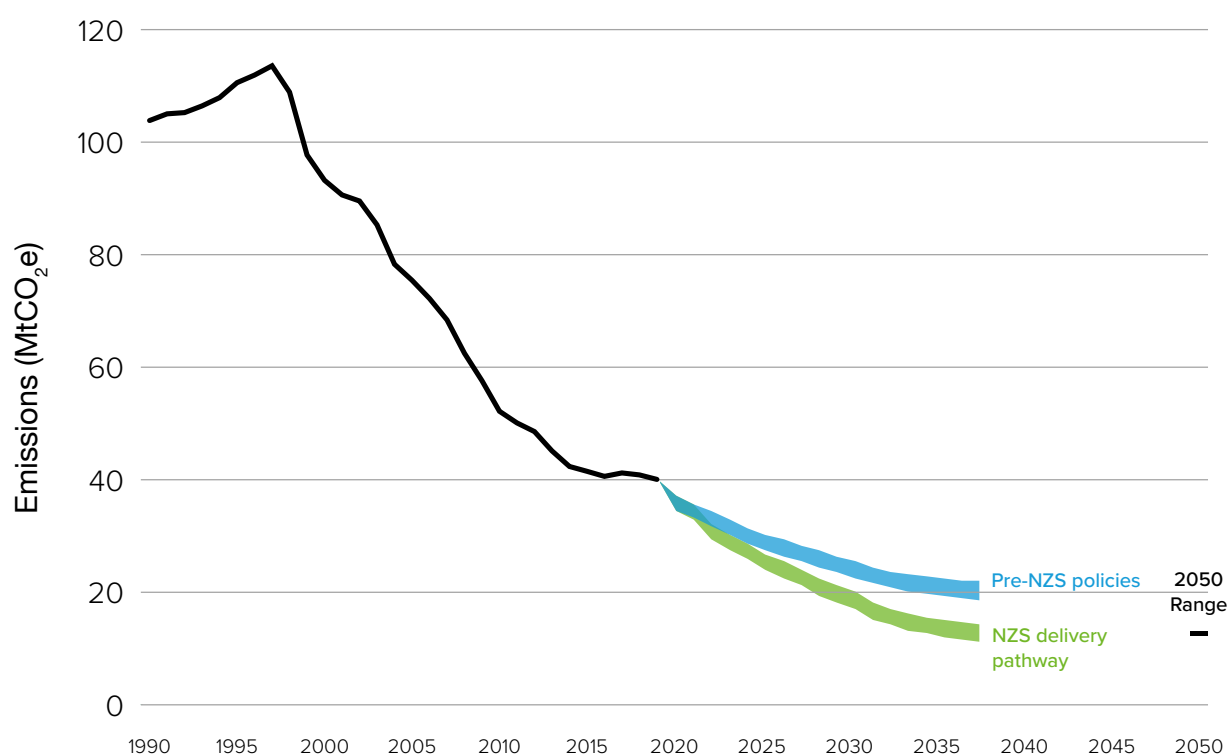
forums, and allows us to think practically about how we deliver across the UK. We will also consider the interdependencies between land use sectors and other goals.

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 intend 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 CO₂ 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.

In 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 MtCO₂/year of engineered removals by 2030, in line with CCC⁸⁵ 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 CO₂, 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:

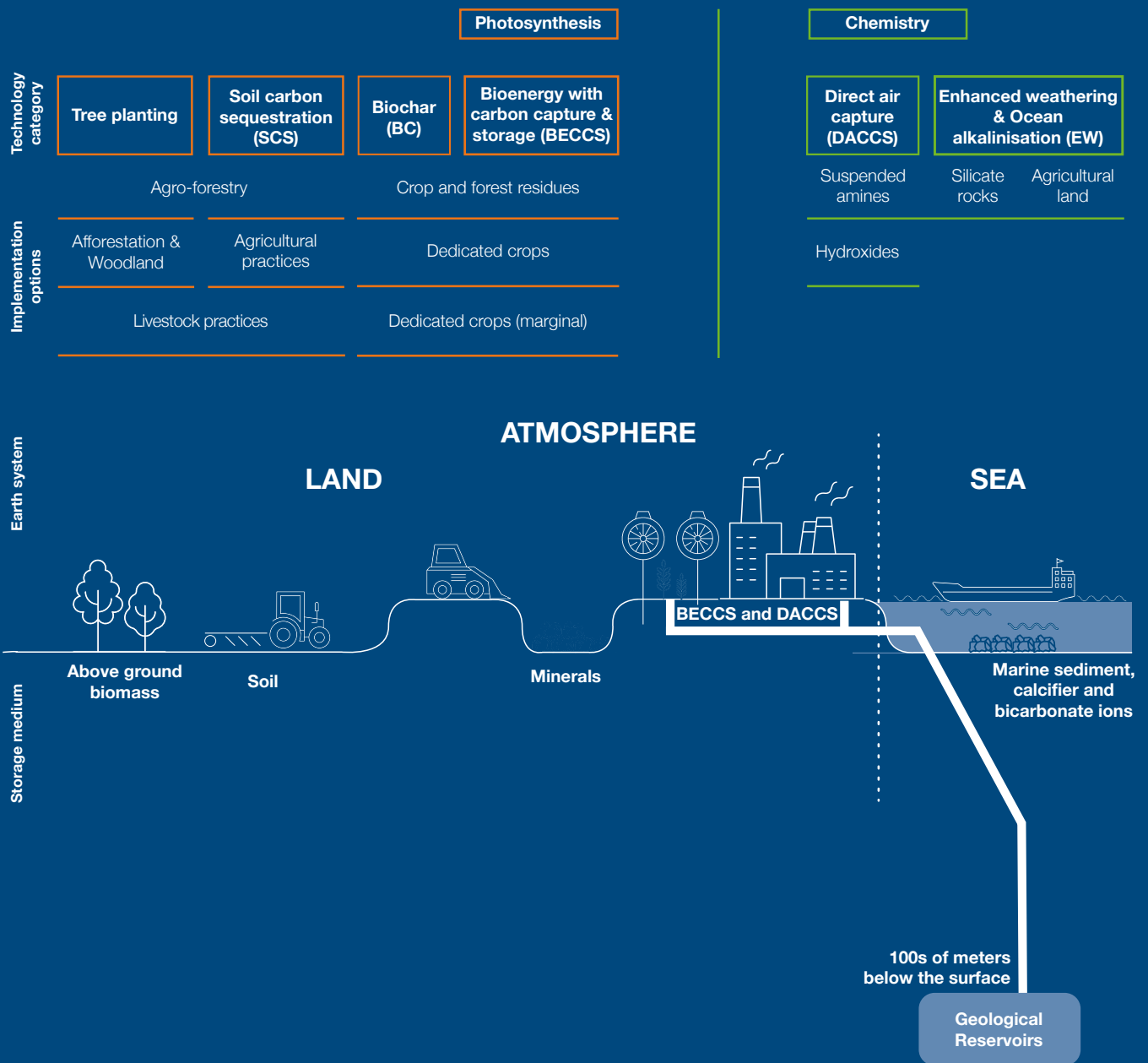
- Nature-based approaches: such as afforestation, and soil carbon sequestration.
- Engineering-based approaches: such as Direct Air Carbon Capture and Storage (DACCS), Bioenergy with Carbon Capture and Storage (BECCS), wood in construction, biochar, and enhanced weathering (EW).

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

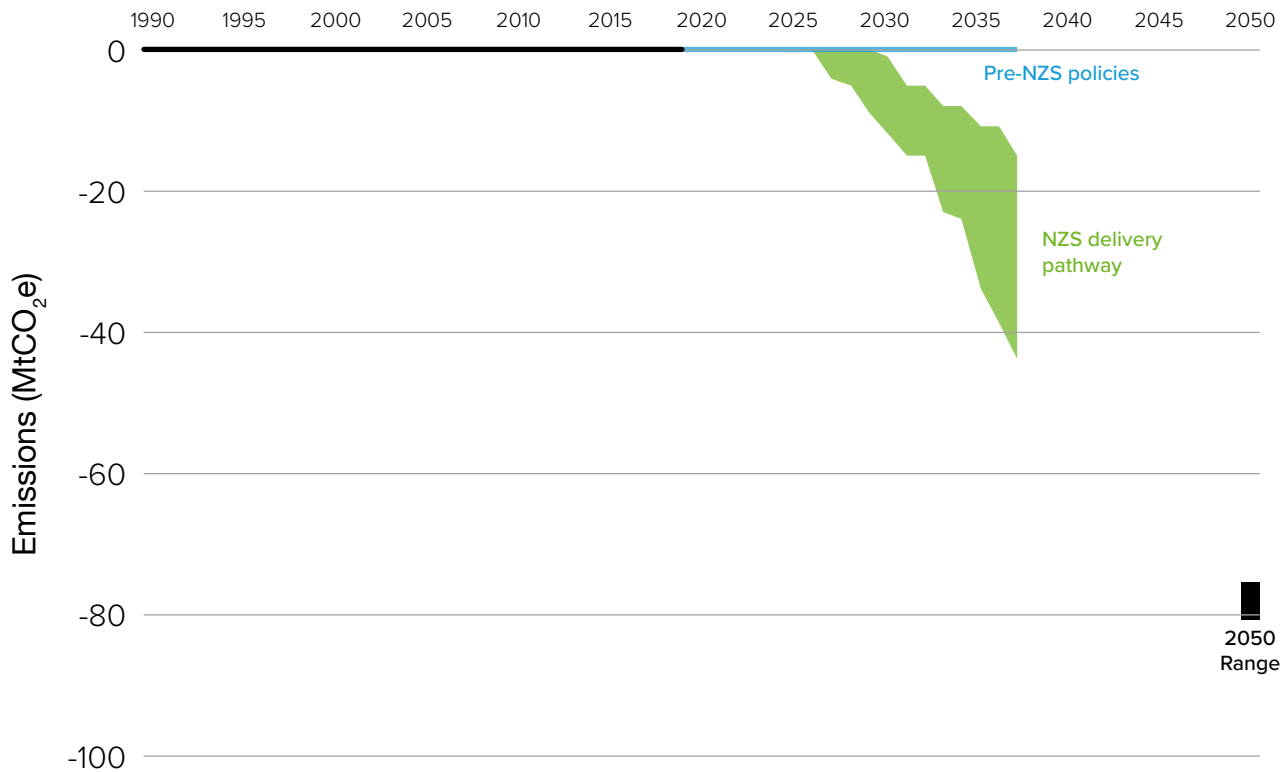
7. There is also a need to ensure that GGRs result in a permanent net reduction in atmospheric carbon. This is a complex task which, at least in the near-term, may require case-by-case scrutiny of the carbon intensity of GGR supply chains and long-term indirect emissions of GGR projects. Developing a

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 MtCO₂ today to at least 5 MtCO₂ by 2030 and to around 23 MtCO₂ 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 CO₂ 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 MtCO₂ 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 CO₂ 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 CO₂ 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.

CO₂ Transport and Storage networks

By the early 2030s, CO₂ 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 CO₂ 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 MtCO₂/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 CO₂e 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 CO₂ 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 CO₂ 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 CO₂ removal by capturing CO₂ from the air then safely and permanently storing it deep below the seabed in an offshore geological storage site. The offshore Acorn CO₂ 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

- 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 '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>
- 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>
- ⁴ BEIS (2020), 'Energy White Paper: Powering our Net Zero Future', <https://www.gov.uk/government/publications/energy-white-paper-powering-our-net-zero-future>
- ⁵ BEIS analysis based on 2019 data from BEIS (2021), 'Digest of UK Energy Statistics', <https://www.gov.uk/government/collections/digest-of-uk-energy-statistics-dukes#2021>
- ⁶ BEIS (2021) 'Decarbonisation readiness: call for evidence on the expansion of the 2009 Carbon Capture Readiness requirements', <https://www.gov.uk/government/consultations/decarbonisation-readiness-call-for-evidence-on-the-expansion-of-the-2009-carbon-capture-readiness-requirements>
- ⁷ CCC (2021) 'Independent Assessment of UK Climate Risk June 2021' – <https://www.theccc.org.uk/publication/independent-assessment-of-uk-climate-risk/>
- ⁸ National Grid ESO (2020), 'Annex 2 Final Cost-benefit Analysis Report from Phase 1 outputs of National Grid ESO's Offshore Coordination Project', <https://www.nationalgrideso.com/document/182936/download>
- ⁹ BEIS (2021), 'Smart Systems and Flexibility Plan 2021: Appendix I – Electricity system flexibility modelling' https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1003787/smart-systems-appendix-i-electricity-system-flexibility-modelling.pdf
- ¹⁰ BEIS (2021), 'Smart metering statistics, quarterly update June 2021', <https://www.gov.uk/government/collections/smart-meters-statistics>
- ¹¹ BEIS (2021) 'Proposals for a Future System Operator role' – <https://www.gov.uk/government/consultations/proposals-for-a-future-system-operator-role>
- ¹² BEIS (2021) 'Energy code reform: governance framework' – <https://www.gov.uk/government/consultations/energy-code-reform-governance-framework>
- ¹³ BEIS (2021) 'Capacity Market 2021: call for evidence on early action to align with net zero' – <https://www.gov.uk/government/consultations/capacity-market-2021-call-for-evidence-on-early-action-to-align-with-net-zero>
- ¹⁴ BEIS (2021) 'Energy retail market strategy for the 2020s' – <https://www.gov.uk/government/publications/energy-retail-market-strategy-for-the-2020s>

- ¹⁵ BEIS analysis based on 2019 data from BEIS (2021), 'Digest of UK Energy Statistics', <https://www.gov.uk/government/collections/digest-of-uk-energy-statistics-dukes#2021>
- ¹⁶ BEIS (2021) 'Longer Duration Energy Storage Demonstration (LODES) competition' - <https://www.gov.uk/government/collections/longer-duration-energy-storage-demonstration-lodes-competition>
- 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.
- ²³ BEIS analysis based on the Energy Innovation Needs Assessment (EINA) methodology with updated domestic and global scenarios; figures consider the direct jobs linked to hydrogen production, stationary CHP fuel cells and domestic distribution only. Vivid Economics (2019), 'Hydrogen and fuel cells (EINA sub-theme)', https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/845658/energy-innovation-needs-assessment-hydrogen-fuel-cells.pdf
- ²⁴ BEIS (2021), 'Low Carbon Hydrogen Supply 2 Competition', <https://www.gov.uk/government/publications/low-carbon-hydrogen-supply-2-competition>
- ²⁵ BEIS (2021), 'Open Consultation: Design of a business model for low carbon hydrogen', <https://www.gov.uk/government/consultations/design-of-a-business-model-for-low-carbon-hydrogen>
- ²⁶ BEIS (2021), 'Open Consultation: Design of a business model for low carbon hydrogen', <https://www.gov.uk/government/consultations/designing-the-net-zero-hydrogen-fund>

- ²⁷ BEIS (2021), ‘Open Consultation: Designing a UK low carbon hydrogen standard’, <https://www.gov.uk/government/consultations/designing-a-uk-low-carbon-hydrogen-standard>
- 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.
- ³⁵ Government analysis suggests up to 5,000 CCUS jobs could be supported in 2025 across industry, power, and transport and storage network.
- ³⁶ BEIS (2019), ‘Energy Innovation Needs Assessment’, <https://www.gov.uk/government/publications/energy-innovation-needs-assessments>
- ³⁷ National Atmospheric Emissions Inventory (2021), ‘Greenhouse Gas emissions reports’, https://naei.beis.gov.uk/reports/reports?section_id=3
- ³⁸ Employment figures sourced from ONS (2018), ‘Industry (2, 3 and 5 – digit SIC) – Business Register and Employment Survey (BRES): Table 2’, <https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/datasets/industry235digitsicbusinessregisterandemploymentsurveybrestable2> Indirect jobs estimates based on ONS (2019), ‘Type I UK employment multipliers and effects, reference year 2015’, <https://www.ons.gov.uk/economy/nationalaccounts/supplyandusetables/adhocs/009746typeiukemploymentmultipliersandeffectsreferenceyear2015>
- ³⁹ National Atmospheric Emissions Inventory (2021), ‘Greenhouse Gas emissions reports’, https://naei.beis.gov.uk/reports/reports?section_id=3

- ⁴⁰ BEIS analysis (2021), 'Net Zero Industry Pathway (N-ZIP) model', <https://www.theccc.org.uk/wp-content/uploads/2020/12/N-ZIP-Model.xlsb>
- ⁴¹ The figures were derived by the CCC based on research from 2018 (Scott, et al., 2018). This research acknowledges that there are a range of possible scenarios that differ greatly in resource efficiency savings. The CCC's balanced pathway assume savings consistent with the high scenario. Empirical evidence on the likelihood of these scenarios is limited. The balanced pathway also includes estimated savings from industrial buildings, which are covered in the Heat & Buildings chapter.
- ⁴² CCC (2020), 'Sixth Carbon Budget', <https://www.theccc.org.uk/publication/sixth-carbon-budget/>
- ⁴³ Defined by the IDS as sites outside a 25km radius from the 6 main industrial clusters (Grangemouth, Teesside, Humberside, Merseyside, South Wales and Southampton)
- ⁴⁴ National Atmospheric Emissions Inventory, 'Emissions from NAEI large point sources', <https://naei.beis.gov.uk/data/map-large-source>
- ⁴⁵ Locations outside of the 6 main clusters where co-location of industrial units could yield integrated solutions
- 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>
- ⁴⁷ Buildings Research Establishment (2020), 'The Housing Stock of the United Kingdom', https://files.bregroup.com/bretrust/The-Housing-Stock-of-the-United-Kingdom_Report_BRE-Trust.pdf
- 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>.
- ⁵¹ ONS (2020), 'Households projections for England', <https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationprojections/datasets/householdprojectionsforengland>, Table 401

- ⁵² MHCLG (2020), 'English Housing Survey 2019 to 2020', <https://www.gov.uk/government/statistics/english-housing-survey-2019-to-2020-headline-report>, Annex table 2.2.
- ⁵³ BEIS (2020), 'Energy Consumption in the UK 2020', <https://www.gov.uk/government/statistics/energy-consumption-in-the-uk-2020>
- ⁵⁴ 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
- 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.
- ⁵⁸ BEIS (2020), 'Non-domestic National Energy Efficiency Data-Framework', <https://www.gov.uk/government/statistics/non-domestic-national-energy-efficiency-data-framework-nd-need-2020>
- ⁵⁹ BEIS analysis, this figure excludes industrial buildings. BEIS (2020), 'Final UK greenhouse gas emissions national statistics: 1990 to 2018', <https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-national-statistics-1990-to-2018>, Table 19
- ⁶⁰ BEIS (2016), 'Building Energy Efficiency Survey', <https://www.gov.uk/government/publications/building-energy-efficiency-survey-bees>
- ⁶¹ BEIS (2020), 'Final 2018 UK greenhouse gas emissions national statistics: 1990 to 2018', <https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-national-statistics-1990-to-2018>
- ⁶² BEIS analysis based on the Energy Innovation Needs Assessment (Vivid Economics, 2019)
- ⁶³ IEEG (2020) 'Rebuilding for resilience - energy efficiency's offer for a net zero compatible stimulus and recovery', <https://www.theeig.co.uk/news/starstarnew-reportstarstar-rebuilding-for-resilience-energy-efficiency-s-offer-for-a-net-zero-compatible-stimulus-and-recovery/>. Derived from Jan Rosenow and others (2018). Assumes EPC band C by 2030 with cost savings at 2020 prices.
- ⁶⁴ BEIS (2021), 'Sustainable warmth: protecting vulnerable households in England', <https://www.gov.uk/government/publications/sustainable-warmth-protecting-vulnerable-households-in-england>
- ⁶⁵ Curl and Kearns (2017) 'Housing improvements, fuel payment difficulties and mental health in deprived communities', International Journal of Housing Policy, <https://www.tandfonline.com/doi/full/10.1080/14616718.2016.1248526>.
- ⁶⁶ University of Cambridge (2017), 'Do House Prices and Rents in the Private Rented Sector Reflect Energy Efficiency Levels' https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/910853/beis-cambridge-house-price-report.pdf

- ⁶⁷ No or low-regrets' means actions that are cost-effective now and will continue to prove beneficial in future. For example, installing energy efficiency measures reduce consumer bills now, while making buildings warmer and comfier, but have the added benefit of making future installations of low carbon heating more cost effective.
- ⁶⁸ BEIS (2021), 'Opportunity areas for district heating networks in the UK: Second National Comprehensive Assessment', <https://www.gov.uk/government/publications/opportunity-areas-for-district-heating-networks-in-the-uk-second-national-comprehensive-assessment>
- ⁶⁹ CITB (2021), 'Building Skills for Net Zero' https://www.citb.co.uk/media/kkpkwc42/building_skills_net_zero_full_report.pdf
- ⁷⁰ *Decarbonisation of Homes in Wales Advisory Group*, Welsh Government, <https://gov.wales/decarbonisation-homes-wales-advisory-group>
- ⁷¹ International aviation and shipping emissions are not included in domestic transport as they are reported separately.
- ⁷² [International Aviation and Shipping emissions are not included in the UK's 68% NDC target and are included in carbon budgets from CB6.](#)
- ⁷³ Welsh Government (2021), 'Electric vehicle charging strategy for Wales', <https://gov.wales/electric-vehicle-charging-strategy-wales>
- ⁷⁴ BEIS analysis of 1990-2019 UK GHG emissions statistics. 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>.
- ⁷⁵ Defra (2020), 'Agricultural Transition Plan 2021 to 2024', <https://www.gov.uk/government/publications/agricultural-transition-plan-2021-to-2024>
- ⁷⁶ 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>
- ⁷⁷ Defra (2018), 'Resources and waster strategy for England', <https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-national-statistics-1990-to-2019>
- ⁷⁸ BEIS (2021), 'Final UK greenhouse gas emissions national statistics', <https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-national-statistics-1990-to-2019>
- ⁷⁹ Defra (2017), 'UK ratifies new agreement to tackle global warming', <https://www.gov.uk/government/news/uk-ratifies-new-agreement-to-tackle-global-warming>
- ⁸⁰ *The Ozone-Depleting Substances and Fluorinated Greenhouse Gases (Amendment etc.) (EU Exit) Regulations 2019*. Available at: <https://www.legislation.gov.uk/ukdsi/2019/9780111177136>.
- ⁸¹ Defra (2018), '25 Year Environment Plan', <https://www.gov.uk/government/publications/25-year-environment-plan>

- ⁸² Defra (2021), 'Environmental land management schemes: payment principles', <https://www.gov.uk/government/publications/environmental-land-management-schemes-payment-principles/environmental-land-management-schemes-payment-principles> [https://www.gov.uk/government/publications/environmental-land-management-schemes-payment-principles#:~:text=We%20will%20set%20payment%20rates,a%20wide%20range%20of%20activities](https://www.gov.uk/government/publications/environmental-land-management-schemes-payment-principles/environmental-land-management-schemes-payment-principles#:~:text=We%20will%20set%20payment%20rates,a%20wide%20range%20of%20activities).
- ⁸³ Defra (2021), 'Sustainable Farming Incentive: Defra's plans for piloting and launching the scheme', <https://www.gov.uk/government/publications/sustainable-farming-incentive-scheme-pilot-launch-overview/sustainable-farming-incentive-defras-plans-for-piloting-and-launching-the-scheme>
- ⁸⁴ Cynfoeth Naturiol Cymru Natural Resources Wales (2020), 'National Peatland Action Programme, 2020-2025', <https://cdn.cyfoethnaturiol.cymru/media/692545/national-peatlands-action-programme.pdf>
- ⁸⁵ CCC (2021), '2021 Progress Report to Parliament', <https://www.theccc.org.uk/wp-content/uploads/2021/06/Progress-in-reducing-emissions-2021-Report-to-Parliament.pdf>
- ⁸⁶ National Infrastructure Commission (2021), 'Engineered greenhouse gas removals', <https://nic.org.uk/app/uploads/NIC-July-2021-Engineered-Greenhouse-Gas-Removals-UPDATED.pdf>
- ⁸⁷ CCC (2020), 'The Sixth Carbon Budget: Greenhouse gas removals', <https://www.theccc.org.uk/wp-content/uploads/2020/12/Sector-summary-GHG-removals.pdf>
- ⁸⁸ Energy Systems Catapult (2020), 'Innovating to Net Zero: UK Net Zero Report', <https://es.catapult.org.uk/reports/innovating-to-net-zero/>
- ⁸⁹ National Grid (2020), 'Future Energy Scenarios', <https://www.nationalgrideso.com/document/173821/download>
- ⁹⁰ Minx et al (2018), 'Environmental Research Letters', *IPO*, Volume 13, Number 6
- ⁹¹ McLaren, D (2020), 'Quantifying the potential scale of mitigation deterrence from greenhouse gas removal techniques', *Climatic Change*, 162, 2411-2428, <https://link.springer.com/article/10.1007/s10584-020-02732-3>
- ⁹² CCC (2020), 'Sixth Carbon Budget', <https://www.theccc.org.uk/publication/sixth-carbon-budget/>
- ⁹³ BEIS (2021), 'Greenhouse Gas Removal Methods Technology Assessment Report', <https://www.gov.uk/government/publications/greenhouse-gas-removal-methods-technology-assessment-report>
- ⁹⁴ BEIS (2020), 'The Ten Point Plan for a Green Industrial Revolution', <https://www.gov.uk/government/publications/the-ten-point-plan-for-a-green-industrial-revolution>
- ⁹⁵ BEIS (2021), 'Projects selected for Phase 1 of the Direct air capture and greenhouse gas removal programme', <https://www.gov.uk/government/publications/direct-air-capture-and-other-greenhouse-gas-removal-technologies-competition/projects-selected-for-phase-1-of-the-direct-air-capture-and-greenhouse-gas-removal-programme>