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Science and Technology Committee

Clean Growth: Technologies for meeting the UK's emissions reduction targets

Twentieth Report of Session 2017–19

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Science and Technology Committee

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Contacts

All correspondence should be addressed to the Clerk of the Science and Technology Committee, House of Commons, London SW1A 0AA. The telephone number for general inquiries is: 020 7219 2793; the Committee's e-mail address is: scitechcom@parliament.uk.

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In 2015, the states party to the United Nations Framework Convention on Climate Change (including the UK) agreed that they would seek to restrict the increase in the global average temperature to "well below 2°C above pre-industrial levels" and pursue "efforts to limit the temperature increase to 1.5°C above pre-industrial levels". The Intergovernmental Panel on Climate Change has warned that global warming of 2˚C above pre-industrial levels could lead to increased risk of droughts and flooding, sea level rises, ecosystem change and consequent species loss and extinction on land and in the sea, reduced productivity for agriculture and fishing and climate-related poverty and disease. The UK was the first country to legislate for legally binding greenhouse gas emissions targets and earlier this year became the first country in the G7 to legislate for net-zero emissions. Since 2000, the UK has achieved greater decarbonisation than any other country in the G20. It has outperformed its first (2008–2012) and second (2013–2017) carbon budgets by around 1% and 14% respectively, and is on track to outperform its third carbon budget (2018–2022). However, the Committee on Climate Change has warned that the UK is not on track to meet its fourth (2023–2027) and fifth (2028–2032) carbon budgets.

The UK's progress

There are a number of areas in which Government policy to support the deployment of low-carbon technologies has been delayed or cut back. For example:

- the 'plug-in grant' for low-emissions cars was reduced from £4,500 to £3,500 for the lowest-emissions cars in October 2018, and cut completely for other low-emissions cars;
- the 'feed-in tariff' for low-carbon power generation was closed in April 2019 without a successor scheme in place;
- the Energy Companies Obligation scheme was restricted to vulnerable households only in November 2018, despite the Government conceding that this would "result in lower carbon emissions reductions being achieved"—the Government consulted on "building an 'able-to-pay' market for energy efficiency" in October 2017 and said that it would respond in 2018, but a response has still not been published; and
- following the cancellation of the 'zero-carbon homes' policy in 2015, the Government pledged in 2018 to consult on changes to Part L of the building regulations (covering energy performance of buildings) in order to support the development of low-carbon heating technologies—however, this consultation has still not been launched (although the Chancellor announced in the 2019 Spring Statement that a 'Future Homes Standard' would be introduced to deliver homes with "low carbon heating and world-leading levels of energy efficiency", but only by 2025).

Achieving the Government's key targets will require an acceleration of deployment of low carbon technologies:

- the Government wants "almost every car and van to be zero emission" by 2050, which is equivalent to removing almost 20,000 conventional cars every week on average, from now until 2050, whereas around 1,200 new ultra-low emissions vehicles were registered each week in 2018;
- the Government also wants "as many homes as possible to be EPC Band C by 2035 where practical, cost-effective and affordable". This would equate to improving the energy efficiency of around 20,000 English homes (just under 40 per English constituency) per week until 2035—in contrast, the Committee on Climate Change reported that around 2,400 energy loft or wall insulations were installed per week in 2017;
- the Government has said that "by 2050, we will also likely need to fully decarbonise how we heat our homes", which would require at least 15,000 homes to transfer to a low-carbon heating system every week until 2050—this compares to a projection of 220 low-carbon heat systems being installed each week under the Government's 'Renewable Heat Incentive' from now until 2021; and
- the Government has set out its "aspiration" to reach woodland cover of 12% in England by 2060, which would require the net growth of around 120 hectares of woodland per week—in 2018, net woodland growth was around 20 hectares per week.

Recommendations for change

Transport

The transport sector is now the largest-emitting sector of the UK economy. The Government should bring forward the proposed ban on sales of new conventional cars and vans to 2035 at the latest. This ban should explicitly cover hybrid as well as internal combustion engines. There are significant emissions associated with the manufacture of vehicles. In the long-term, widespread personal vehicle ownership does not appear to be compatible with significant decarbonisation. The Government should not aim to achieve emissions reductions simply by replacing existing vehicles with lower-emissions versions.

Alongside the Government's existing targets and policies, it must develop a strategy to stimulate a low-emissions transport system, with the metrics and targets to match. This should aim to reduce the number of vehicles required, for example by: promoting and improving public transport; reducing its cost relative to private transport; encouraging vehicle usership in place of ownership; and encouraging and supporting increased levels of walking and cycling.

In the near-term, the Government must also reconsider the fiscal incentives for consumers to purchase both new and used vehicle models with lower emissions, and develop a strategy by the time of the Spring Statement 2020 to use vehicle excise duty and other incentives to drive the purchase of vehicle models with lower average emissions.

Heating and energy efficiency

Domestic, commercial and industrial heating is responsible for around a third of the UK's overall emissions, which is unchanged from 2009. The decarbonisation of heating will be critical to the UK achieving its long-term emissions reductions targets, but there remains considerable uncertainty surrounding what mix of low-carbon heating technologies represents the best decarbonisation pathway for the UK, or what mix the Government will pursue. The Government must urgently develop a clearer strategy for decarbonising heat. This will require large-scale trials of different heating technologies operating in homes and cities to build the evidence base required for long-term decisions. The Government must commit now to large-scale trials of low-carbon heating technologies, convening relevant stakeholders to determine what evidence must be gathered and to co-ordinate existing work. It should further support the deployment of low-carbon heating technologies by setting out a clear roadmap by the time of the Spring Statement 2020 for rebalancing levies on electricity and gas, to better reflect the emissions intensities of each fuel.

Emissions associated with heating can also be reduced through energy efficiency measures such as improved insulation. Previous initiatives to encourage domestic energy efficiency improvements in the 'able-to-pay' market have failed because they have focused too narrowly on providing financial support for specific interventions. The Government's new energy efficiency policy must provide all homeowners with the incentive to make energy efficiency improvements to their property, with particular thought given to lower income households, as well as the financial means to do so. By the time of the Spring Statement 2020 the Government should consider adjusting Stamp Duty so that it varies according to the energy performance of the home as well as the price paid for it. The Government should additionally establish a 'Help to Improve' scheme by July 2020 that offers matched funding and interest-free loans to homeowners, to cover the costs of making energy efficiency improvements.

Power generation

Power generation was responsible for around 15% of the UK's greenhouse gas emissions in 2018. The power generation sector has achieved significant decarbonisation over the course of the last carbon budget period, accounting for 75% of the UK's total emissions reductions between 2012 and 2017. Nevertheless, the Committee on Climate Change has made clear that "further reduction in the emissions intensity of power generation […] remains the lowest-cost path towards economy-wide decarbonisation". Although onshore wind power and large-scale solar power are low-cost and low-carbon, the deployment of new installations of these technologies has fallen drastically since 2015. The Government must ensure that there is strong policy support for new onshore wind power and large-scale solar power projects for which there is local support and projected

cost-savings for consumers over the long-term. The Government should actively encourage and support local authorities to adopt planning practices that promote local support for such renewable energy projects.

The Government must additionally develop mechanisms to promote community ownership and profit-sharing of low-carbon projects, such as joint ventures, split ownership or shared revenue. The delay between the end of the feed-in tariff scheme and the start of the Smart Export Guarantee scheme has caused unnecessary disruption to the smart energy and small-scale generation market. The Government must ensure that it reviews the functioning of the Smart Export Guarantee scheme by the end of 2020, and should be ready to include a minimum price floor if there is evidence of a lack of market competitivity—for example, if uptake of tariffs is not significantly greater than the current number of tariffs or if the tariffs offered are significantly lower than wholesale electricity prices.

Market regulation

Regulation of UK energy markets will play a key part in the development of a smart and flexible energy system. The energy markets regulator has an explicit duty to protect consumers' interests in the reduction of gas- and electricity-supply emissions of targeted greenhouse gases, alongside other considerations such as minimising costs. However, there is no specific link between the regulator's objectives and the UK's emissions reduction targets. The Government should consider the case for amending the energy market regulator's principal objective so that it explicitly includes ensuring that regulations align with the emissions reduction targets set out in the Climate Change Act 2008.

Ofgem must ensure that its second price control framework does not dilute its support for innovation and that the framework should further enable and incentivise network operators to innovate as part of their core business, rather than through standalone projects. Ofgem should work with network operators, energy suppliers and flexibility services providers to ensure that flexibility systems are always considered and deployed ahead of infrastructure construction, where possible and affordable.

Local authorities

Local authorities also have a vital role to play in the UK's decarbonisation. Many local authorities are pursuing emissions reductions projects, but the capacity and capability for decarbonisation at the local level varies. The Government should introduce a statutory duty on local authorities in England and Wales by Green Week 2020, to develop emissions reduction plans in line with the national targets set by the Climate Change Act 2008, and to report periodically on progress made against these plans.

In preparation for this new obligation, the Government should establish centralised support to help local authorities develop decarbonisation strategies and deliver initiatives aimed at reducing greenhouse gas emissions. It should also support local authorities' access to low-cost, long-term finance in order to enable the delivery of such strategies.

Consumers

There is also an important role for consumers. Although public support for measures to reduce emissions appears high, this is not always matched with awareness of what actions consumers can take to support decarbonisation. The Government should publish an easily-accessible, central guide for members of the public explaining what measures individuals and households can take to support the UK's decarbonisation. It should re-introduce a telephone and visiting advice service in England which offers bespoke advice on measures such as residential energy efficiency and low-carbon heating and transport.

Greenhouse gas removal

The Government's new ambition, to reach net-zero emissions by 2050, will probably require the active removal of at least 130 million tonnes of carbon dioxide from the atmosphere annually by 2050. This is significantly greater than the extent of greenhouse gas removal envisioned in any of the Government's previous 'illustrative pathways' to meeting its original 2050 target, and is also at the limit of what is expected to be reasonably deliverable. The step-change in greenhouse gas removal required will necessitate a significant increase in current support for greenhouse gas removal technologies. Some urgently require research and development, whereas others could be deployed at scale now with the correct support. The Government should be ready to increase funding for research, development and demonstration of greenhouse gas removal technologies. It must also ensure that it is seizing currently available opportunities for greenhouse gas removal, and should develop an effective framework for managing and incentivising forestation and land use management to achieve net emissions removals.

Carbon capture and storage has been widely identified as a key technology for decarbonisation in several sectors. The Energy Technologies Institute estimated, prior to the UK's net-zero emissions ambition, that meeting the UK's original 2050 emissions targets without the use of carbon capture and storage would incur an additional £30bn in costs. Industry must have clarity on the framework through which it can invest in carbon capture, usage and storage (CCUS), as well as the timetable for the Government's CCUS Action Plan. The Government must provide greater clarity on the details of its action plan, including on: what it considers to be deployment at scale; what constitutes cost-effectiveness or sufficient cost-reduction; how it expects to share costs with industry; and what the major milestones for the plan are, as well as when they are expected to be achieved. The Government should learn from previous carbon capture and storage projects and ensure that a sufficient number of projects, of sufficient scale, are undertaken to optimise the chance of successful deployment, and that the knowledge gained from publicly-funded work is publicly accessible.

A just transition

The decarbonisation of the UK's economy is critical for the environment and is a legally-binding target for the Government. Although decarbonisation offers opportunity for economic growth, it will inevitably also entail costs. The Committee on Climate Change has estimated that achieving net-zero emissions could cost around 1–2% of GDP by 2050. It is important that these costs are shared fairly among citizens. The Government

must ensure that its policies for achieving net-zero emissions consider the economic impacts on individuals. For example, the Government should aim to cover the costs of measures through progressive means rather than through energy bills. In line with the Government's focus on 'place' in its Industrial Strategy, the Government should include the potential for supporting economic growth in disadvantaged regions in its determination of where to locate demonstration projects and other initiatives.

Our inquiry

4. As part of this inquiry, we launched a call for evidence on 23 July 2018, seeking written submissions regarding technologies for meeting Clean Growth emissions reduction targets. We received over 80 pieces of written evidence and took oral evidence from 27 witnesses including academics, trade associations, relevant advisory bodies, energy network operators, the Committee on Climate Change and the Minister of State for Energy and Clean Growth, Rt Hon Claire Perry MP. We also visited National Grid System Operator and SSE (an energy distribution network operator) to learn more about the challenges and opportunities of decarbonisation for transmission and distribution networks respectively, and we visited the Local Energy Oxfordshire project in Oxford to learn more about community energy projects. To assist us in our work, we appointed Dr Jonathan Radcliffe, who leads the Energy Systems and Policy Analysis Group at the University of Birmingham, as a Specialist Adviser for our inquiry.[13] We are grateful to everyone who contributed to our inquiry.

Aims of this Report

5. We recognise that action is required across the economy if the UK is to meet its carbon emissions targets. We could not cover every aspect of this in an inquiry spanning four evidence sessions so we have focused on what we feel to be the most important areas for Government action. Nonetheless, we encourage the Government to deliver across the economy and support the work of the Committee on Climate Change and other organisations in working towards reducing the UK's carbon emissions.

6. In this Report, we make recommendations for what the Government should do to support the development and deployment of technologies that can reduce the UK's emissions, in general and for specific sectors of the economy.

13 Dr Jonathan Radcliffe declared his interests on 22 January 2019: employee of the University of Birmingham, current recipient of public research funding from UK Research and Innovation and UK government departments, and previous recipient of industry funding.

2 UK Greenhouse Gas Emissions

7. This Chapter examines the UK's emissions reductions since the passage of the Climate Change Act 2008 as well as future emissions reductions targets.

Historic emissions

8. Since 2000, the UK has achieved greater decarbonisation than any other country in the G20.[14] It has outperformed its first (2008–2012) and second (2013–2017) carbon budgets by around 1% and 14% respectively.[15] However, the Committee on Climate Change has noted that "the majority (around 80%) of the [overachievement against the second carbon budget] has occurred due to changes in the UK's share of the EU Emissions Trading System cap, rather than a reduction in actual emissions".[16] The Government itself has acknowledged that the overachievement arising from these changes "is purely an accounting impact and not related to actual UK emissions".[17] Furthermore, significant emissions reductions in some sectors, such as transport and heavy industry, coincided with the 2008 recession and have not substantially reduced any further since then.[18] These factors, and the lack of progress against key policy indicators, led the Committee on Climate Change to conclude in February 2019 that "policies failed to produce expected reductions in emissions" during the second carbon budget period, and that the overachievement against the UK's emissions reductions targets was "not due to policy".[19]

9. Progress on emissions reductions has also been concentrated in relatively few sectors of the UK economy. In particular, the UK has achieved significant decarbonisation of the power generation sector, mostly as a result of coal power increasingly being replaced by gas-fired and renewable power. This has helped to drive a fall in power sector emissions of 55% since 2012, representing 75% of the UK's total emissions reductions over that period.[20] However, in contrast to the power generation sector, emissions from the transport, domestic and agricultural sectors have fallen only slightly—or in some cases have even risen—since 2012.[21] Numerous submissions to our inquiry, such as those from the Energy Systems Catapult, National Grid and UK Research and Innovation, flagged that progress towards the next carbon budgets would require significant acceleration in emissions reductions from these other sectors.[22]

14 PwC, 'Time to get on with it: The Low Carbon Economy Index 2018' (2018), p8
15 Department of Energy and Climate Change, 'Final Statement for the First Carbon Budget Period' (2014) and Department for Business, Energy and Industrial Strategy, 'Final Statement for the Second Carbon Budget' (2019)
16 Letter from Lord Deben to Rt Hon Claire Perry MP, 15 February 2019
17 Department for Business, Energy and Industrial Strategy, 'Updated Energy and Emissions Projections 2018' (2019), p20
18 Department for Business, Energy and Industrial Strategy, '2017 UK greenhouse gas emissions: final figures—data tables' (2019), Table 3
19 Letter from Lord Deben to Rt Hon Claire Perry MP, 15 February 2019
20 Committee on Climate Change, '2018 Progress Report to Parliament' (2018), p30
21 Department for Business, Energy and Industrial Strategy, 'Alternative Format 2018 UK greenhouse gas emissions: provisional figures—data tables' (2019), Tables 1 and 4
22 For example, see: Cadent (CGE0015), para 1; National Grid (CGE0019), paras 3.1–3.2; Energy Systems Catapult (CGE0029), para 6; Decarbonised Gas Alliance (CGE0032), para 9; The Royal Society (CGE0056), para 13; UK Research and Innovation (CGE0058), para 4; and Durham Energy Institute (CGE0065), paras 1–2

10. The Climate Change Act 2008 allows the Government to decide to carry forward any outperformance of a carbon budget to the following budget period.[23] With the second carbon budget having been outperformed by the equivalent of 383.9 million tonnes of carbon dioxide (383.9 $MtCO_2e$), the Government could have decided to carry forward the whole of, or part of, this amount to the third carbon budget. In March 2019, our Chair wrote to the Clean Growth Minister encouraging the Government not to use its power to carry forward any of the over-achievement of the previous carbon budget,[24] on the basis that:

- future carbon budgets were set in accordance with advice from the Committee on Climate Change that assumed overachievements in previous budgets would not be carried forward;[25]
- the overachievement of the second carbon budget was mostly not attributable to Government policies;[26]
- the most cost-effective path to meeting the UK's emissions target for 2050, as determined by the Committee on Climate Change, was more stringent even than existing carbon budgets;[27]
- the states party to the United Nations Framework Convention on Climate Change (including the UK) agreed in 2015 that they would seek to restrict the increase in the global average temperature to "well below 2°C above pre-industrial levels" and pursue "efforts to limit the temperature increase to 1.5°C above pre-industrial levels",[28] which is more ambitious than the long-term emissions targets by which the existing carbon budgets had been set;[29] and
- we had heard from several stakeholders during our inquiry of the importance of urgency in emissions reductions.[30]

11. The Government subsequently wrote to the Chairman of the Committee on Climate Change on 6 June to state that it had decided to provisionally carry forward 88$MtCO_2e$, pending advice from the Committee on Climate Change on "technical changes to the baseline used to measure our emissions".[31] This refers to anticipated changes in how the UK calculates and reports its emissions: to fully include emissions from peatland; and to reflect international standardisation of the method used to determine the equivalent warming potentials of difference greenhouse gases.[32] It would appear that 88$MtCO_2e$ of the 384$MtCO_2e$ total outperformance was carried forward provisionally as this represented the amount not attributable to changes in the UK's share of the EU Emissions Trading

23 Climate Change Act 2008, section 17
24 Letter from Rt Hon Norman Lamb MP to Rt Hon Claire Perry MP, 20 March 2019
25 Committee on Climate Change , 'The Fourth Carbon Budget' (2010), pp31–32; Committee on Climate Change, 'The Fifth Carbon Budget' (2015), p115; and Letter from Lord Deben to Rt Hon Claire Perry MP, 15 February 2019
26 Letter from Lord Deben to Rt Hon Claire Perry MP, 15 February 2019
27 Committee on Climate Change, '2018 Progress Report to Parliament' (2018), p18
28 United Nations, 'Paris Agreement' (2015)
29 Committee on Climate Change, 'Building a low-carbon economy–the UK's contribution to tackling climate change' (2008), Part I
30 For example, see: Greenpeace (CGE0022), para 2; Royal Academy of Engineering and allied institutions (CGE0055), para 9; Royal Society (CGE0056), para 4
31 Letter from Chris Skidmore MP to Lord Deben, 6 June 2019
32 Committee on Climate Change 'Net Zero: The UK's contribution to stopping global warming' (2019), p139

System cap.[33] The Government clarified that it had "no intention of using [any of the] overperformance to meet Carbon Budget 3" and stated that the carry-forward would "be released once it is clear that it will not be needed to address any technical changes in the baseline".[34]

12. **The UK has achieved world-leading emissions reductions for over two decades. However, this has not been exclusively the result of Government policies. The Government has decided to carry forward the equivalent of 88 million tonnes of carbon dioxide from the second carbon budget to the third, as permitted by the Climate Change Act 2008, pending advice from the Committee on Climate Change on technical changes to how the UK calculates and reports its emissions. *The Government must not use outperformance of the second carbon budget to weaken its targets for subsequent carbon budgets. As soon as possible after the Committee on Climate Change's advice on technical changes to the UK's emissions baseline, the Government should unambiguously declare its commitment to follow that advice.***

13. The accounting frameworks of the United Nations Framework Convention on Climate Change, and of the UK's domestic carbon budgets, are based on the concept of "territorial emissions".[35] Territorial emissions comprise greenhouse gas emissions emitted from within a country's territory, excluding emissions associated with international aviation and shipping. The main alternative to territorial emissions is to count "consumption emissions", which comprise the greenhouse gas emissions associated with any products or services consumed within a country. The Department for Environment, Food and Rural Affairs has published estimates of the UK's consumption emissions since 1997.[36] While the UK's territorial emissions fell 37% from 1997 to 2016, its consumption emissions fell by just 9% in the same period.[37]

14. The Decarbonised Gas Alliance warned us that one cause of the discrepancy between reductions in territorial and consumption emissions was that "too much" of the UK's territorial emissions reductions had "occurred due to offshoring of manufacturing".[38] For example, it highlighted the closure of the Redcar steelworks in 2015, which caused almost half of the emissions reductions from UK industry in 2016.[39] Several others, including Drax Group and the Royal Academy of Engineering and allied organisations, made similar points, and warned that less efficient manufacturing processes internationally could mean that such "offshoring" of UK heavy industry could lead to higher net emissions globally.[40] The Minister of State for Energy and Clean Growth, Claire Perry MP, argued that the UK

33 Department for Business, Energy and Industrial Strategy, 'Updated Energy and Emissions Projections 2018' (2019), p20

34 Letter from Chris Skidmore MP to Lord Deben, 6 June 2019

35 Department of Energy and Climate Change, 'Alternative approaches to reporting UK Greenhouse Gas Emissions' (2015)

36 Department for Environment, Food and Rural Affairs, 'UK's Carbon Footprint 1997–2016' (2019)

37 Department for Business, Energy and Industrial Strategy, '2016 UK greenhouse gas emissions: final figures—data tables' (2018), Table 1 and Department for Environment, Food and Rural Affairs, 'UK's Carbon Footprint 1997–2016' (2019), p3

38 Decarbonised Gas Alliance (CGE0032), paras 7–8

39 Committee on Climate Change, 'Meeting Carbon Budgets: Closing the policy gap—2017 Report to Parliament'(2017), p93

40 For example, see: Drax Group plc (CGE0025), para 35; Royal Academy of Engineering and allied institutions (CGE0055), para 10; and Johnson Matthey (CGE0066), para 9

was also reducing its emissions through increased resource efficiency and highlighted the UK's improved performance on consumption emissions since 2007,[41] over which period they had fallen by 21%.[42]

15. Lord Deben, Chairman of the Committee on Climate Change, told us that territorial emissions were used to monitor emissions internationally, and in the UK's domestic carbon budgets, because they can be measured more accurately and are easier for a country to influence than consumption emissions.[43] However, he said that consumption emissions figures were important for highlighting the global nature of climate change and the importance of actions in the UK that have international consequences, arguing that ultimately "you need both" measurements. Following an inquiry into consumption-based emissions reporting in 2012, the Energy and Climate Change Committee similarly wrote:

> We accept that territorial emissions should remain the basis for international climate negotiations. However, the UK Government's emphasis on territorial emissions means that the responsibility for reducing emissions embedded in the products that we import lies with the—often, developing—countries where the goods are manufactured […] We recommend that [the Department of Energy and Climate Change] increase the extent to which they consider consumption-based emissions when making policy.[44]

In its response to that Committee, the then Government said that it would "take steps to increase the prominence of consumption-based emissions on websites, and in statistical releases, where both territorial emissions and consumption emissions could be presented".[45] However, consumption emissions were not mentioned in the Clean Growth Strategy or in the Government's latest annual emissions statement.[46]

16. **Progress against the UK's emissions reductions targets must not be achieved by 'offshoring' UK industry and displacing the UK's territorial emissions to be counted instead in its consumption emissions. The Government should do more to meet its commitment to increase the prominence of consumption emissions statistics in its publications.** ***The Government should include consumption emissions alongside territorial emissions in all future publications on UK emissions. It should consider the impact of all policies on consumption emissions as well as territorial emissions, and ensure that progress is not achieved by 'offshoring' emissions to other countries to the detriment of the global environment. We do not accept that territorial emissions should be the sole basis for international negotiations. The United Kingdom's decarbonisation targets should also include consumption emissions.***

41 Q422
42 Department for Environment, Food and Rural Affairs, 'UK's Carbon Footprint 1997–2016' (2019)
43 Q32
44 Energy and Climate Change Committee, Twelfth Report of Session 2010–2012, 'Consumption-Based Emissions Reporting', HC 1646, paras 53 and 80
45 Energy and Climate Change Committee, Second Special Report of Session 2012–2013, 'Consumption-Based Emissions Reporting: Government Response to the Committee's Twelfth Report of Session 2010–12', HC 488, pp4–5
46 Department for Business, Energy and Industrial Strategy, 'Clean Growth Strategy' (2017) and 'Annual Statement of Emissions for 2017' (2019)

Net-zero emissions

17. In 2015, the states party to the United Nations Framework Convention on Climate Change (including the UK) agreed that they would seek to restrict the increase in the global average temperature to "well below 2°C above pre-industrial levels" and pursue "efforts to limit the temperature increase to 1.5°C above pre-industrial levels".[47] The Intergovernmental Panel on Climate Change has since said, in 2018, that "climate models project robust differences in regional climate characteristics" between global warming of 2˚C compared to 1.5˚C, including:

- increased regional risk of droughts and flooding;
- sea level rises of an estimated additional 0.1m, requiring faster adaption in coastal areas and small islands;
- increased amounts of ecosystem change, ocean acidification, and consequent species loss and extinction on land and in the sea;
- reduced productivity for agriculture and fishing; and
- increased spread of climate-related poverty and disease.[48]

The Panel further stated that, in order to meet the ambition of 1.5˚C, net global emissions would probably have to reach zero by 2045–2055. In response to a request for advice from the UK, Scottish and Welsh Governments on how the UK could achieve such a target,[49] the Committee on Climate Change subsequently concluded in 2019 that the UK could achieve net-zero emissions by 2050 "with known technologies, alongside improvements in people's lives, and within the expected economic cost that Parliament accepted when it legislated the existing 2050 target".[50] It recommended that the UK legislate "as soon as possible" to strengthen its emissions reductions targets and set a new target of zero overall emissions by 2050.[51]

18. On 12 June 2019, the Government laid a statutory instrument modifying the Climate Change Act 2008 to strengthen the UK's 2050 greenhouse gas emissions target, from a reduction on 1990 levels of 80% to a reduction of 100%, *i.e.* to reach net zero greenhouse gas emissions by 2050.[52] This was approved by Parliament on 26 June 2019,[53] making the UK the first country in the G7 to legislate for net-zero emissions.[54] The Prime Minister (Rt Hon Theresa May MP) stated, however, that the UK would conduct an assessment of its strengthened target within the next five years, to "confirm that other countries are taking similarly ambitious action".[55] She also stated that the UK would "retain the ability to use international carbon credits", arguing that "using international credits within an appropriate monitoring, reporting and verification framework is the right thing to do

47 United Nations, 'Paris Agreement' (2015), Article 2
48 Intergovernmental Panel on Climate Change, 'Global Warming of 1.5˚C: Summary for Policymakers' (2018)
49 Letter from Rt Hon Claire Perry MP, Roseanna Cunningham MSP and Lesley Griffiths AM to Lord Deben, 15 October 2018
50 Committee on Climate Change, 'Net Zero: The UK's contribution to stopping global warming' (2019), p11
51 Committee on Climate Change, 'Net Zero: The UK's contribution to stopping global warming' (2019)
52 Draft Climate Change Act 2008 (2050 Target Amendment) Order 2019
53 The Climate Change Act 2008 (2050 Target Amendment) Order 2019 (SI 2019/1056)
54 'Britain to become first G7 country with net zero emissions target', Reuters, 11 June 2019
55 'PM Theresa May: we will end UK contribution to climate change by 2050', Prime Minister's Office, accessed 16 June 2019

for the planet, allowing the UK to maximise the value of each pound spent on climate change mitigation". Carbon credits allow countries to transfer emissions reductions between themselves so that one country that has overachieved on its emissions reductions targets can offset a country that has not met its emissions reductions targets, and are permitted under Article 6 of the Paris Agreement.[56] The Committee on Climate Change has acknowledged that carbon credits could lower the overall cost of global emissions reductions by facilitating greatest effort in countries best-suited to making them (for example due to land, biomass or solar resources).[57] However, it argued that domestic action would do more to improve air quality and reduce technological costs, and therefore recommended that the UK should "aim to meet the recommended net-zero target in 2050 without use of carbon units if possible".[58]

19. **We commend the Government for adopting a net-zero emissions target, in line with the 2015 Paris Agreement. It is vital now that this ambition is backed up with policies to ensure that the UK meets its targets.** ***The Government must develop and act on policies to ensure that the UK is on track to meet a 2050 net-zero emissions target. It must seek to achieve this through, wherever possible, domestic emissions reductions. However, it should also work to develop robust international frameworks for carbon units trading, to ensure that effective and efficient methods for reducing global emissions are supported where available.***

20. In its request for advice on a UK target for net-zero emissions, the Government explicitly excluded "carbon budgets already set in legislation" from the scope of its request.[59] In its report, the Committee on Climate Change stated that it did "not recommend changes to the fourth or fifth carbon budgets at this time" and instead said that "the priority now should be to strengthen policy to ensure that the fourth and fifth budgets are outperformed in preparation for a tougher sixth carbon budget".[60] However, the Committee on Climate Change went on to say that it "will consider whether the fourth and fifth carbon budgets should be tightened in legislation as part of our advice on the sixth carbon budget".[61]

21. **We commend the Government on responding promptly to the Intergovernmental Panel on Climate Change's 2018 report on 1.5˚C global warming, by asking the Committee on Climate Change (CCC) for advice on net-zero emissions. However, it is disappointing that the Government excluded existing carbon budgets from the scope of this advice.** ***The Government should explicitly state, in advance of the CCC's advice on the sixth carbon budget, its willingness to amend the fourth and fifth carbon budgets in line with the CCC's cost-effective path to net-zero emissions by 2050 if recommended to do so.***

22. Following his oral evidence to us, allegations of a conflict of interest were published in the press regarding Lord Deben's positions as the Chairman of the Committee on Climate Change and as the Chairman of Sancroft International, a sustainable business

56 United Nations, 'Paris Agreement' (2015), Article 6
57 Committee on Climate Change, 'Net Zero: The UK's contribution to stopping global warming' (2019), pp130–132
58 Committee on Climate Change, 'Net Zero: The UK's contribution to stopping global warming' (2019), p132
59 Letter from Rt Hon Claire Perry MP, Roseanna Cunningham MSP and Lesley Griffiths AM to Lord Deben, 15 October 2018
60 Committee on Climate Change, 'Net Zero: The UK's contribution to stopping global warming' (2019), p263–264
61 Committee on Climate Change, 'Net Zero: The UK's contribution to stopping global warming' (2019), p30

consultancy.[62] We subsequently wrote to the Committee on Climate Change and to Lord Deben personally, seeking clarification on any potential conflict of interest and any measures in place to address this.[63]

23. **Lord Deben, the Chairman of the Committee on Climate Change, gave evidence to our Committee. He did not declare his interest as the Chair of Sancroft International. This company has had amongst its clients Drax, the largest recipient of renewable energy subsidies in the country, and Johnson Matthey, who are about to make a huge investment in electric vehicles. These should have been declared to the Science and Technology Committee.**

62 'Tory peer in £600,000 conflict of interest: Climate Change chief John Gummer faces calls to quit over payments from 'green businesses' to his family firm where daughter he famously fed a beef burger during the height of the BSE crisis is a director', Mail on Sunday, 2 February 2019

63 Letter from Rt Hon Norman Lamb MP to Chris Stark, 25 February 2019; Letter from Chris Stark to Rt Hon Norman Lamb MP, 11 March 2019; Letter from Rt Hon Norman Lamb MP to Lord Deben, April 2019; and letter from Lord Deben to Rt Hon Norman Lamb MP, 6 June 2019

3 The Clean Growth Strategy

24. The Government published its 'Clean Growth Strategy' in October 2017, setting out how it intended to meet the fourth and fifth carbon budgets.[64] This Chapter assesses the strategy as a whole, with specific sectors being discussed in subsequent chapters.

Policy gaps

25. Professor Jim Watson, Director of the UK Energy Research Centre, and Malcolm Brinded, representing the Royal Academy of Engineering and allied institutions, both praised the commitment expressed in the Clean Growth Strategy to meeting the UK's emissions targets.[65] Several stakeholders, such as the Renewable Energy Association, also pointed to what they perceived to be a lack of urgency in the strategy, or a mismatch between the ambition of the strategy and the Government's current policies.[66] When it published the Clean Growth Strategy, the Government estimated that the quantifiable policies proposed within it, if implemented, could lead to the UK achieving 94% and 93% of the emissions reductions needed to meet its fourth and fifth carbon budgets respectively (compared to baseline emissions in 1990).[67] The Government's most recent projections have updated this to 95% and 93% respectively.[68] The Minister for Energy and Clean Growth, Claire Perry MP, told us, however, that she considered the projected shortfall to be "small", and argued that since the projections were calculated she had seen "an acceleration of focus and policy delivery and a further reduction in cost":

> The Committee will have seen things like the spring statement and the announcement that we want all new homes from 2025 to be built without fossil fuel heating, which is an example of a policy for which we have costed no carbon reduction at all […] I am confident that we will meet these budgets within the timeframes we are given.[69]

Chris Skidmore MP, interim Clean Growth Minister, subsequently wrote to us to list the main policies whose emissions reductions potential had not yet been included in the Government's projections:

- the Future Homes Standard;
- the Offshore Wind Sector Deal;
- the Industrial Energy Transformation Fund;
- the industrial energy efficiency scheme;
- the deployment of carbon capture, usage and storage at scale during the 2030s;

64 Department for Business, Energy and Industrial Strategy, 'Clean Growth Strategy' (2017)
65 Qq39 and 41
66 For example, see: Renewable Energy Association (CGE0026), para 23; Decarbonised Gas Alliance (CGE0032), para 10; E.ON (CGE0036), para 13; Environmental Defense Fund Europe (CGE0042), para 1; Durham Energy Institute (CGE0065), para 3
67 HM Government, 'The Clean Growth Strategy' (2017), p40
68 Department for Business, Energy and Industrial Strategy, 'Updated Energy and Emissions Projections 2018' (2019), p20
69 Q415

- the upgrade of all fuel poor homes to Energy Performance Certificate Band C by 2030 where practical, cost-effective and affordable;
- a ban on sales of new conventional petrol and diesel cars and vans by 2040;
- an ambition to remove all diesel-only trains from the network by 2040;
- an ambition to make cycling and walking the natural choices for shorter journeys, or as part of a longer journey by 2040;
- implementation of the smart systems plan; and
- exploration of new and innovative ways to manage emissions from landfill.[70]

26. The projected shortfall in emissions reductions was highlighted by Chris Stark, Chief Executive of the Committee on Climate Change, who warned us that there were "gaps in the policies that needed to be filled if we wanted to meet the fourth and fifth carbon budgets" and that there was additionally "lots of risk attached to those policies that the Government had already made".[71] Malcolm Brinded, representing the Royal Academy of Engineering, the Energy Institute and other engineering institutions, told us that there was widespread agreement that the UK was "not going to meet the carbon budgets on the trajectory [it is] on".[72] Although the UK has achieved the greatest decarbonisation of the G20 nations since 2000, its rate of decarbonisation has been slowing and it fell to fourth place among G20 nations for annual reductions in 2017.[73] Lord Deben, Chairman of the Committee on Climate Change, told us that if he "were to put [his] finger on the thing that [he was] most worried about on climate change, it would be the lack of urgency".[74] The Minister for Energy and Clean Growth, Claire Perry MP, argued, however, that the UK had "the most detailed plan for emissions reduction" internationally and that although she "absolutely agree[d] that we need to raise our ambition", "you have to have a really detailed plan to do that".[75]

Deploying existing technologies

27. Numerous submissions to our inquiry highlighted the importance of supporting the deployment of existing technologies as well as the development of less mature technologies.[76] For example, the Royal Academy of Engineering and allied institutions told us that "innovative policy making that works to break down silos and drives large-scale deployment of existing low-carbon solutions is more urgent than policy focused on the development of new technologies".[77] They argued that a "comprehensive review of incentives and regulations is required" to support this. Achieving the Government's key targets would require an acceleration of deployment of low carbon technologies:

70 Department for Business, Energy and Industrial Strategy (CGE0089)
71 Q2
72 Q39
73 Department for Business, Energy and Industrial Strategy, '2018 UK Greenhouse Gas Emissions, Provisional Figures' (2019), p3 and PwC, 'Time to get on with it: The Low Carbon Economy Index 2018' (2018), p8
74 Q4
75 Qq455–457
76 For example, see: ABB (CGE0010), section 1.3; Nuclear Industry Association (CGE0018), para 5; E.ON (CGE0036), para 16; Royal Academy of Engineering and allied institutions (CGE0055), para 2.1; The Royal Society (CGE0056), para 7; Durham Energy Institute (CGE0065), para 19; and Centre for Research into Energy Demand Solutions (CGE0070), para 17
77 Royal Academy of Engineering and allied institutions (CGE0055), para 17

- the Government wants "almost every car and van to be zero emission" by 2050,[78] which is equivalent to removing almost 20,000 conventional cars every week on average, from now until 2050,[79] whereas around 1,200 new ultra-low emissions vehicles were registered each week in 2018;[80]

- the Government also wants "as many homes as possible to be EPC Band C by 2035 where practical, cost-effective and affordable",[81] which Tim Lord, Director of Clean Growth at the Department for Business, Energy and Industrial Strategy, clarified to us represented a "very significant majority of homes".[82] This would equate to improving the energy efficiency of around 20,000 English homes (just under 40 per English constituency) per week until 2035[83]—in contrast, the Committee on Climate Change reported that around 2,400 energy loft or wall insulations were installed per week in 2017;[84]

- the Government has said that "by 2050, we will also likely need to fully decarbonise how we heat our homes",[85] which would require at least 15,000 homes to transfer to a low-carbon heating system every week until 2050[86]—this compares to a projection of 220 low-carbon heat systems being installed each week under the Government's 'Renewable Heat Incentive' from now until 2021; and[87]

- the Government has set out its "aspiration" to reach woodland cover of 12% in England by 2060,[88] which would require the net growth of around 120 hectares of woodland per week—in 2018, net woodland growth was around 20 hectares per week.[89]

28. Although the rate of deployment may reasonably be expected to grow over the long timescales in question, there are also a number of areas in which Government policy to support the deployment of low-carbon technologies has been delayed or cut back. For example:

78 Department for Transport, 'The Road to Zero' (2018), p2
79 Department for Transport, 'Vehicle Licensing Statistics: Annual 2018' (2019), p3; Committee analysis
80 Department for Transport, 'Vehicle Licensing Statistics: Annual 2018' (2019), p1; Committee analysis
81 Department for Business, Energy and Industrial Strategy, 'The Clean Growth Strategy' (2017), p13
82 Q470
83 Ministry of Housing, Communities and Local Government, 'English Housing Survey Headline Report 2017–2018' (2019), Annex Table 2.7; Committee analysis—the National Infrastructure Commission has similarly estimated that the potential for cost-saving energy efficiency improvements equates to "21,000 improvements being installed every week between now and 2035": National Infrastructure Commission, 'National Infrastructure Assessment' (2018), p45
84 Committee on Climate Change, '2018 Progress Report to Parliament' (2018), p85
85 Department for Business, Energy and Industrial Strategy, 'Clean Growth Strategy', p75
86 There were 24m properties with gas meters in 2016, which will not include some off-grid properties that use fossil fuels to heat their homes—Department for Business, Energy and Industrial Strategy, 'Sub-National Electricity and Gas Consumption Statistics' (2018), p22; National Grid similarly told us that "if decarbonisation of heat is to be successful, around 20,000 homes a week between 2025 to 2050 will need to move to a low carbon heat source"—National Grid (CGE0019), para 3.4
87 National Audit Office, 'Low-carbon heating of homes and businesses and the Renewable Heat Incentive' (2018), para 1.17
88 Department for Business, Energy and Industrial Strategy, 'Clean Growth Strategy', p107
89 Forestry Commission England, 'Corporate Plan Performance Indicators' (2018), p11

- the 'plug-in grant' for low-emissions cars was reduced from £4,500 to £3,500 for the lowest-emissions cars in October 2018, and cut completely for other low-emissions cars;[90]
- the 'feed-in tariff' for low-carbon power generation was closed in April 2019 without a successor scheme in place;[91]
- the Energy Companies Obligation scheme was restricted to vulnerable households only in November 2018,[92] despite the Government conceding that this would "result in lower carbon emissions reductions being achieved"[93]—the Government consulted on "building an 'able-to-pay' market for energy efficiency" in October 2017 and said that it would respond in 2018,[94] but a response has still not been published;[95] and
- following the cancellation of the 'zero-carbon homes' policy in 2015,[96] the Government pledged in 2018 to consult on changes to Part L of the building regulations (covering energy performance of buildings) in order to support the development of low-carbon heating technologies[97]—however, this consultation has still not been launched (although the Chancellor has announced that a 'Future Homes Standard' would be introduced to deliver homes with "low carbon heating and world-leading levels of energy efficiency", but only by 2025).[98]

Developing less mature technologies

29. Although many of the technologies required for decarbonisation are ready for large-scale deployment, the Government and others have identified several important technologies that should be supported through research and development, large-scale demonstration and commercialisation.[99] These include low-carbon heating technologies, carbon capture and storage, long-term energy storage technologies, small modular nuclear reactors and hydrogen as a fuel.

30. The Government's Clean Growth Strategy highlighted £2.5bn of investment being put into low carbon technologies between 2015 and 2021.[100] This funding aligns with the UK's

90 'Changes to the Plug-in Car Grant', Department for Business, Energy and Industrial Strategy, accessed 27 May 2019—the plug-in grant is a discount on the price of brand new low-emission vehicles, awarded through a grant the Government gives to vehicle dealerships and manufacturers

91 'About the FIT scheme', Ofgem, accessed 27 May 2019—the feed-in tariff awarded owners of small-scale renewable power generation technologies payments for every unit of power generated and every unit supplied to the grid

92 The Electricity and Gas (Energy Company Obligation) Order 2018 (SI 2018/1183); see also Department for Business, Energy and Industrial Strategy, 'Energy Company Obligation 2018–2022' (2019), p10

93 Department for Business, Energy and Industrial Strategy, 'Energy Company Obligation: ECO3, 2018 to 2022' (2018), p11

94 Department for Business, Energy and Industrial Strategy, 'Call for Evidence: Building a Market for Energy Efficiency' (2017)

95 'Building a market for energy efficiency: call for evidence', Department for Business, Energy and Industrial Strategy, accessed 27 May 2019

96 HM Treasury, 'Fixing the foundations: Creating a more prosperous nation'(2015), p46

97 Department for Business, Energy and Industrial Strategy, 'Clean Growth—Transforming Heating: Overview of Current Evidence' (2018), p9

98 Chancellor of the Exchequer, 'Spring Statement 2019: Written Ministerial Statement' (2019), p4

99 For example, see: Department for Business, Energy and Industrial Strategy, 'Clean Growth Strategy' (2017), p53 and Energy Systems Catapult (CGE0029), para 10

100 Department for Business, Energy and Industrial Strategy, 'Clean Growth Strategy' (2017), p17

participation in 'Mission Innovation', a commitment made at the 2015 Paris conference on climate change to double spending on clean energy research and development from 2015 to 2020.[101] The £2.5bn is broken down into:

- up to £505m for the 'Energy Innovation Programme',[102] which aims to accelerate the commercialisation of innovative clean energy technologies and processes across six themes, into the 2020s and 2030s;
- up to £1.2bn for funding awarded through UK Research and Innovation, including through the Energy Systems Catapult and the Offshore Renewable Energy Catapult;
- up to £246m for the Faraday Challenge,[103] which aims to support the research and development of battery technologies for electric vehicles; and
- up to £620m to be awarded through Government departments.[104]

31. The UK Energy Research Centre argued that "several analyses of public research and development spending on energy in the UK and in other countries have concluded that spending is much too low—particularly when compared to the scale of the challenge posed by climate change".[105] Professor Jim Watson, Director of the UK Energy Research Centre, conceded that it was "very difficult to assess" the 'correct' amount to spend on research and innovation for low-carbon technologies, and that the "international evidence […] is quite thin".[106] Nevertheless, he said that analyses tended to conclude that "budgets should be increased by about five times, sometimes ten times".

32. Of the £2.5bn outlined in the Clean Growth Strategy, £1.14bn (44%) was for "basic and applied research", £900m (35%) was for "technology development" and £530m (21%) was for "technology demonstration".[107] The Government explained that:

> The Government is often more active at earlier stages of innovation, through investment in research, education and skills. Later on, private firms play a bigger role, bringing new technologies to market.[108]

Nevertheless, the Committee on Climate Change has warned that the Government's innovation programme was "generally focused at early-stage innovation: research, development and some demonstration", and that in order "to drive commercialisation and cost reduction successfully, it must be supported by funding and policies to drive deployment and learning-by-doing".[109] Many expressed similar opinions to us.[110] The UK

101 'Overview', Mission Innovation, accessed 26 May 2019
102 'Energy Innovation', Department for Business, Energy and Industrial Strategy, accessed 26 May 2019
103 'Faraday battery challenge: Industrial Strategy Challenge Fund', UK Research and Innovation, accessed 26 May 2019
104 Department for Business, Energy and Industrial Strategy, 'Clean Growth Strategy', p50
105 UK Energy Research Centre (CGE0057), para 6—the Centre cited J. Pless *et al.*, 'Inducing and accelerating clean energy innovation with 'Mission Innovation' and evidence-based policy design', Working Paper (2018) and Research Councils UK, 'Investing in a brighter energy future: Energy Research and Training Prospectus' (2013)
106 Q42
107 Department for Business, Energy and Industrial Strategy, 'Clean Growth Strategy' (2017), p52
108 Department for Business, Energy and Industrial Strategy, 'Clean Growth Strategy' (2017), p49
109 Committee on Climate Change, 'An independent assessment of the UK's Clean Growth Strategy' (2018), p10
110 For example, see: Carbon Capture and Storage Association (CGE0023), para 10; Energy Systems Catapult (CGE0029), paras 12 and 26; Decarbonised Gas Alliance (CGE0032), para 38; UK Energy Research Centre (CGE0057), paras 7 and 16; Energy Technologies Institute (CGE0061); and Johnson Matthey (CGE0066), para 4

Energy Research Centre compared the time that it could take for new technologies to develop from early stage research through to commercialisation (typically three to four decades[111]) with the time left for meeting the fourth and fifth carbon budgets (five to fifteen years), concluding similarly that "policies to demonstrate, scale-up and commercialise existing technologies are perhaps more important [than fundamental research and development] if the UK is to successfully comply with carbon budgets in the 2020s and 2030s".[112] Damitha Adikaari, Acting Director of Science and Innovation for Climate and Energy at the Department for Business, Energy and Industrial Strategy, told us that "in the next iteration of this effort", demonstration "is where the focus will be".[113]

33. In particular, we heard that it would be important to have co-ordinated, large-scale trials rather than smaller, fragmented projects.[114] Johnson Matthey, a multinational chemicals and sustainable technology company, told us that "scale is critical", arguing that funding for projects greater than £100m in scale would be more effective than the same overall money spent on a larger number of projects of around £10m-scale.[115] Malcolm Brinded, representing the Royal Academy of Engineering and allied institutions, explained that "you cannot do a big system design and understand what we mean by that without trying it":

> It is not something that you can do on a desk study and in theory; it is about how consumers respond and how all the integrated system reacts, particularly taking advantage of what big data, smart equipment and grids will enable consumers to do and how consumers will then respond, when it is coupled with clear price signals.[116]

Guy Newey, Director of Strategy and Performance at the Energy Systems Catapult, acknowledged that there were already "dozens" of demonstration projects in place but said that the "key challenge" was to "bring those together in big demonstrations testing the huge questions" such as low-carbon heating, nuclear power and carbon capture and storage.[117] Both Mr Newey and Professor Watson highlighted that the Government would have to accept that some demonstration projects would also be unsuccessful.[118]

Co-ordinating development and deployment

34. Dr Jonathan Radcliffe, who leads the Energy Systems and Policy Analysis Group at the University of Birmingham and acted as the Specialist Adviser for our inquiry, told us that the deployment of new technologies "is a complex, non-linear process, with feed-backs and feed-forwards" and that it "requires support across the innovation process, with a combination of support for early stage research and development, demonstration

111 R. Gross *et al.*, 'How long does innovation and commercialisation in the energy sectors take? Historical case studies of the timescale from invention to widespread commercialisation in energy supply and end use technology', Energy Policy vol 123 (2018)
112 UK Energy Research Centre (CGE0057), paras 7 and 16
113 Q458
114 For example, see: ABB (CGE0010), section 2.0; Greenpeace UK (CGE0022), para 7; Energy Systems Catapult (CGE0029), paras 10, 12 and 20; UK Hydrogen and Fuel Cell Association (CGE0034), para 10; Royal Academy of Engineering and allied institutes (CGE0055), para 2.2; Energy Technologies Institute (CGE0061); and Qq47–52
115 Johnson Matthey (CGE0066), para 2
116 Q67
117 Q52
118 Qq50–51

activities and market mechanisms".[119] Guy Newey, Director of Strategy and Performance at the Energy Systems Catapult, made the similar point that if the Government "does not get the market structures right, there is a real risk that it will just be supporting isolated innovation projects", and would not achieve the system-change required:

> The lesson from the electricity system in the UK is that you need to get the innovation spend—the earlier-stage research and development stuff—lined up with the market mechanisms, and then you can see extraordinary cost reductions in technologies. If you do not do that, you will end up spending bits and bobs of money, but quite significant sums of public money, that will not lead to the kind of change you need.[120]

35. The most commonly referenced example in our written evidence of a technology whose development and deployment had been supported effectively was offshore wind power.[121] The cost of offshore wind power has fallen from around £160/MWh in 2011 to around £60/MWh today,[122] over which time the total generation capacity has increased from 1.8GW to 8.2GW.[123] The most important aspects of the support that has enabled this development were frequently identified as:

- clear, long-term targets for cost reduction and deployment;
- stable support mechanisms to create new markets, such as the Renewable Obligation scheme and contracts for difference framework; and
- constructive partnerships between Government and industry, enabled by industry councils and dedicated innovation co-ordinating bodies.

The Committee on Climate Change has similarly said:

> Offshore wind deployment exemplifies how clear goals, an ambitious strategy and well-designed mechanisms, can encourage and enable the market to reduce cost and help to build wider economic co-benefits. These lessons should be applied more broadly—to meet the challenges […] in transport, industry, buildings and agriculture.[124]

36. **The Government's own projections suggest that the UK is not currently on track to meet its existing emission targets, although we note that there are several significant policies and ambitions that have not yet been included in these calculations. Nevertheless, the rate of deployment of several key low-carbon technologies is significantly lower than what is required to meet the Government's ambitions, and various stakeholders—including the Committee on Climate Change—have expressed**

119 Dr Jonathan Radcliffe (CGE0041), para 12

120 Q46

121 For example, see: Menter Mon (CGE0002); Scottish Carbon Capture and Storage (CGE0021), section 6; Carbon Capture and Storage Association (CGE0023), para 29; Energy UK (CGE0024), para 8; Drax Group plc (CGE0025), para 39; Energy Systems Catapult (CGE0029), para 23; Decarbonised Gas Alliance (CGE0032), para 42; E.ON (CGE0036), para 34; UK Energy Research Centre (CGE0057), paras 21–22; UK Research and Innovation (CGE0058), para 17; Johnson Matthey (CGE0066), para 7; RenewableUK (CGE0067), section 1; Dolphin N2 (CGE0069), para 3.5.1.1;

122 Committee on Climate Change, 'Costs of low-carbon generation technologies' (2011), p3–4 and Department for Business, Energy and Industrial Strategy, 'Contracts for Difference Second Allocation Round Results' (2017)

123 Department for Business, Energy and Industrial Strategy, 'Energy Trends: renewables' (2019), Table 6.1

124 Committee on Climate Change, '2018 Progress Report to Parliament' (2018), p11

concern at the current and projected rate of progress of the UK's decarbonisation. In order to meet the fourth and fifth carbon budgets, emissions reductions cannot continue only in sectors that have decarbonised successfully so far, and must be significantly accelerated in sectors such as transport, heating and agriculture that have made little progress. The step-change in decarbonisation required will need policies to support the deployment and roll-out of existing technologies alongside, and co-ordinated with, significant research, development and demonstration of less mature technologies.

Technologies for export

37. In addition to the need for decarbonisation, the Clean Growth Strategy noted the "enormous potential economic opportunity" of clean growth with "an estimated $13.5 trillion of public and private investment in the global energy sector alone […] required between 2015 and 2030 if the signatories to the Paris Agreement are to meet their national targets".[125] However, despite highlighting this opportunity, the ambitions and policies in the Clean Growth Strategy focused heavily on deployment in the UK.

38. Professor Jonathan Gibbins, Director of the UK Carbon Capture and Storage Research Centre, argued that it was important to consider "how effective technology developments and investments in deployment in the UK are in influencing global outcomes", saying that "technologies that convince other countries they can go to net zero are quite valuable".[126] Malcolm Brinded, representing the Royal Academy of Engineering and allied institutions, similarly told us that exporting low-carbon technologies to emerging economies offered "a huge opportunity to have much greater impact [on climate change], probably at lower cost, than just continuing to drive down our own targets", but highlighted that these opportunities did "not get much focus" in the Clean Growth Strategy.[127] Indeed, none of the fifty "key policies and proposals" in the Strategy addressed emissions reductions outside the UK.[128] Mr Brinded acknowledged that "at a niche level the UK is quite good at this", but argued that "we could do much more":

> There are some programmes from the Department for International Development and so forth and some companies in the UK whose whole focus is on, for example, mobile home solar systems in Africa and south Asia, which are now attracting tens or hundreds of millions in support. The UK is very well placed here […] but we could do much more to support an incubator system and infrastructure and the small- to medium-enterprises and innovators delivering these solutions on the ground. That requires more money on a more sustained basis, and an integrated strategy between the Department for Business, Energy and Industrial Strategy, the Department for International Development, the Department for Transport and the Department for International Trade.[129]

125 Department for Business, Energy and Industrial Strategy, 'Clean Growth Strategy' (2017), p8
126 Q408
127 Q39
128 Department for Business, Energy and Industrial Strategy, 'Clean Growth Strategy' (2017), pp12–16
129 Q75

Professor Jim Watson, Director of the UK Energy Research Centre, indicated that he agreed "with a lot of that",[130] while Dr Nina Skorupska, Chief Executive of the Renewable Energy Association, said that, although different Government departments were "beginning to" improve support for export opportunities, "we still have to do a lot more".[131]

39. The Government published an 'International Research and Innovation Strategy' in May 2019, which included elements addressing sustainability.[132] However, this focused on international collaboration on research and innovation, rather than export opportunities for British technologies and companies.

40. **The UK can simultaneously achieve economic growth and global emissions reductions through the export of low-carbon technologies to other countries. This potentially offers global emissions reduction at lower cost than the same level of reduction in the UK. However, opportunities for delivering emissions reductions outside of the UK were not included in the 50 key policies and proposals of the Government's Clean Growth Strategy. When it laid legislation strengthening the UK's long-term emissions reduction targets, the Government said that it would review the net-zero target within five years, to review the extent to which other countries had followed the UK's lead in setting and acting upon decarbonisation targets.**

41. ***Ahead of its review of international reaction to the UK's net-zero target, the Government should actively encourage other countries to take similarly ambitious action. It should develop a strategy by the end of 2020, identifying opportunities for the UK to encourage and support decarbonisation in other countries, and prioritising action that will achieve the greatest global emissions reduction. This should include cross-Government action to support British companies exporting technologies that can deliver emission reductions abroad.***

42. Tim Lord, Director of Clean Growth at the Department for Business, Energy and Industrial Strategy, told us that "there is a huge amount of cross-Government collaboration" on clean growth, including across the Treasury, the Ministry for Housing, Communities and Local Government and the Department for Transport.[133] The Minister for Energy and Clean Growth, Claire Perry MP, added:

> I think the fact that I do attend Cabinet, that we have a clean growth cross-Government strategy, and that for the first time ever we saw a green-focused financial statement, should give the Committee reassurance that it is absolutely percolating across Government.[134]

Nevertheless, the Minister is situated in one Government Department and is not a Cabinet Minister.[135]

43. ***The Government should increase the number of Ministers across Government Departments working on climate change, including a new Ministerial role at the Foreign and Commonwealth Office with explicit responsibility for delivering multi-lateral action internationally on climate change. Reflecting the critical importance***

130 Q79
131 Qq292–293
132 HM Government, 'International Research and Innovation Strategy' (2019)
133 Q502
134 Q457
135 'Ministers', HM Government, accessed 9 July 2019

of mitigating climate change, and to improve cross-Government co-ordination, the Minister charged with co-ordinating the UK's action on national and international decarbonisation should be a full Cabinet Minister.

4 Decarbonising power generation

44. This Chapter examines the Government's policies for decarbonising the power generated by the UK, covering large-scale renewable power technologies such as onshore and offshore wind farms, small-scale renewable power technologies such as rooftop solar panels, and conventional and emerging nuclear power technologies.

Overview

45. Power generation was responsible for around 15% of the UK's territorial greenhouse gas emissions in 2018.[136] The power generation sector has achieved significant decarbonisation over the course of the last carbon budget period, mostly as coal power generation has been replaced by gas and renewable power generation, and improved efficiencies have reduced demand.[137] Overall, emissions from the power generation sector fell by 59% between 2008 and 2017,[138] and emissions reductions in this sector accounted for 75% of the UK's total emissions reductions between 2012 and 2017.[139]

46. The Committee on Climate Change has made clear that "further reduction in the emissions intensity of power generation […] remains the lowest-cost path towards economy-wide decarbonisation".[140] Eliminating the UK's remaining coal power emissions, as the Government has pledged to do by 2025,[141] would reduce the UK's total emissions by a maximum of a further 4.5%.[142] This compares to overall reductions of around 13% required to meet the fourth carbon budget.[143] Although the proportion of electricity generated from coal has decreased substantially in the UK, natural gas—another, less carbon-intensive, fossil fuel—supplied 40.4% of the UK's electricity in 2017.[144] Low-carbon power generation technologies include onshore and offshore wind power, solar power, wave and tidal power, geothermal power and nuclear power (the Intergovernmental Panel on Climate Change has estimated that the full lifecycle emissions associated with nuclear power are comparable to renewable power technologies such as wind power).[145] Together, these provided around 50.1% of the UK's electricity supply in 2017.[146]

136 Department for Business, Energy and Industrial Strategy, '2018 UK Greenhouse Gas Emissions, Provisional Figures' (2019), p6
137 Committee on Climate Change, '2018 Progress Report to Parliament' (2018), p56
138 Committee on Climate Change, '2018 Progress Report to Parliament' (2018), p53
139 Committee on Climate Change, '2018 Progress Report to Parliament' (2018), p11
140 Committee on Climate Change, '2018 Progress Report to Parliament' (2018), p68
141 Department for Business, Energy and Industrial Strategy, 'Implementing the End of Unabated Coal by 2025' (2018)
142 Department for Business, Energy and Industrial Strategy, 'Provisional UK greenhouse gas emissions national statistics: 2018' (2019), Tables 1 and 2; Committee analysis
143 Department for Business, Energy and Industrial Strategy, '2018 UK Greenhouse Gas Emissions, Provisional Figures' (2019), p3 and Carbon Budget Order 2011 (SI 2011/1603); Committee analysis
144 Department for Business, Energy and Industrial Strategy, 'Digest of United Kingdom Energy Statistics 2018' (2018), p117
145 Intergovernmental Panel on Climate Change, 'Working Group III Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change' (2014), p539
146 Department for Business, Energy and Industrial Strategy, 'Digest of United Kingdom Energy Statistics 2018' (2018), p117

47. The Government has stated its intention to "regulate the closure of unabated coal power generation units by 2025".[147] Seven of the UK's eight operating nuclear power stations are also scheduled to close by 2030.[148] Across all power generation technologies, around two-thirds of existing power stations are expected to close by 2030.[149] Against this backdrop of planned power station closures, the demand for electricity is anticipated to grow substantially, in particular as sectors such as transport and heating electrify.[150] In total, the Committee on Climate Change has estimated that the amount of low-carbon electricity generated each year will have to more than double during the 2020s, requiring the generation of 130–145TWh of additional low-carbon energy by 2030 (taking into account the generation capacity expected to close by 2030).[151] Were this to be met using just one low-carbon power generation technology, this would be equivalent to increasing the current generation from onshore wind power by a factor of 5.7, offshore wind power by a factor of 7.6, solar power by a factor of 13.0, or nuclear power by a factor of 3.0.[152] National Grid System Operator, which is responsible for balancing the supply and demand of electricity in Great Britain, has similarly estimated that the UK will need to more than double its low-carbon power generation capacity by 2030, and increase it by a factor of between 3.1 to 3.8 by 2050 to reach its existing emissions targets (corresponding to increases of around 50GW and 100–130GW respectively).[153]

48. The Minister of State for Energy and Clean Growth, Claire Perry MP, indicated to us that the Government expected the main components of this future low-carbon power generation supply to consist of offshore wind power, nuclear power and gas power used in combination with carbon capture and storage.[154] As part of its 'Industrial Strategy', the Government agreed sector deals with the nuclear and offshore wind power industries.[155] The nuclear sector deal has four main aims:

- to reduce the cost of new-build projects by 30% by 2030;
- to reduce the estimated costs of decommissioning by 20% by 2030;
- to increase female participation to 40% of the workforce by 2030; and
- to achieve up to £2bn of new domestic and international contracts by 2030.[156]

The offshore wind sector deal aims to:

- increase the UK content of new wind turbines to 60% by 2030;
- increase female participation to 33% by 2030; and
- increase exports fivefold to £2.6bn by 2030.[157]

147 Department for Business, Energy and Industrial Strategy, 'Implementing the End of Unbated Coal by 2025' (2018), p3
148 'Country Nuclear Power Profiles—United Kingdom', International Atomic Energy Agency, accessed 17 April 2019
149 National Infrastructure Commission, 'Smart Power' (2016), p5
150 National Grid Energy Systems Operator, 'Future Energy Scenarios 2018' (2018), p3
151 Committee on Climate Change, '2018 Progress Report to Parliament' (2018), p59
152 Current generation taken from Department for Business, Energy and Industrial Strategy, 'Digest of UK Energy Statistics 2018' (2018); Science and Technology Committee analysis
153 National Grid System Operator, 'Future Energy Scenarios' (2018), p96
154 Q440
155 HM Government, 'Industrial Strategy: Nuclear Sector Deal' (2018) and 'Industrial Strategy: Offshore Wind Sector Deal' (2019)
156 HM Government, 'Industrial Strategy: Nuclear Sector Deal' (2018), p7
157 HM Government, 'Industrial Strategy: Offshore Wind Sector Deal' (2019), p4

The offshore wind sector deal also entails up to £250m investment from industry to build the UK supply chain and up to £557m from the Government to finance new offshore wind capacity. In place of a sector deal, the Government has published a carbon capture, usage and storage 'action plan'.[158] This committed to "the UK having the option to deploy carbon capture, usage and storage at scale during the 2030s subject to the costs coming down sufficiently".[159]

49. The Government has estimated that the offshore wind sector deal could lead to the deployment of 30GW of new generation capacity by 2030,[160] corresponding to around 100TWh of low-carbon electricity per year (compared to the 130–145TWh the Committee on Climate Change estimated that the UK would need).[161] The Government did not estimate the new generation capacity that the nuclear sector deal would deliver. However, given the £18bn value of the new 3.3GW (~25TWh/yr) reactor at Hinkley Point C, the Government's ambition for £2bn of domestic and international contracts to be won by 2030 suggests that the nuclear sector deal will not deliver significant proportions of the UK's additional power needs.[162] The Minister told us that "nuclear has a part to play in the [future energy] mix" but said that the Government has to "spend taxpayers' money wisely".[163] It therefore seemed as though the Government planned to meet the bulk of the UK's additional power generation needs through the 2020s by installing new offshore wind power. Indeed, Dr Robert Gross, co-Director of the UK Energy Research Centre, told us that "the only really big show in town between now and 2030 is the offshore wind sector deal".[164]

50. The Offshore Renewable Energy Catapult advised us that the Government's target for offshore wind was "very achievable, with much of the 30GW in the pipeline in one form or another".[165] Professor Keith Bell, co-Director of the UK Energy Research Centre, further told us that it was "entirely credible" that the UK could deploy the low-carbon power generation capacity it would need to fulfil its fourth and fifth carbon budgets, and indicated that it was already "well on the way" to achieving this.[166] The Committee on Climate Change, however, has estimated that the announced Government investment in renewable power would provide an additional 60TWh per year by 2030, and that the new nuclear reactor at Hinkley Point, if built, would provide 25TWh per year.[167] This would leave a 'gap' of 50–60TWh by 2030. Dr Nina Skorupska, Chief Executive of the Renewable Energy Association, similarly told us that the UK was "not on track" to deploying the low-carbon power generation required for its fourth and fifth carbon budgets.[168]

51. Dr Gross said that the Government's aims were "perfectly achievable" but said that the focus on offshore wind power meant that the UK was therefore "very largely putting all of [its] eggs in that basket".[169] The Committee on Climate Change has warned that

158 HM Government, 'The UK Carbon Capture Usage and Storage deployment pathway: An Action Plan' (2018)
159 HM Government, 'The UK Carbon Capture Usage and Storage deployment pathway: An Action Plan' (2018), p7
160 HM Government, 'Industrial Strategy: Offshore Wind Sector Deal' (2019), p4
161 Committee analysis assuming a load factor of about 40%, which offshore wind has consistently achieved since 2013—Department for Business, Energy and Industrial Strategy, 'Digest of UK Energy Statistics 2018' (2018), p185
162 'Hinkley Point C contract signed', Department for Business, Energy and Industrial Strategy, accessed 30 May 2019
163 Qq441–442
164 Q232
165 Offshore Renewable Energy Catapult (CGE0081)
166 Q232
167 Committee on Climate Change, '2018 Progress Report to Parliament' (2018), pp59 and 64
168 Q232
169 Q232

the Government's power generation decarbonisation strategy was not "credible" because of the "significant risks associated with it" and the lack of "multiple plausible pathways to achieve the necessary level of decarbonisation".[170] It therefore recommended that the Government develop "robust contingency plans that allow for additional low-carbon generation to be brought forward in the event of delay or cancellation of planned projects, or imports of electricity below projected levels".[171] This appears to be warranted, given the recent uncertainty surrounding nuclear power projects.[172]

Managing intermittent renewable energy

52. Renewable power generation is generally 'intermittent', meaning that its output is variable and uncontrollable. For example, wind turbines only generate power when the wind is blowing. Although this poses challenges to the UK energy system, Duncan Burt, Director of Operations at National Grid System Operator (which is responsible for balancing supply and demand on the electricity transmission system—the core network that transfers high-voltage power between power stations and local distribution networks), told us that "it is very easy to get to very high levels of renewable generation and to 100% zero carbon generation over the next six or seven years for regular periods of operation".[173] Indeed, National Grid Electricity System Operator has stated its ambition to be able to operate the grid using entirely 'zero-carbon' power sources by 2025, subject to sufficient generation (this contrasts to the Government's statement that "one possible pathway to 2032 […] could be achieved by growing low carbon sources such as renewables and nuclear to over 80% of electricity generation).[174] In fact, Great Britain is already achieving increasing periods of zero-carbon power generation. For example, on 8 May 2019, Great Britain met its electricity demands for over a week without using coal power—for the first time since the Industrial Revolution—and later that month went two weeks without coal power.[175] The UK Energy Research Centre has further reported that, although "the additional costs of adding variable renewable generation to an electricity system can vary quite dramatically […] they are usually modest, with higher costs normally the result of inflexible or sub-optimal systems".[176]

53. **We commend National Grid Electricity System Operator for its ambition to be able to manage a 'zero carbon' electricity grid by 2025. This goes significantly beyond the Government's projections for possible renewable power deployment by 2032, and indicates that any 'over-delivery' on the deployment of low-carbon power generation in the 2020s will not be incompatible with the electricity transmission system. *We urge distribution network operators to adopt a similar ambition to National Grid System Operator, of operating a zero carbon grid by 2025. Ofgem should work with distribution network operators to ensure that the regulatory framework required to allow this***

170 Committee on Climate Change, '2018 Progress Report to Parliament' (2018), pp74 and 78
171 Committee on Climate Change, '2018 Progress Report to Parliament' (2018), p83
172 'Toshiba's UK withdrawal puts Cumbria nuclear plant in doubt', BBC News, 8 November 2018 and 'Nuclear plant in Anglesey suspended by Hitachi', BBC News, 17 January 2019
173 Q297
174 National Grid System Operator, 'Zero Carbon Operation 2025' (2019) and HM Government, 'Clean Growth Strategy' (2017), p96
175 'UK has first coal-free week for a century', BBC News, 9 May 2019 and 'Britain in two-week coal-free record', BBC News, 31 May 2019
176 UK Energy Research Centre, 'The costs and impacts of intermittency—2016 update' (2017), p1

is in place. If sufficient progress is not made we urge the Government to consider strengthening Ofgem's mandate to require the distribution network operators to speed up the investment and upgrading of the distribution networks required.

54. **The Government has indicated that it expects requirements for new power generation capacity to be met through offshore wind power, nuclear power and gas-fired power with carbon capture and storage. There is considerable risk that these technologies may not provide the generation capacity required.** ***The Government must set out in its response to this Report how it intends to monitor and address any potential shortfall in power generation capacity, and ensure that this can be achieved with low emissions and costs.***

Large-scale renewable power

New generation capacity

55. The Government has said that its "main mechanism for supporting low-carbon electricity generation" is through 'contract for difference' agreements (see Box 1).[177] These have supported the deployment of 5.5GW of renewable power generation capacity since they started in 2015,[178] and were identified by several witnesses as having been an important factor in the falling costs of renewable power technologies.[179] However, since 2017, contracts for difference have been available only for "less-established" technologies such as offshore wind power or tidal power, and not for "established technologies" including onshore wind power and large-scale solar power (the contract for difference framework refers to established and less-established technologies as 'Pot 1' and 'Pot 2' technologies respectively).[180] The Government has signalled its intention to continue this policy through the 2020s.[181]

Box 1: Contracts for Difference

Under the contract for difference mechanism, the Government signs contracts with renewable energy project developers (through the Low Carbon Contracts Company (LCCC), a Government-owned company) agreeing that for the duration of the contract, the LCCC will pay the developer the difference between the 'reference price' (a measure of the average market price) and the 'strike price' (the price negotiated at the beginning of the contract) for any electricity the developer sells into the grid. This guarantees the developer a stable price for the electricity it generates for the duration of the contract, usually 15 years. In the event that the wholesale price rises above the negotiated strike price, the developer instead pays the LCCC. The net cost of all payments made to contracted developers is funded through a levy on licensed electricity suppliers.

177 'Contracts for Difference', Department for Business, Energy and Industrial Strategy, accessed 3 June 2019

178 Department of Energy and Climate Change, 'Contracts for Difference (CFD) Allocation Round One Outcome' (2015) and Department for Business, Energy and Industrial Strategy, 'Contracts for Difference Second Allocation Round Results' (2017)

179 For example, see Drax Group plc (CGE0025), para 39

180 Department for Business, Energy and Industrial Strategy, 'Budget Notice for the Second CFD Allocation Round' (2017)

181 Department for Business, Energy and Industrial Strategy, 'Clean Growth Strategy' (2017), p99

Contracts for Difference are awarded through Allocation Rounds in which renewable power developers bid for contracts in a 'pay as clear' auction. The Government sets an overall budget cap for each auction as well as a maximum permissible strike price for each technology. Developers then make sealed bids of the capacity they are offering and the lowest strike price they would accept. The project with the lowest strike price is awarded a contract first. Each subsequent project wins a contract if its expected cost, when added to the cost of the previous winning projects in the auction, comes below an overall budget cap. Projects that have already won a contract have their strike price raised to that of the latest project being assessed and the revised overall cost of the auction is reassessed against the budget cap. The auction stops once a project's cost breaches the budget cap when added to the costs of projects that have already won.

The first Allocation Round in 2015 held separate auctions for different groups (or "pots") of technologies:

Pot 1—established technologies (such as onshore wind power and solar power); and

Pot 2—less established technologies (such as offshore wind power and wave power).

Sources: 'Contracts for Difference', Department for Business, Energy and Industrial Strategy, accessed 17 April 2019; 'CfD Overview', National Grid ESO, accessed 17 April 2019; National Audit Office, 'Investigation into the 2017 auction for low-carbon electricity generation contracts' (2018)

56. Numerous stakeholders contributing to our inquiry argued for the inclusion of established technologies in future contract for difference auctions.[182] In addition to the stakeholders that contributed to our inquiry, contract for difference auctions open to Pot 1 technologies have been recommended by independent organisations such as the Committee on Climate Change and the National Infrastructure Commission.[183] Alongside their low carbon intensity, the main argument for supporting the market for established renewable power generation technologies was their low cost. In particular, the cost of new wind power generation capacity in Europe has fallen continuously since at least 2015,[184] and the Government estimated in 2016 that onshore wind power would have the lowest deployment cost of any power generation technology—including those using fossil fuels—from 2020 onwards (the analysis included carbon pricing costs but not the wider system costs of different technologies).[185]

57. The Government therefore argued that "onshore wind and solar costs have already fallen significantly, and global market dynamics will continue to drive this, so it is right for us to have scaled back support in those areas".[186] However, RenewableUK has reported that new onshore wind installations fell by nearly 80% in 2018 to the lowest level since 2011, which it claimed was despite that fact that "there is currently 4,466MW [over seven times what was installed in 2018] of shovel-ready onshore wind that has gone through the local planning process".[187] The Solar Trade Association similarly reported a 95% drop in

182 For example, see: EDF Energy (CGE0020), para 8; Energy UK (CGE0024), paras 5–6; E.ON (CGE0036), para 17; RenewableUK (CGE0067), section 2; Qq65 and 262–263

183 Committee on Climate Change, '2018 Progress Report to Parliament' (2018), p54 and National Infrastructure Commission, 'National Infrastructure Assessment' (2018), pp40–42

184 Wind Europe, 'Financing and investment trends' (2019), p17

185 Department for Business, Energy and Industrial Strategy, 'Electricity Generation Costs' (2016), p29

186 Department for Business, Energy and Industrial Strategy (CGE0016), para 18

187 'New onshore wind installations plummet in 2018', RenewableUK, accessed 3 June 2019

deployment of new solar power in 2018 compared to 2015 and highlighted the UK's last-place ranking for anticipated growth in solar power out of 20 established global markets, as rated by Solar Power Europe.[188] Furthermore, planning permission applications for renewable generation fell in 2016 and 2017, from a total equivalent generation capacity of 2.5GW to 0.9GW.[189] Professor Keith Bell, co-Director of the UK Energy Research Centre, explained that it was not subsidy that Pot 1 technologies required from contracts for difference, but that instead "it is a question of the right contractual framework that allows the cost of capital to be reduced and allows the investment to be unlocked".[190] Dr Nina Skorupska, Chief Executive of the Renewable Energy Association, added that, with policies to support renewable technologies all ended or ending soon without replacement (other than for offshore wind power), "the general lack of a clear policy and framework beyond 2020 is stifling investment".[191]

58. Nevertheless, the costs of established renewable technologies are expected to continue falling. BVG Associates, a renewable energy consultancy firm, has estimated that the cost of onshore wind power could fall below the wholesale price of electricity in 2023, and therefore result in lower bills for consumers.[192] It projected that a series of five contract for difference auctions for onshore wind power, held at 18 month intervals between 2019 and 2025, could deliver a net benefit of £1.6bn to energy consumers over the total lifetime of the 15-year contract periods and an overall economic benefit of at least £8–12bn. Modelling commissioned by Citizens Advice in 2015 similarly found that the cost to consumers of excluding onshore wind power from the 2017 contract for difference auction would be £500m.[193] Additionally, a 2018 study from University College London argued that restoring Pot 1 auctions would help to improve the competitivity of UK heavy industry, by reducing its electricity costs to nearer the European average.[194] Lord Deben, Chairman of the Committee on Climate Change, told us that the Government "must either allow [onshore wind power] to be part of the structure […] or tell the public the extra cost that we are paying for our electricity because we do not do it".[195]

59. Despite these projected cost-savings, the 2017 Conservative manifesto stated that the party did "not believe that more large-scale onshore wind power is right for England".[196] The Minister for Energy and Clean Growth, Claire Perry MP, further explained that "people find these wind turbines to be very unsightly" and stated that the UK "could be generating all the wind power [it needs] offshore with concomitant industrial benefits".[197] The Government's own surveys have revealed, however, that 79% of the public support the use of onshore wind power and that 61% would be happy to have a large scale renewable

188 Solar Trade Association (CGE0053), para 3 and Solar Power Europe, 'Global Market Outlook for Solar Power 2018–2022' (2018), p20

189 Committee on Climate Change, '2018 Progress Report to Parliament' (2018), p61

190 Qq235–237; the Committee on Climate Change, of which Prof Bell was recently made a member, similarly said in 2017 that "with suitable long-term contracts [renewable power technologies] can be deployed without subsidy beyond the application of a carbon price to fossil fuel generation"—'Five reflections on Dieter Helm's Cost of Energy Review', Committee on Climate Change, accessed 7 June 2019

191 Q251

192 BVG Associates, 'The Power of Onshore Wind' (2018)—this report was commissioned by ScottishPower Renewables, Innogy, Statkraft and Vattenfall

193 Citizens Advice, 'Generating Value? A Consumer Friendly Electricity Generation Policy' (2016)

194 M. Grubb and P. Drummond, 'UK Industrial Electricity Prices: Competitiveness in a Low Carbon World' (2018)

195 Q21

196 Conservative and Unionist Party, 'Forward, Together: Our Plan for a Stronger Britain and a Prosperous Future' (2017), p22

197 Q443

energy development in their area.[198] Energy UK noted that "robust local planning rules" already ensured that new installations of these technologies would go ahead only where the local community supported them.[199] Indeed, there has been some criticism that changes to planning guidance in 2015 "place an effective moratorium on onshore wind projects without decisive and deliberate action from local councils or communities and increases the risk profile of the planning applications that are submitted".[200] It has also been argued that the UK's restrictive planning framework is responsible for the fact that the UK's new onshore wind farms have some of the smallest turbines in Europe,[201] despite the fact that larger turbines lead to greater power output, improved reliability and therefore cheaper costs.[202]

60. RenewableUK has argued that wind farms can provide job creation, inward investment and the provision of facilities for local communities, and estimated that for each installed megawatt of wind power capacity, around £100,000 stays in the community and surrounding areas during the lifetime of a project.[203] However, the British Academy has reported that "the UK has had a less stable environment" for supporting community energy projects than international leaders such as Denmark and Germany,[204] which have some of the highest rates of onshore wind power use in Europe as a result of "extensive local community ownership of onshore wind turbines".[205] Research suggests that increasing the public stake in projects by promoting community ownership and profit-sharing, and requiring meaningful public consultations (which provides an opportunity for participation) can build and maintain public support.[206] However, Community Energy England, a not-for-profit organisation representing community energy projects, reported that 2018 was "the toughest year yet for community energy, with new generation capacity falling steeply in comparison to previous years".[207] It blamed this principally on cuts to the feed-in tariff (see paragraphs 69 to 74) combined with a "restrictive planning environment".[208] An alliance of over twenty sustainable energy stakeholders, led by the Green Alliance, published a 'manifesto for community energy' in 2019, advocating:

- measures to ensure that the energy system values community energy, such as encouragement for public authorities to consider social impact in their energy supply or incentives for distribution system operators to support community energy projects;

- support for community energy innovation, for example by lowering the minimum levels of investment required from community energy initiatives in energy trials, ensuring trials are publicised and accessible to community groups, or providing central guidance and other support for community groups; and

198 Department for Business, Energy and Industrial Strategy, 'BEIS Public Attitudes Tracker: March 2019 (Wave 29)' (2019), pp25–26
199 Energy UK (CGE0024), para 6
200 Centre for Sustainable Energy 'Survey of local authority wind policies' (2017), p2; the policy guidance was changed by HCWS42, 18 June 2015
201 WindEurope, 'Wind energy in Europe in 2018' (2019), p20 and RenewableUK, 'Onshore Wind: the UK's Next Generation' (2019), p18
202 'Developments in Wind Power', POSTnote 602, Parliamentary Office of Science and Technology, May 2019
203 'Communities & Energy', RenewableUK, accessed 7 June 2019
204 British Academy, 'Cultures of Community Energy: International case studies' (2016), p3
205 WindEurope, 'Wind energy in Europe in 2018' (2019), p17 and International Energy Agency, '20 Renewable Energy Policy Recommendations' (2018), p14
206 'Developments in Wind Power', POSTnote 602, Parliamentary Office of Science and Technology, May 2019
207 Community Energy England, 'Community Energy State of the Sector 2019' (2019), p1
208 Community Energy England, 'Community Energy State of the Sector 2019' (2019), p3

- leadership, including requirements on commercial developers to offer shared ownership to community groups, consideration of community benefit in planning application decisions, or reinstating community energy projects into the Social Investment Tax Relief regime.[209]

61. In contrast to the UK Government's position, the Scottish Government stated in 2017 that "Scotland will continue to need more onshore wind development and capacity" and called on the UK Government to use its reserved powers and established market mechanisms to support onshore wind power projects.[210] The Welsh Government also called on the UK Government "to enable onshore wind and solar technologies to compete in the Contract for Difference mechanism to reduce overall costs and enable the continued renewable deployment needs to meet the UK's legally binding decarbonisation goals".[211] Giving evidence to the Business, Energy and Industrial Strategy Committee in November 2017, the Clean Growth Minister highlighted that "under the current contract for difference rules, it is impossible to bring forward geographically specific wind farms, much as we would like to".[212]

62. **Although onshore wind power and large-scale solar power are low-cost and low-carbon, the deployment of new installations of these technologies has fallen drastically since 2015. Onshore wind power in particular could lower costs to energy consumers as well as contributing to the UK's decarbonisation, and there is widespread support for increased Government support for such projects across Great Britain. *The Government must ensure that there is strong policy support for new onshore wind power and large-scale solar power projects for which there is local support and projected cost-savings for consumers over the long-term. The Government should actively encourage and support local authorities to adopt planning practices that promote local support for such renewable energy projects. The Government must additionally develop mechanisms to promote community ownership and profit-sharing of low-carbon projects, such as joint ventures, split ownership or shared revenue.***

63. Offshore wind power is set to be supported by the Offshore Wind Sector Deal as well as the Government's allocation of up to £557m for Pot 2 contract for difference auctions.[213] However, we heard of other less-established renewable power generation technologies that could also support clean growth in the UK during our inquiry, such as wave power, tidal power and geothermal power.[214] RenewableUK warned us that "as currently set up, the contract for difference [mechanism] is not a mechanism that will support marine renewables—or any new renewable technology—as they seek to secure the early-stage investment in smaller-scale projects" required to move these technologies from technology development to commercialisation.[215] RenewableUK consequently advocated the development of 'Innovation Power Purchase Agreements', which was supported by

209 Green Alliance, 'A manifesto for community energy' (2019)
210 Scottish Government, 'Onshore wind: policy statement' (2017)
211 Welsh Government, 'Public position on onshore wind and solar' (2017)
212 Oral evidence taken before the Business, Energy and Industrial Strategy Committee on 28 November 2017, HC 596/597, Q140
213 HM Government, 'Industrial Strategy: Offshore Wind Sector Deal' (2019) and Department for Business, Energy and Industrial Strategy, 'Clean Growth Strategy' (2017), p99
214 For example, see: Renewable Energy Association (CGE0026), paras 7 and 9; Nova Innovation Ltd (CGE0044); Marine Energy Wales (CGE0047); The Geological Society (CGE0051), para 3; RenewableUK (CGE0067), section 3
215 RenewableUK (CGE0067), section 3

other marine energy stakeholders.[216] These agreements would be made between developers of certain renewable power technologies and large-scale energy consumers, with the Government providing tax rebates to the consumer covering the difference between the "emerging technology price" of the energy supplied by the developer and the market price, so that they would not incur a cost penalty for entering into such agreements.[217] The "emerging technology price" would be determined according to a pre-defined framework set by the Government, starting at an agreed value (proposed to be around £290/MWh) and decreasing as the total capacity deployed increases. Agreements would only be eligible for projects supplying up to 5MW of generation capacity. A cross-sector proposal for Innovation Power Purchase Agreements estimated that the maximum cost to the Government of such a scheme would average £141m per year over twenty years. Marine Energy Wales proposed that future Pot 2 contract for difference auctions additionally include a minimum allocation to be awarded to specific technologies, in order to support them through larger-scale commercialisation.[218]

64. **The marine energy sector has come together to propose market support mechanisms to support marine and other less-established renewable power technologies through technology development and commercialisation.** ***The Government should examine the case for supporting 'Innovation Power Purchase Agreements' and setting minimum allocations of future contract for difference auctions to specific technologies, to support the development and commercialisation of renewable power technologies that are less-established than offshore wind power.***

Repowering existing generation capacity

65. The Committee on Climate Change's estimate that 130–145TWh of additional low-carbon energy would be required by 2030 was based on the assumption that existing renewable power generation capacity that was scheduled to close during the 2020s would be replaced or have its life extended.[219] The average lifetimes of wind and solar farms—the two most common renewable power technologies in the UK—are around 20–25 years.[220] With the UK's first commercial renewable power projects installed through the 1990s, these installations are starting to near the end of their expected lifetimes.

66. The number of wind farms projected to reach the end of their lifetimes increases substantially from 2029 onwards.[221] This is notable given that RenewableUK, the trade association for the wind, wave and tidal energy industries, has estimated that it could take up to 10 years to start the planning process required to repower a wind farm.[222] The Government revised the National Planning Policy Framework in 2018 to exclude repowering projects from the stricter planning guidance for new wind farm projects,[223] but RenewableUK has warned that repowering projects are still threatened by a "lack of

216 See: Menter Mon (CGE0002); Sustainable Marine Energy (CGE0013), para 9; Marine Energy Wales (CGE0047), para 5.3; RenewableUK (CGE0067), section 3
217 Scottish Renewables, 'UK Marine Energy 2019' (2019), pp14–19
218 Marine Energy Wales (CGE0047), para 5.3
219 Committee on Climate Change, '2018 Progress Report to Parliament' (2018), p59
220 Department for Business, Energy and Industrial Strategy, 'Digest of United Kingdom Energy Statistics 2018' (2018), p159; RenewableUK, 'Onshore Wind: the UK's Next Generation' (2019), p2; and IHS Markit, 'Predictions for the PV industry in 2019' (2019), p5
221 RenewableUK, 'Onshore Wind: the UK's Next Generation' (2019), p4
222 RenewableUK, 'Onshore Wind: the UK's Next Generation' (2019), p9
223 Ministry of Housing, Communities and Local Government, 'National Planning Policy Framework' (2018), para 154

visibility surrounding the planning process".[224] It recommended that "UK Government, devolved governments and assemblies, local authorities and other key stakeholders should work in conjunction with the industry to create a supportive planning policy framework", including:

- clear criteria for the assessment of prospective repowering applications;
- a specific repowering framework for Environmental Impact Assessments and development plan policies that acknowledges the existing use of a site for wind power;
- promotion of the benefits of large turbines; and
- a presumption in favour of granting evergreen planning consent subject to the usual conditions dealing with decommissioning and restoration at the end of the life of the windfarm.[225]

67. RenewableUK also argued that the Government "should ensure that an appropriate market mechanism is in place to enable repowering".[226] Professor Keith Bell, co-Director of the UK Energy Research Centre, told us that although the risk attached to re-powering existing wind farms should in principle be lower than for building new farms due to the re-use of existing sites and connections to the power networks, there was a mixed degree of optimism in the wind power community regarding the ability for re-powering projects to go ahead without some form of contractual security.[227] Dr Nina Skorupska, Chief Executive of the Renewable Energy Association, indicated that the ability of existing onshore wind power sites to repower without market support would vary site-by-site.[228]

68. ***The Government should develop, by the end of 2020, a clear planning permission framework for re-powering existing onshore wind farms, and ensure that national planning policy facilitates re-powering with the most efficient technology and does not block proposals that attract local support. It must also monitor the proportion of onshore wind power sites that apply for permission to repower, and be ready to provide market support (for example through eligibility for contracts for difference) if this is not close to 100%.***

Small-scale renewable power

The Smart Export Guarantee scheme

69. Small-scale renewable power generation technologies include solar panels, small wind turbines and units that convert waste into biogas.[229] Until recently, these have been supported by a 'feed-in tariff' scheme, which paid owners of small-scale generation technologies according to the electricity they generated (the generation tariff) and the amount they provided to the grid instead of using themselves (the export tariff).[230] The

224 RenewableUK, 'Onshore Wind: the UK's Next Generation' (2019), p9
225 RenewableUK, 'Onshore Wind: the UK's Next Generation' (2019), p19
226 RenewableUK, 'Onshore Wind: the UK's Next Generation' (2019), p19
227 Q259
228 Q261
229 Department for Business, Energy and Industrial Strategy, 'The Future for Small-Scale Low-Carbon Generation' (2019), p24
230 'Feed-In Tariff (FIT) rates', Ofgem, accessed 7 June 2019

market regulator, Ofgem, split the costs of the scheme across energy suppliers, who ultimately passed it on to consumers through their energy bills.[231] However, the scheme was closed to new applications on 1 April 2019.[232] Announcing its decision to close the scheme, the Government argued that "growth in the small-scale low-carbon generation sector must be sustainable; driven by competition and innovation, not direct subsidies".[233] It also explained that the feed-in tariff scheme's "fixed and flat rate export tariff does not align with the wider government objectives to move towards market-based solutions, cost reflective pricing and the continued drive to minimise support costs on consumers".[234]

70. The Government has said that around 80% of the power generation capacity supported by the feed-in tariff was in the form of rooftop solar panels.[235] The Solar Trade Association told us that, due to the "the lack of appropriate regulatory scaffolding and lack of local flexibility markets", the smart energy market was "threatened" by the closure of the feed-in tariff.[236] It reported that domestic installations of solar panels had fallen each year since 2015,[237] which is when the Government first announced that it would start winding down parts of the feed-in tariff scheme.[238] Following a survey of its members in 2018, the Renewable Energy Association reported that over 40% of UK solar installers were considering leaving the industry in response to the closure of the feed-in tariff and that 78% were considering reducing staffing levels.[239] The Association also noted that previous changes in the feed-in tariff, to reduce the tariff offered, had led to an estimated 9,000 job losses in the solar panel industry.[240] The Solar Trade Association labelled the delay between the closure of the feed-in tariff scheme and details of any successor programme "a damaging policy hiatus".[241]

71. Since closing the feed-in tariff scheme, the Government has announced that a 'Smart Export Guarantee' scheme would be set up in its place, coming into force from the end of December 2019.[242] Under the scheme, large energy suppliers will be required to offer at least one export tariff scheme to small-scale generators, but would be free to set the form (within the accepted framework) and value of the tariff per kWh supplied (subject to it being always greater than zero).[243] The Government's hope is that such a scheme would foster innovation in the smart energy market, and create the conditions for small-scale

231 Ofgem, 'Feed-in Tariffs Annual Levelisation Process (2017–2018)' (2018)
232 Ofgem, 'Feed-in Tariffs: Essential Guide to Closure of the Scheme' (2019)
233 Department for Business, Energy and Industrial Strategy, 'The Feed-In Tariffs Scheme' (2018), para 4
234 Department for Business, Energy and Industrial Strategy, 'The Feed-In Tariffs Scheme' (2018), para 14
235 'Proposals to protect consumers whilst guaranteeing payments for households with solar by unlocking smarter energy system', Department for Business, Energy and Industrial Strategy, accessed 7 June 2019
236 Solar Trade Association (CGE0053), para 6
237 Solar Trade Association (CGE0053), para 3
238 Department for Business, Energy and Industrial Strategy, 'The Feed-In Tariffs Scheme' (2018), para 10
239 Renewable Energy Association, 'New data shows significant solar job losses if full Government proposals enacted' (2018)
240 Renewable Energy Association, 'New data shows significant solar job losses if full Government proposals enacted' (2018)
241 'MPs back solar industry call for fair market payment', Solar Trade Association, accessed 11 June 2019
242 Department for Business, Energy and Industrial Strategy, 'The Future for Small-Scale Low-Carbon Generation: Response to consultations on policy proposals for a Smart Export Guarantee, and on proposed amended licence conditions' (2019), p7
243 Department for Business, Energy and Industrial Strategy, 'The Future for Small-Scale Low-Carbon Generation: Response to consultations on policy proposals for a Smart Export Guarantee, and on proposed amended licence conditions' (2019), p7

generation to be rewarded according to its market value.[244] Notwithstanding its concern with the delay between the closure of the feed-in tariff and the start of the Smart Export Guarantee, the Renewable Energy Association said that it welcomed the new scheme overall as a "positive step towards a more decarbonised, local, and cheaper power system".[245]

72. Certain details of the announced Smart Export Guarantee scheme have, however, caused industry concern. In response to the consultation on the Smart Export Guarantee scheme, the Solar Trade Association highlighted the vulnerability of households operating small-scale generation or storage systems compared to large-scale operators, as well as the potentially limited number of households with smart meters capable of fulfilling the requirements of the Smart Export Guarantee scheme.[246] It argued that, in order to safeguard the small generation market, the Government should set a "fair minimum export floor price". Dr Nina Skorupska, Chief Executive of the Renewable Energy Association, similarly told us that her Association was advocating a "framework that makes sense from a market perspective but also makes sense for a consumer or developer", and indicated that this would require a "minimum index-linked safe tariff".[247] Professor Keith Bell, co-Director of the UK Energy Research Centre, also told us that "some kind of minimum export price would be extremely useful", but accepted that "there is a bit of work to do to define what that would be".[248] In addition to advocating a minimum export price, Dr Skorupska has also said that "minimum contract lengths should be required to give future generators certainty".[249] The Durham Energy Institute also told us that the new scheme should be "guaranteed over a sufficiently long time frame to ensure that continuity, consistency and clarity releases private investment".[250]

73. In its confirmation of the Smart Export Guarantee scheme in June 2019, the Government stated that Ofgem would report annually on the uptake and nature of tariffs offered and committed itself to "monitor[ing] whether the market is delivering an effective range of options for small exporters".[251] It also commented that "since the closure of the feed-in tariff scheme, there have been encouraging early signs that a nascent export market is developing":

> Some suppliers are offering or trialling export tariffs, either in line with the wholesale price or at levels comparable with the feed-in tariff export tariff

244 Department for Business, Energy and Industrial Strategy, 'The Future for Small-Scale Low-Carbon Generation: Response to consultations on policy proposals for a Smart Export Guarantee, and on proposed amended licence conditions' (2019), p8

245 'Government confirms details and timeline for a Smart Export Guarantee', Renewable Energy Association, accessed 11 June 2019

246 Solar Trade Association, 'The Future for Small-Scale Low Carbon Generation: A Consultation on a Smart Export Guarantee—Response on behalf of the Solar Trade Association' (2019)

247 Q282

248 Q282

249 'Government confirms details and timeline for a Smart Export Guarantee', Renewable Energy Association, accessed 11 June 2019

250 Durham Energy Institute (CGE0065), para 31

251 Department for Business, Energy and Industrial Strategy, 'The Future for Small-Scale Low-Carbon Generation: Response to consultations on policy proposals for a Smart Export Guarantee, and on proposed amended licence conditions' (2019), p7

> rate. We believe that these encouraging signals show that suppliers are keen to engage in this market and meaningful and competitive offerings will come through, without government taking the role of price setting.[252]

These are, however, only early signs. The Solar Trade Association is monitoring the emergence of supplier offers for small-scale generators and so far lists just two offers from one supplier, alongside small-scale trials from two other suppliers.[253]

74. **The delay between the end of the feed-in tariff scheme and the start of the Smart Export Guarantee scheme has caused unnecessary disruption to the smart energy and small-scale generation market. Nonetheless, the move towards a framework that facilitates greater flexibility and innovation in these markets is welcome, provided it offers a fair and sufficient means of compensation for owners of small-scale renewable generation capacity and a sufficient incentive for people to make the initial investment in such technologies. *The Government must ensure that it reviews the functioning of the Smart Export Guarantee scheme by the end of 2020, and should be ready to include a minimum price floor if there is evidence of a lack of market competitivity—for example, if uptake of tariffs is not significantly greater than the current number of tariffs or if the tariffs offered are significantly lower than wholesale electricity prices.***

Business rates

75. The Solar Trade Association additionally told us that its "industry has been further dismayed by the continuation of discriminatory business rate treatment of rooftop solar [power]".[254] In 2017, the Valuation Office Agency (an executive agency sponsored by HM Revenues and Customs) revised the methodology it applied to determine the rates applied to solar power, because the technology was more established than it had been at the previous valuation.[255] This led to a sharp increase in rates, from between threefold to eightfold, for some solar power generation owners including schools and hospitals.[256] The Solar Trade Association has since negotiated reduced business rates for companies that sell the majority of the solar power they generate, but this reduction does not apply to organisations that consume what they generate themselves (despite the potential for this to be more efficient, since no electricity transmission is required).[257] Consequently, the Association now provides guidance on how companies can establish 'special purpose vehicles' so that their panels are legally distinct entities from which they can then 'buy' their electricity.[258] A spokesman for the Association has reportedly said that "firms are circumnavigating the rates by doing this, but it is administratively expensive".[259] Additionally, an exemption from business rates for microgeneration sites (those producing no more than 50kW) ended

252 Department for Business, Energy and Industrial Strategy, 'The Future for Small-Scale Low-Carbon Generation: Response to consultations on policy proposals for a Smart Export Guarantee, and on proposed amended licence conditions' (2019), p15
253 'Smart Export Guarantee League Table', Solar Trade Association, accessed 11 June 2019
254 Solar Trade Association (CGE0053), para 4
255 Solar Trade Association, 'The 2017 business rates revaluation: impact on self-owned commercial rooftop solar PV' (2016)
256 Solar Trade Association, 'Briefing: Solar Business Rates Changes'
257 Solar Trade Association and Valuation Office Agency, 'Photovoltaic Memorandum of Agreement: Revaluation 2017' (2016)
258 Solar Trade Association, 'Minimising business rates impact for rooftop solar installations in England and Wales: SPV toolkit' (2017)
259 'Rates shock for green innovators', Lombard, accessed 11 June 2019

on 31 March 2017.[260] The Solar Trade Association has called for rooftop solar panels to be classed as "excepted plant and machinery" under the business rate regulations,[261] to match the exception already applied to combined heat and power units.[262]

76. **The Government must make sure that business rates incentivise embedded low-carbon generation and do not cause existing embedded generation to be disconnected.** ***The Government should reduce business rates for organisations that consume the majority of the power they generate to match the rates of organisations that sell the majority of their generation—and stop the administrative burden of loopholes that are being used to counter the discrepancy in rates. The Government should also reinstate the microgeneration exemption from business rates for renewable energy installations producing no more than 50kW. In its response to this Report, the Government should set out why combined heat and power units have been classed as excepted plant and machinery under the business rate regulations, but such a provision is not applied to solar panels and energy storage systems.***

Network charge reforms

77. Despite discussion of the closure of the feed-in tariff and the business rate rises, Dr Skorupska, Chief Executive of the Renewable Energy Association, told us that "the biggest challenge to small-scale renewables are the grid reforms".[263] This refers to Ofgem's proposals to change how the costs of electricity networks are recovered (see Box 2). This has been prompted by Ofgem's concern that "the current framework for residual charging may result in inefficient use of the networks":

> As a result of changes in technology and other factors, some network users are increasingly able to adjust the timing and volume of their production and/or consumption of electricity, reducing their exposure to charges. Therefore current residual charges will increasingly fall on those network users who are not able to do this. Those who are less likely to be able to adjust their consumption are likely to include residential and small business consumers in general and more vulnerable consumers in particular.[264]

Ofgem has therefore proposed introducing a fixed charge so that consumers pay only according to their 'customer segment' rather than the extent to which they use the network.[265] In addition to protecting vulnerable consumers, Ofgem has argued that this could save consumers £0.5–1.6bn by 2040.[266]

260 The Valuation for Rating (Plant and Machinery) (England) (Amendment) Regulations 2008 (SI 2008/2332)
261 Solar Trade Association, 'Budget Briefing' (2017)
262 The Valuation for Rating (Plant and Machinery) (England) (Amendment) Regulations 2001 (SI 2001/846)
263 Q282
264 Open letter from Ofgem, 4 August 2017
265 Ofgem, 'Targeted charging review: minded to decision and draft impact assessment' (2018)
266 Ofgem, 'Targeted charging review: minded to decision and draft impact assessment' (2018), pp5–6

Box 2: Network costs

The costs associated with building, maintaining and operating electricity networks are currently recovered through two main charges levied on electricity consumers (through their bills): 'forward-looking charges'; and 'residual charges'.

Forward-looking charges are based on projected use of the network whereas **residual charges** are applied retrospectively to recover any costs not recovered through forward-looking charges. The overall costs, incorporating both components, are determined through Ofgem's price controls, which set the total revenue the network companies are allowed to earn.

Ofgem has said that "residual charges are not intended to send signals or provide incentives to use networks in any particular way", which is instead the role of the forward-looking charges.

Source: Ofgem, 'Targeted charging review: minded to decision and draft impact assessment' (2018)

78. The Solar Trade Association has warned, however, that "a flat, fixed rate will dampen the price signal sent to consumers to encourage the uptake of technologies, products and behaviours that encourage flexibility".[267] Following the publication of Ofgem's proposals, six relevant trade associations, including the Renewable Energy Association and the Association for Decentralised Energy, issued a joint statement arguing that the proposals ran "contradictory to Government's ambition to decarbonise the energy system and create a market for flexibility".[268] Ofgem itself has estimated that the average domestic consumer using solar power with energy storage could see network charges increase from £25 per year to £64 per year, while small- to medium-sized enterprises using on-site generation and storage could see charges increase from £204 per year to £1,099 per year.[269]

79. **Ofgem must consider the interests of future consumers as well as current consumers in its decisions, including the need for decarbonisation. The projected increases in network costs for consumers and businesses that have installed on-site generation and flexibility technologies, arising from Ofgem's proposed network charging reforms, will act as a disincentive for further consumers or enterprises to install similar technologies. This is not conducive to the overall goal of decarbonisation. However, Ofgem is right to seek to avoid the costs of network usage falling increasingly on vulnerable consumers. *Ofgem must revise its proposed network charging reforms to ensure that they do not disincentivise the deployment of technologies that will contribute to the decarbonisation of the UK's energy system. The Government must ensure that vulnerable consumers do not pay an increasing proportion of network costs, and that all households have the ability to deploy technologies that will reduce their cost of energy and help to decarbonise the economy.***

267 Solar Trade Association, 'Press Release: United against the TCR', 6 February 2019

268 Letter from BEAMA, Association for Decentralised Energy, techUK, Renewable Energy Association, Solar Trade Association and RenewableUK to Rt Hon Greg Clark, 4 February 2019

269 Ofgem, 'Targeted charging review: minded to decision and draft impact assessment' (2018), p47

Nuclear power

Conventional nuclear power

80. The Intergovernmental Panel on Climate Change has estimated that the full lifecycle emissions associated with nuclear power are significantly lower than coal or gas power, less than solar power and comparable to wind power.[270] In 2017, nuclear power accounted for 21% of the UK's electricity generation.[271]

81. The UK currently has eight nuclear power plants, of which seven are planned to close by 2030.[272] These seven have a generation capacity of 7.7GW, or 87% of existing nuclear capacity.[273] One new plant, at Hinkley Point in Somerset, is currently under construction, which should provide 3.2GW of capacity by 2025.[274] There are proposals for new plants at Sizewell, in Suffolk, and at Bradwell, in Essex, which would be expected to provide a further 3.2GW and 2.3GW of generation capacity respectively.[275] However, plans for new reactors at Moorside, in Cumbria, Wylfa, in Anglesey, and Oldbury, in Gloucestershire, have reportedly been recently suspended.[276] The Minister for Energy and Clean Growth, Claire Perry MP, explained that:

> You have to spend taxpayers' money wisely. Given the precipitous decline [in costs], particularly in other renewable technologies, it became apparent that some of the financial proposals put forward for Wylfa in particular were just not good value for money, but those negotiations and conversations continue.[277]

The National Infrastructure Commission estimated in 2018 that the "average cost of the electricity system as a whole between 2030 and 2050 is broadly comparable between investing heavily in nuclear power stations or investing heavily in renewables".[278] However, it noted that whereas cost-reductions for renewable power technologies have had a track record of outperforming expectations, nuclear power costs have displayed "no discernible trend in construction costs over time". This appears to be substantiated by historic evidence.[279] Dr Robert Gross, co-Director of the UK Energy Research Centre, similarly told us that there was no evidence of cost reductions in nuclear power outside of East

270 Intergovernmental Panel on Climate Change, 'Climate Change 2014: Mitigation of Climate Change—Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change' (2014), p539
271 Department for Business, Energy and Industrial Strategy, 'Digest of United Kingdom Energy Statistics 2018' (2018), p117
272 'Country Nuclear Power Profiles: United Kingdom', International Atomic Energy Agency, accessed 12 June 2019
273 'Country Nuclear Power Profiles: United Kingdom', International Atomic Energy Agency, accessed 12 June 2019
274 'About Hinkley Point C', EDF Energy, accessed 12 June 2019
275 'Sizewell C proposals', EDF Energy and 'Bradwell B Project Website', CGN and EDF Energy, both accessed 12 June 2019
276 'Toshiba's UK withdrawal puts Cumbria nuclear plant in doubt', BBC News, 8 November 2018 and 'Nuclear plant in Anglesey suspended by Hitachi', BBC News, 17 January 2019
277 Q441
278 National Infrastructure Commission, 'National Infrastructure Assessment' (2018), p36
279 J. Lovering *et al.*, 'Historical construction costs of global nuclear power reactors', Energy Policy vol 91 (2016)

Asia.[280] Looking forward, however, the Energy Systems Catapult told us that "UK nuclear new build has very significant cost reduction potential",[281] provided that the Government could work with stakeholders to provide "schedule and budget certainty".[282]

82. Tom Greatrex, Chief Executive of the Nuclear Industry Association, told us that "it is the cost of capital that has the biggest single impact" on the cost of nuclear power, and said that the viability of future nuclear projects would be "determined largely by how much progress is made on adopting a more appropriate financing model".[283] In November 2018, the Secretary of State for Business, Energy and Industrial Strategy, Greg Clark MP, said that the Government was exploring alternative financing models for new nuclear plants.[284] In particular, he mentioned a 'Regulated Asset Base' model, which would provide a return to investors determined by an independent regulator (see Box 3). Professor Dieter Helm, of Oxford University, has said that such a model was "second best" behind direct Government procurement, but accepted that since direct procurement was essentially "ruled out by the Treasury imposed constraints", the Regulated Asset Base model was "both plausible and preferable to the Hinkley model" (the main alternative).[285] In contrast, the National Infrastructure Commission has cautioned that "there is limited experience of using the regulated asset base model for anything as complex and risky as nuclear [power]" and said that "it is not clear what the best model" for financing new nuclear power projects would be.[286] Dr Gross told us that a new nuclear power station "could be cheaper than Hinkley", but that in order to achieve this the Government would need to "take a public stake in the ownership" of the plant.[287]

Box 3: The Regulated Asset Base model

Under the Regulated Asset Base model, an independent regulator manages the return on investment that investors in the construction of an infrastructure asset receive. This return on investment is recovered from consumers. In the case of a nuclear power station, this would be through consumers' energy bills. Depending upon the details of the model used, investors can start to receive their return on investment during the construction of the power plant. This can increase the attractiveness to investors, who currently must invest many years before the plant will start generating power and therefore income. Different models either involve investors accepting all of the risks of the project not being completed (in return for a greater return on investment) or the risk being shared between investors and consumers. A Regulated Asset Base model has been used to fund construction of the Thames Tideway Tunnel project.

Sources: National Audit Office, 'Hinkley Point C' (2017), Appendix 4; Professor Helm, 'The Nuclear RAB Model', Energy Futures Network Paper 27 (2018); and National Audit Office, 'Review of the Thames Tideway Tunnel' (2017)

280 Qq275–276
281 Energy Systems Catapult (CGE0029), para 24
282 Energy Technologies Institute, 'The ETI Nuclear Cost Drivers Project: Summary Report' (2018)
283 Qq238 and 271
284 'After the trilemma—4 principles for the power sector', speech by Rt Hon Greg Clark MP, 15 November 2018
285 Professor Helm, 'The Nuclear RAB Model', Energy Futures Network Paper 27 (2018)—the "Hinkley model" refers to the financing used for Hinkley Point C, the main element of which was a contract for difference agreed directly between the Government and the NNB Generation Company that developed the power station, see: National Audit Office, 'Hinkley Point C' (2017), paras 1.2–1.5
286 National Infrastructure Commission, 'National Infrastructure Assessment' (2018), p38
287 Q281

83. The Secretary of State for Business, Energy and Industrial Strategy told Parliament in January 2019 that the Government intended to publish its assessment of the Regulated Asset Base model for new nuclear power projects "by the summer at the latest".[288] Tom Greatrex told us that there was "real urgency" in the need for a decision from the Government on future financing models for nuclear power,[289] and highlighted one timepoint in particular:

> There is a point at which you can, in a relatively straightforward way, transfer the supply chain [from Hinkley to Sizewell] and use the same equipment while the supply chain is in place. That means EDF needs to make a final investment decision, probably in 2021–22, so that needs a policy framework in the next year or so to be able to be in a sufficiently strong position to deliver that project, get the maximum cost reduction and make that contribution to help replace the fleet, most of which is going off by 2030.[290]

This aligns with the National Infrastructure Commission's recommended "one by one" approach to new nuclear plants, in which the UK seeks to maintain—but not grow—its nuclear industry and supply chains, by planning to be building no more than one new nuclear plant at a time.[291]

84. **Although it is not possible to directly compare the costs of different power generation technologies, the Government is right to support nuclear power subject to it representing value for money, because full lifecycle emissions from nuclear power will help the UK to achieve its emissions reduction targets.** ***The Government must make a decision on implementing a regulated asset base framework for nuclear power by the end of this year. Subject to value for money, the Government should seek to support new nuclear power generation so as to sustain, but not grow, the UK's nuclear power industry. It must anticipate any gap in future generation capacity such a policy would cause, and support sufficient renewable power alternatives to fill the gap.***

Small modular nuclear reactors

85. Small modular nuclear reactors (SMRs) are made of standardised factory-manufactured parts delivered ready for assembly,[292] although Tom Greatrex clarified that "SMRs are used as a catch-all term for a whole range of different technologies".[293] SMRs may offer nuclear power at lower cost than conventional nuclear power plants because of their amenability to mass manufacture, as a result of their size and standardisation. Rolls-Royce, a major developer of SMRs, told us that these reactors "offer a convincing alternative to the uncertainties of large nuclear new build in the UK" and said that it was "prepared to invest in [an SMR development] programme, if matched by Government support".[294]

288 Rt Hon Greg Clark MP, 'Statement on suspension of work on the Wylfa Newydd nuclear project', 17 January 2019
289 Q238
290 Q278
291 National Infrastructure Commission, 'National Infrastructure Assessment' (2018), p39
292 'Small Modular Nuclear Reactors', POSTnote 580, Parliamentary Office of Science and Technology, July 2018
293 Q273
294 Rolls-Royce Plc (CGE0039), Executive Summary and paras 1.4–1.6

86. The Government's 'Expert Finance Working Group on Small Nuclear Reactors' recently concluded that the UK "could be well placed to develop first-of-a-kind small reactors projects".[295] It made seven recommendations for Government action to support development of SMRs in the UK, including:

- providing resources for 'first of a kind' demonstrator projects, in exchange for intellectual property and other rights that "investors would expect";
- working with stakeholders from the energy, nuclear and finance sectors to develop a common understanding of the risks associated with SMR projects, to remove perceptions of risks that have so far acted as barriers to investment;
- establishing an advanced manufacturing supply chain initiative for SMRs, similar to the initiative launched for offshore wind; and
- developing nuclear regulations adapted to SMRs.[296]

87. One component of the Government's Nuclear Sector Deal was a new framework for SMRs, with the Government providing up to £56m to support the research and development of advanced nuclear technologies and stating its intention to "bring together vendors, utilities, energy intensive users and the finance sector to further develop credible commercial propositions that could be financed by the private sector" in response to the Expert Finance Working Group's recommendations for developing first-of-a-kind projects.[297] Tom Greatrex indicated that "the whole range" of recommendations from the Expert Finance Working Group "need to be implemented if [the UK wants] to try to have the opportunity of small modular reactors".[298]

88. **The Government's support for small modular nuclear reactors in the Nuclear Sector Deal is welcome.** ***The Government must ensure that it delivers on the recommendations from the Expert Finance Working Group on Small Nuclear Reactors, including on regulatory developments, without undue delay. The Government should set out, in its response to this Report, what steps it has taken since the publication of the Group's report and propose a pathway—with indicative dates for key milestones—for the deployment of a first-of-a-kind small modular nuclear reactor by 2030.***

Nuclear fusion

89. Conventional nuclear power and small modular nuclear reactors generate power from nuclear fission, which is the separation of heavy elements into lighter ones.[299] An alternative is to generate power from nuclear fusion, which is the production of heavier elements from light ones.[300] Tokamak Energy Ltd described the following benefits of nuclear fusion:

295 Expert Finance Working Group on Small Nuclear Reactors, 'Market framework for financing small nuclear' (2018), p4
296 Expert Finance Working Group on Small Nuclear Reactors, 'Market framework for financing small nuclear' (2018), p5
297 HM Government, 'Industrial Strategy: Nuclear Sector Deal' (2018), pp21–23
298 Q274
299 'New Nuclear Power Technologies', POSTnote 457, Parliamentary Office of Science and Technology, February 2014
300 'Nuclear Fusion', POSTnote 192, Parliamentary Office of Science and Technology, January 2003

> Fusion energy from tokamaks will be clean and safe. There is no emission of carbon from combustion, no long-lived radioactive waste and no risk of meltdown or proliferation. There is plentiful fuel for mankind's total needs for millennia.[301]

Professor Jim Skea, of Imperial College London, told us however that the "problem" with nuclear fusion was that "while fusion has stayed 30 or 40 years in the future, other things like nuclear fission and renewable energy have achieved that kind of goal in the shorter term".[302] The Engineering and Physical Sciences Research Council has said that although "the timeline for delivery is beyond the 2050 emission target, fusion is an attractive technology that needs to be developed".[303]

90. The UK has a national nuclear fusion programme at the Culham Centre for Fusion Energy, which also hosts the Joint European Torus (currently the most powerful magnetic fusion device in the world) on behalf of the EUROfusion consortium funded as part of EURATOM 2020.[304] Both programmes receive funding from the EU under the EURATOM treaty. The Government confirmed in 2017 its intention to leave EURATOM as it leaves the EU.[305] The Government signed an agreement with the European Commission in March 2019 to keep the Joint European Torus open until the end of 2020, securing at least €100m in additional inward investment from the EU.[306]

91. Tokamak Energy Ltd, which aims to accelerate the development and deployment of fusion energy, told us that it had now attracted over £50m of private investment but argued that the Government should "do more to encourage stronger private investment in fusion energy development", flagging recent developments in the USA:

> The US Nuclear Energy Innovation and Modernization Act (NEIMA) was passed in January 2019. It explicitly includes fusion in the definition of "advanced nuclear reactor" and provides for establishment of a regulatory framework for advanced nuclear power plants, including fusion, by December 2027.[307]

Acknowledging the UK Atomic Energy Authority's recently announced 'Spherical Tokamak for Energy Production' project that aims to design and build a compact fusion power station in the UK by 2040,[308] Tokamak Energy Ltd nevertheless argued that the Government should "do more to encourage stronger private investment in fusion energy development, for example by matching some of the legislative and policy measures used in the USA to encourage private ventures to develop fusion technology and future fusion power plants".[309]

301 Tokamak Energy Ltd (CGE0004), para 3
302 Q408
303 'Fusion', Engineering and Physical Sciences Research Council, accessed 9 July 2019
304 'Culham Centre for Fusion Energy', Culham Centre for Fusion Energy, accessed 9 July 2019
305 European Union (Notification of Withdrawal) Act 2017, section 1 and HM Government, 'Explanatory Notes: European Union (Notification of Withdrawal) Act 2017' (2017), chapter 9
306 'Future of JET secured with new European contract', Department for Business, Energy and Industrial Strategy, accessed 9 July 2019
307 Tokamak Energy Ltd (CGE0075), para 5
308 'Spherical Tokamak opportunities', Nuclear Advanced Manufacturing Research Centre, accessed 9 July 2019
309 Tokamak Energy Ltd (CGE0075), paras 6 and 9–11

92. **Nuclear fusion is unlikely to make a substantial contribution to the UK's net-zero target for 2050. Nevertheless, it could ultimately provide significant quantities of energy from abundant fuels and without radioactive waste.** ***The Government must ensure that, whatever the terms of the UK's departure from the European Union, the long-term future of nuclear fusion research in the UK is not disrupted. It should additionally review the case for providing support for the nuclear fusion industry similar to the measures introduced recently by the US Government.***

5 Decarbonising transport

93. Domestic transport (i.e. excluding international aviation and shipping originating or arriving in the UK) was responsible for around 27% of the UK's territorial greenhouse gas emissions in 2018.[310] It was the only major sector of the UK energy system to have increasing emissions over the course of the last carbon budget.[311] The Committee on Climate Change stated in 2018 that the transport sector was "significantly off-track from the cost-effective path" for meeting the UK's emissions targets.[312] In this Chapter we, focus on emissions from road transport, and the targets and policies the Government should adopt to help to decarbonise the UK's road transport system.

Internal combustion engine vehicles

Fiscal incentives

94. The Committee on Climate Change has suggested that the main reason for the recent increase in transport emissions has been growing demand for car and van travel combined with slowing efficiency gains.[313] This is borne out by statistics published by the Department for Transport in 2018, which showed that the distances driven in cars and vans, and overall emissions from cars and vans, have both been steadily growing since 2013.[314] This is despite the fact that, according to the Centre for Research into Energy Demand Solutions, there "remains substantial potential for improvement" in the efficiency of conventional cars and vans in the "short to medium term".[315] The Society of Motor Manufacturers and Traders told us that average new car emissions in the UK rose by 0.8% from 2016 to 2017, the first rise in emissions on record.[316] It estimated that 55% of this was attributable to consumers buying less efficient models and 45% to consumers switching from diesel to petrol cars. For example, registrations of superminis fell 14.3% from 2016 to 2017, while registrations of SUVs grew 5.1%.[317] In its 2018 progress report to Parliament, the Committee on Climate Change recommended that the Government implement stronger fiscal incentives to encourage consumers to buy lower emitting vehicles.[318]

95. Car owners must currently pay vehicle excise duty, which varies by carbon emissions and fuel type.[319] When the car is registered, the duty applied covers a spectrum from £0 to £2,135 according to fuel type and emissions. However, from the second year onwards the standard rate is £145, £135 or £0 for petrol and diesel cars, 'alternative fuel' cars, and fully electric cars respectively.[320] Although these rates favour vehicles with lower emissions,

310 Department for Business, Energy and Industrial Strategy, '2018 UK Greenhouse Gas Emissions, Provisional Figures' (2019), p6
311 Committee on Climate Change, '2018 Progress Report to Parliament', p16
312 Committee on Climate Change, '2018 Progress Report to Parliament', p147
313 Committee on Climate Change, '2018 Progress Report to Parliament', p147
314 Department for Transport, 'Transport Statistics: Great Britain 2018' (2018), pp4 and 8
315 Centre for Research into Energy Demand Solutions (CGE0070), para 15
316 Society of Motor Manufacturers and Traders (CGE0030), para 10
317 Society of Motor Manufacturers and Traders, 'New Car CO2 Report 2018' (2018), p5—the average new SUV emits 27.6% more carbon dioxide per km than the average new supermini
318 Committee on Climate Change, '2018 Progress Report to Parliament', p176
319 'Vehicle tax rates', HM Government, accessed 18 April 2019
320 'Vehicle tax rates', HM Government, accessed 18 April 2019—alternative fuel vehicles include hybrids and those that run on bioethanol and liquid petroleum gas

Andy Eastlake, Managing Director of the Low Carbon Vehicle Partnership, told us that he thought the Government had "undermined the use of vehicle excise duty as a tool in driving CO_2 behaviour":

> There is significant CO_2-related vehicle excise duty in the first year. Very few people see that because it is wrapped up in the price of their vehicle or their lease. Eighty-five per cent of vehicles are financed in some way; these days, not many people buy a vehicle with cash. The used car market is where vehicle excise duty potentially has more power and capability, and now there is a flat-rate vehicle excise duty for anything other than a zero-emission electric vehicle.[321]

96. **There is significant scope for emissions reductions in the transport sector as a result of the purchase of more efficient vehicle models, without requiring technological developments or alternative fuel sources. However, the current fiscal incentives for cars are not sufficient to encourage consumers to purchase lower-emissions vehicles, given that most of the increase in average new car emissions in 2017 was caused by consumers choosing more emitting models. *The Government must reconsider the fiscal incentives for consumers to purchase both new and used vehicle models with lower emissions, and develop a strategy by the time of the Spring Statement 2020 to use vehicle excise duty and other incentives to drive the purchase of vehicle models with lower average emissions. This must include consideration of post-sales vehicle excise duty and the second-hand market.***

Emissions regulations

97. Under EU law, the UK currently has legislation setting maximum average emissions standards for cars and vans.[322] This aims for average car emissions to drop to 95g of CO_2 per km by 2020 (compared to 161gCO_2/km in 2006). The EU has recently agreed new standards requiring a further reduction on 2021 levels of 15% by 2025 and 37.5% by 2030.[323] These will come into force on 1 January 2020. This is after the UK's scheduled departure from the EU, meaning that the standards would not automatically be incorporated into UK law on exit day.[324] The European Parliament has also approved the European Commission's proposals for new legislation regarding emissions from heavy-duty vehicles.[325] This would require a 15% reduction in average new truck emissions by 2025 and a 30% reduction by 2030 compared to 2019.[326] The Government informed us that since "new heavy duty vehicle CO2 regulation has yet to be finalised and adopted by the EU", its implementation in the UK "will depend on when this is achieved and the terms on which the UK leaves the EU".[327] Prior to the EU's new standards being agreed, the UK Government stated that, in

321 Q123—with tax rates of £145 applied to petrol and diesel cars and £135 applied to hybrid cars or those powered by bioethanol and liquid petroleum gas, there is not strictly speaking a "flat rate" duty for all cars other than a zero-emission vehicle

322 Council and Parliament Regulation (EU) No 333/2014 and Council and Parliament Regulation (EU) No 510/2011

323 Council and Parliament Regulation (EU) 2019/631—these standards will be weakened slightly for manufacturers whose new car sales are at least 35% zero- or low-emission by 2030

324 European Union (Withdrawal) Act 2018, section 3

325 European Parliament, 'Results of Plenary votes', 18 April 2019

326 European Parliament, 'CO2 emission standards for heavy-duty vehicles' (2019)

327 Department for Transport (CGE0088)

the context of Brexit, it "will pursue a future approach to vehicle emissions regulation that is at least as ambitious as the current arrangements",[328] but it is not clear whether or not this commitment applies to regulations that the EU has since agreed.

98. ***The Government must commit, prior to the UK's withdrawal from the European Union, to adopting transport emissions regulations that are, as a minimum, in line with current and future EU regulations on transport emissions. This should include legislation regarding emissions reductions requirements for heavy duty vehicles, regardless of the terms of the UK's departure from the EU.***

Ultra-low emissions vehicles

The Government's targets

99. The Government's stated long-term ambitions for decarbonising road transport are for:

- between 50% and 70% of new car sales and "up to 40%" of new van sales being ultra-low emission by 2030;[329]
- no sales of new conventional petrol and diesel cars and vans by 2040; and
- "almost every car and van" to be zero emission by 2050.[330]

The Government has said that "the 2040 ambition is consistent with [the UK's original overall decarbonisation] target" (to achieve 80% decarbonisation compared to 1990, by 2050).[331] However, Professor Jim Watson, Director of the UK Energy Research Centre, told us that "the 2040 target for phasing out fossil vehicles is just not ambitious enough".[332] Modelling undertaken by the UK Energy Research Centre projected that a 2040 ban "may neither hit the [original 2050 emissions reductions] target nor make the early gains needed for a 1.5°C trajectory".[333] Instead, it suggested that a 2040 ban would have to include hybrid as well as conventional cars in order to meet the UK's existing targets, and that this ban would have to be brought forward to 2030 in order to align with a pathway to 1.5°C global warming.[334] Lord Deben, Chairman of the Committee on Climate Change, similarly told us that if the Government did "not bring those dates forward, the contribution that is necessary from the electrification of motor vehicles will not be sufficient to meet the requirements of the budgets".[335] We heard from several other witnesses who also advocated an earlier ban.[336] The Committee on Climate Change has recommended that the Government's planned ban both be brought forward, to "2035

328 HM Government, 'Delivering Clean Growth: Progress Against Meeting Our Carbon Budgets—The Government Response to the Committee on Climate Change' (2018), p45

329 The Office for Low Emission Vehicles currently defines an 'ultra low emission vehicle' to be one that emits less than 75g of carbon dioxide from the tailpipe per kilometre driven measured against the European test cycle; the Government has said that it "expect[s]" to tighten this criterion to 50g from 2021—Department for Transport, 'Road to Zero' (2018), p24

330 Department for Transport, 'The Road to Zero' (2018), p2

331 Department for Transport (CGE0088)

332 Q79

333 UK Energy Research Centre, 'Review of Energy Policy: 2018' (2018), p8

334 C. Brand and J. Anable, ''Disruption' and 'continuity' in transport energy systems: the case of the ban on new conventional fossil fuel vehicles', ECEEE Summer Study Proceedings (2019)

335 Q23

336 For example, see: OVO Energy (CGE0007), para 6.6; E.ON (CGE0036), para 35; Qq116 and 118

at the latest", and cover "any car or van with petrol or diesel combustion engines" (*i.e.* including hybrid vehicles).[337] When we asked the Government for the basis on which it disagreed with the Committee on Climate Change and other stakeholders with regards to the date of the ban, it declined to explain.[338]

100. Conversely, the Society of Motor Manufacturers and Traders told us that is was "concerned about the significantly high ambition levels that have been set for the uptake of ultra-low and zero emission cars and vans […] by 2030".[339] However, Professor Watson countered that although "some car manufacturers say that it is terribly difficult […] that is what companies say when faced with something challenging".[340] Indeed, some manufacturers, such as Nissan and Volvo, appear to have set themselves more ambitious targets than the UK's current targets (both are aiming for electric vehicles to make up half of their sales in Japan and Europe by 2025).[341] Numerous countries, including Norway, India, China, Slovenia, Austria, Israel, the Netherlands, Ireland, Denmark and Scotland, also have more ambitious targets than the UK's current targets (with prospective bans starting between 2025 and 2035),[342] undermining the Government's statement to us that it seeks to "maintain the UK's leadership position".[343] Both the UK Energy Research Centre and the Committee on Climate Change have said that an earlier ban on conventional vehicle sales would deliver not only emissions reductions but also economic benefit to the UK.[344]

101. The Government's ultimate goal is for "almost every car and van" to be zero emission by 2050.[345] In order for this to be consistent with a 2040 target for banning the sales of conventional vehicles, this would require the scrappage of many cars at a maximum age of 10 years. In contrast, the Society of Motor Manufacturers and Traders reports that the current average age of scrappage is 14 years and that this has been rising since 2009.[346] This average age would suggest that a ban by at least 2036 would be required to meet the overall aim of a zero-emission vehicle fleet by 2050.

102. **The Government has said that a 2040 ban on the sale of conventional cars and vans is consistent with the UK's current emissions reductions targets for 2050, but this has been disputed by independent organisations such as the UK Energy Research Centre and the Committee on Climate Change. There is a strong case for bringing the date for a future ban forward, given that several manufacturers already have more ambitious commitments in place. *The Government should act on the advice of the Committee on Climate Change and bring forward the proposed ban on sales of new conventional cars and vans to 2035 at the latest. This ban should explicitly cover hybrid as well as internal combustion engines.***

337 Committee on Climate Change, 'Net Zero: The UK's contribution to stopping global warming' (2019), pp198–200
338 Department for Transport (CGE0088)
339 Society of Motor Manufacturers and Traders (CGE0030), para 5
340 Q80
341 'Nissan aims to sell 1 million electrified vehicles a year by FY2022', Nissan and 'Volvo Cars aims for 50 per cent of sales to be electric by 2025', Volvo, both accessed 10 June 2019
342 Committee on Climate Change, '2018 Progress Report to Parliament' (2018), p167 and 'Denmark embraces electric car revolution with petrol and diesel ban plan', Reuters, 2 October 2018
343 Department for Transport (CGE0088)
344 Q79 and Committee on Climate Change, 'Net Zero: The UK's contribution to stopping global warming' (2019), pp198–200
345 Department for Transport, 'The Road to Zero' (2018), p2
346 Society of Motor Manufacturers and Traders, '2018 UK Automotive Sustainability Report' (2018), p23

Ultra-low emissions vehicle uptake

103. The Committee on Climate Change has determined a pathway of annual electric vehicles sales that it estimates would be indicative of sufficient progress towards the UK's long-term emissions targets.[347] Sales of electric cars are currently falling behind these volumes, with the shortfall growing each year since 2014.[348] Andy Eastlake, Managing Director of the Low Carbon Vehicle Partnership, also warned us that electric vehicle uptake "is not increasing at the rate that we probably need to see to deliver the trajectory defined in the 'Road to Zero' [strategy]".[349] A 2018 survey of British consumers by Deloitte reported the following consumer concerns as barriers to increased uptake of electric vehicles:

- driving range (26% of consumers);
- cost (24%);
- lack of charging infrastructure (22%); and
- the time required to charge (13%).[350]

Other surveys have reported different proportions of consumers for each concern, but found the same concerns.[351] Over time, technological improvements in electric vehicles are expected to improve the range, costs and charging time characteristics.[352] Nevertheless, there is a role for the Government to play in addressing these consumer concerns.[353]

Charging infrastructure

104. Concerns regarding range, charging time and charging infrastructure are all related to the availability of chargepoints. Although the Government has said that the UK has "one of the largest, and most comprehensive rapid [chargepoint] networks in Europe",[354] and is spending £1.5bn on support for zero-emission vehicles,[355] PwC has noted that "public charging infrastructure in the UK […] has not [evolved] at the same rate as the electric vehicle stock".[356] Whereas the number of electric vehicles has grown at close to a 100% compound annual growth rate since 2012, the equivalent rate for the number of chargepoints available has been 44%. Several submissions to our inquiry, including from the Society of Motor Manufacturers and Traders and UK Research and Innovation, argued

347 Committee on Climate Change, '2009 Progress report to Parliament' (2009), p101 and Committee on Climate Change, '2018 Progress Report to Parliament' (2018), Supporting Data Table 5.13

348 Committee on Climate Change, '2018 Progress Report to Parliament' (2018), p166 and Supporting Data Table 5.13; Department for Transport, 'Vehicle Licensing Statistics: Annual 2018' (2019), p1; Committee analysis

349 Q99

350 Deloitte, 'New Market, New Entrants, New Challenges: Battery Electric Vehicles' (2018), p6

351 For example, see: Department for Transport, 'Public attitudes towards electric vehicles: 2016' (2016), p7; and National Franchised Dealers Association (CGE0073), para 23

352 Automotive Council UK, 'The Roadmap Report—Towards 2040: A Guide to Automotive Propulsion Technologies' (2018), p30

353 See, for example: Drax Group plc (CGE0025), paras 13–16; Society of Motor Manufacturers and Traders (CGE0030), para 20; Royal Academy of Engineering and allied institutions (CGE0055), para 6.2

354 Department for Transport, 'Road to Zero' (2018), p90

355 Q435

356 PwC, 'Charging ahead! The need to upscale UK electric vehicle charging infrastructure' (2018), p3

that better charging infrastructure was required to drive uptake of electric vehicles,[357] and the Government itself has stated that "it is clear that […] many more public chargepoints will be needed" and that "the consumer experience of public electric vehicle charging needs to be improved".[358]

105. National Grid identified five types of location that would require chargepoints:

- at home;
- on streets, for those without on-site parking at home;
- at common destinations such as places of work;
- at local fast-charging stations; and
- along the motorway network.[359]

National Grid advised that with just 54 charging stations in total, placed at appropriate points along the strategic road network, 99% of drivers in England and Wales would be within 50 miles of a chargepoint, regardless of the direction in which they were travelling.[360] It estimated that this could be delivered at a cost of £0.8bn, which it said equated to 65p per year, for all registered road vehicles, over the 40-year lifetime of the assets.[361] However, it warned that "investment will be needed by industry and enabled by government":

> Whilst the private sector has ambitions to invest in the 'connection to car' [the chargepoint itself], and we will support the wider grid reinforcement, there is a risk that the 'connection to the grid' [between the chargepoint and the existing grid infrastructure] may not take place until mass market electric vehicle adoption kicks in. Without some targeted intervention in this specific area, there is a risk that the roll-out will not happen fast enough, or with sufficient capacity to be able to meet the needs of the increasing number of cars that will require charging.[362]

National Grid has suggested that the costs for this infrastructure could be recovered either through the private sector charging more for motorway charging, through vehicle excise duty or car tax, from consumers' electricity bills or from general taxation.[363] Highways England has committed £15m to ensure that its users are within 20 miles of a rapid chargepoint along 95% of the strategic road network in England, but as of July 2018 it had only issued grants to two local authorities and received applications from a further four.[364]

357 For example, see: ABB (CGE0010), section 4.0; National Grid (CGE0019), paras 3.11–3.18; Drax Group plc (CGE0025), paras 14–16; Society of Motor Manufacturers and Traders (CGE0030), paras 23–24; Environmental Defense Fund Europe (CGE0042), para 6; ChargePoint (CGE0054), para 4.2; Royal Academy of Engineering and allied institutions (CGE0055), paras 6.2 and 50; UK Research and Innovation (CGE0058), para 9; Durham Energy Institute (CGE0065), para 8; National Franchised Dealers Association (CGE0073), paras 23–29

358 Department for Transport, 'Road to Zero' (2018), p82

359 National Grid (CGE0019), para 3.12

360 National Grid (CGE0019), para 3.13

361 National Grid (CGE0019), para 3.14

362 National Grid (CGE0019), paras 3.17–3.18

363 National Grid, 'Electric vehicle charging: Enabling the switch' (), p5

364 Department for Transport, 'Road to Zero' (2018), p97

106. Several submissions, including from the Royal Academy of Engineering and allied institutions, highlighted the importance of local charging.[365] The Government has set aside £4.5m grant funding for local authorities to deliver on-street charging.[366] The Royal Academy of Engineering and allied institutions told us that "ensuring local authorities take up government funding schemes" would be important to the acceleration of a chargepoint roll-out.[367] Another particular aspect that was commonly raised was the importance of interoperability between different chargepoint networks.[368] The National Franchised Dealers Association told us that of the fourteen major chargepoint networks in the UK, only three were interoperable, which meant that electric vehicle drivers "will likely need a subscription to multiple operators to ensure that they can recharge their cars when travelling longer distances".[369] It pointed to market solutions to this being developed in the USA, and to the 'Open Charge Point Protocol' being developed in the Netherlands, but warned that "there is little sign of a wide-ranging private sector interoperability agreement being implemented in the UK".[370]

107. In its latest review of potential future 'energy scenarios', National Grid stated that all of its possible scenarios "assume strong growth in electric vehicles".[371] Although it anticipated this placing up to 30% extra demand for total energy on the grid by 2050, it estimated that 'smart' charging (where electric vehicles respond to current electricity demand to shift their charging to periods of low demand) could reduce the corresponding increase in peak power demand to just 9%.[372] Ofgem argued that, managed correctly, electric vehicles' potential ability to "act as storage where they are able to export electricity to the grid" at times of peak demand could add flexibility to the UK energy system and assist in its management.[373] EDF Energy cautioned that, in order for this to be the case, it would be "critical to ensure that the majority of electric vehicles are charged smartly for the majority of the time":

> This is an achievable outcome that can be based on technology that is already available. The roll-out of smart meters and half hourly settlement in the domestic sector should facilitate a greater adoption of smart charging. However, while off-peak charging will be cheaper, the convenience of fast charging options, at any time of day, means that a smart outcome for the system as a whole is not guaranteed. Government and stakeholders should therefore continue to promote smart outcomes and technology and monitor progress in this area.[374]

365 For example, see: National Grid (CGE0019), para 3.12; Drax Group plc (CGE0025), para 15 and Royal Academy of Engineering and allied institutions (CGE0055), para 50
366 Department for Transport, 'Road to Zero' (2018), p85
367 Royal Academy of Engineering and allied institutions (CGE0055), para 50
368 For example, see: Society of Motor Manufacturers and Traders (CGE0030), para 24; Royal Academy of Engineering and allied institutions (CGE0055), para 50; National Franchised Dealers Association (CGE0073), paras 24–29
369 National Franchised Dealers Association (CGE0073), paras 24–25
370 National Franchised Dealers Association (CGE0073), paras 26–27
371 National Grid System Operator, 'Future Energy Scenarios' (2018), p72
372 National Grid System Operator, 'Future Energy Scenarios' (2018), p82
373 Ofgem (CGE0033), para 30—similar points were made by, among others: E.ON (CGE0036), para 20; Centre for Research into Energy Demand Solutions (CGE0070), para 21
374 EDF Energy (CGE0020), para 15

108. The Automated and Electric Vehicle Act 2018 introduced powers for the Government to regulate the provision of public electric vehicle charging points and hydrogen refuelling points in order to:

- standardise aspects of these points (such as the components used to connect vehicles to the points, or the payment methods used);
- require large fuel retailers or service area operators to provide refuelling points; and
- require operators of such points to publish and share information regarding the location and current status of those points.[375]

There were also provisions in the Act for the Government to regulate all charge points so that they were 'smart', meaning that they could receive, transmit, process and react to relevant information.[376] In addition to these powers, Tanya Sinclair, Policy Director UK and Ireland for ChargePoint, highlighted powers enabled by the Act to penalise companies whose charging points were unreliable.[377] However, the Government has not yet introduced any regulations permitted by the Act. Ms Sinclair told us that the Government now "need to switch on those powers".[378] The Government indicated to us that it intends to consult on its powers to regulate smart charging "in the coming months with a view to laying the regulations by early next year".[379]

109. **The availability of chargepoints is a significant factor in consumer uptake of electric vehicles. Although the extent of the UK's charging infrastructure is growing, it is not expanding at a pace to match the roll-out of electric vehicles. Interoperability of different chargepoint networks will be required to avoid the need for a roll-out of multiple extensive networks. Widespread adoption of electric vehicles will not necessarily require an unmanageable increase in power generation requirements, but in order for the electricity demand from widespread electric vehicles to be more comfortably met, and in order for electric vehicles to contribute to increased grid flexibility, smart charging will have to be commonplace.**

110. ***The Government must ensure sufficient roll-out of rapid chargepoints along the strategic road network, and smart chargepoints at domestic, destination (such as places of work or shopping centres) and local sites. It should work with public services and owners of public land, such as schools and hospitals, to accelerate the deployment of chargepoints. The Government's forthcoming consultation on the regulation of charging infrastructure must determine measures to deliver interoperability, compatibility with a smart energy system, public availability of real-time information on the current functionality of chargepoints, and enforcement powers to ensure that chargepoints are reliable.***

375 Automated and Electric Vehicles Act 2018, Part 2
376 Automated and Electric Vehicles Act 2018, section 15
377 Q129
378 Q129
379 Department for Transport (CGE0088)

Costs and other sales barriers

111. Electric cars typically have higher upfront costs but lower running costs compared to conventional cars. Deloitte has estimated that the overall cost of owning an electric vehicle would reach parity with conventional vehicles by around 2021–2024;[380] some studies, such as that from Palmer *et al.*, have suggested that the overall costs of electric vehicles can already be lower than conventional vehicles.[381] The Government offers a 'plug-in grant' of £3,500 for vehicles with emissions of less than 50g of carbon dioxide per km and a zero emission range of at least 70 miles.[382] The grant was previously £4,500 and a smaller grant was available for low-emission vehicles with less impressive emissions characteristics, but this was changed in October 2018.[383] The Government explained that this change would "focus our funding on the cleanest vehicles, and ensure that the grant remains sustainable as the UK market for ultra low emission vehicles develops". However, the Society of Motor Manufacturers and Traders told us that the plug-in grant had "been an essential lever" in encouraging the uptake of low-emissions vehicles and said the Government's decision was "a shock to the industry and risks damaging the market and further confusing consumers as to which technology to buy".[384] Since the changes to the Plug-In Grant, overall sales of low-emission cars have fallen for the first time in 26 months (although fully electric vehicles sales have continued to grow),[385] which Mike Hawes, Chief Executive of the Society for Motor Manufacturers and Traders, has described as a "grave concern":

> Manufacturers have invested billions to bring these vehicles to market but their efforts are now being undermined by confusing policies and the premature removal of purchase incentives. If we are to see widespread uptake of these vehicles, which are an essential part of a smooth transition to zero emission transport, we need world-class, long-term incentives and substantial investment in infrastructure.[386]

Prior to the cutback of the grant, the Green Alliance, a charitable environmental think tank, had said that although the Government should "plan to reduce the subsidy per electric vehicle as costs fall", international experience demonstrated that this should be done "according to a transparent formula" to avoid shocks to the market.[387]

112. **It is disappointing that the Government cut back the plug-in grant with electric vehicle sales below the indicative target set by the Committee on Climate Change. *The Government should set out, by the time of the Spring Statement 2020, how it intends to adjust the plug-in grant scheme in the future, using a transparent framework linked to ultra-low emissions vehicles sales.***

380 Deloitte, 'New Market, New Entrants, New Challenges: Battery Electric Vehicles' (2018), p8
381 K. Palmer *et al.*, 'Total cost of ownership and market share for hybrid and electric vehicles in the UK, US and Japan', Applied Energy vol 209 (2018)
382 'Changes to the Plug-in Car Grant', Office for Low Emissions Vehicle, accessed 13 June 2019
383 'Changes to the Plug-in Car Grant', Office for Low Emissions Vehicle, accessed 13 June 2019
384 Society of Motor Manufacturers and Traders (CGE0030), para 20
385 'Bump in the road to zero as low emission car demand reverses in June', Society of Motor Manufacturers and Traders, accessed 4 July 2019—see also monthly registration data published by the Society of Motor Manufacturers and Traders
386 'Bump in the road to zero as low emission car demand reverses in June', Society of Motor Manufacturers and Traders, accessed 4 July 2019
387 Green Alliance, 'How the UK can lead the electric vehicle revolution' (2018), p9

113. In an attempt to reduce the running costs of electric vehicles, the Scottish Government has developed a public network of chargepoints that are mostly free to use, subject to a one-off £20 registration fee.[388] Sales of electric vehicles in Scotland grew by 67% in 2017 compared to 24% in England, but a lower proportion of overall vehicles sales in Scotland were of electric cars than in England.[389] Scotland also has fewer ultra-low emissions vehicles per head than England overall.[390]

114. ***The Government should evaluate the impact of the free charging offered by the ChargePlace Scotland charging network as well as other potential incentive schemes for electric vehicle use.***

115. Almost half of new car registrations in the UK were fleet vehicles (purchased in bulk for uses such as rental cars, company cars or taxis) in 2018.[391] Andy Eastlake, Managing Director of the Low Carbon Vehicle Partnership, highlighted these as a particular target for fiscal incentives, arguing that "it is far more difficult to change an emotional purchase of an SUV for the school run than it is a company for a necessary vehicle for which there are potentially more tools in place that we could use to drive adoption".[392] However, he said that company car taxation had been "significantly disrupted" with recent decisions, noting that 'benefits in kind' tax on a fully electric vehicle would rise to 16% in 2019/20 before falling to 2% in 2020/21.[393] The Government explained this by saying that it wanted to provide long-term certainty by maintaining previously announced rates,[394] although this contrasts with its willingness to change the plug-in grant at short notice.[395]

116. The Green Alliance has also argued that the Government should target the fleet vehicle market—including the Government's own car fleet—given that this sector could more easily offset the high upfront costs of electric vehicles against their low running costs.[396] It specifically recommended that:

- the Government increase its electric vehicle commitment from 25% of the central Government fleet by 2022 to 100% of the central and local government fleets; and
- the Government commit to maintaining zero-rated vehicle excise duty for ultra-low emissions vehicles until 2022, and consider extending it to hybrid vehicles.[397]

The Government has since stated its intention for 100% of the central Government car fleet to be electric by 2030,[398] and announced that it had already reached almost 23%.[399] The European Parliament has approved the European Commission's proposals for new

388 'Electric Vehicles and ChargePlace Scotland', Energy Saving Trust, accessed 13 June 2019
389 Committee on Climate Change, 'Reducing emissions in Scotland: 2018 Progress Report to Parliament' (2018), p59
390 Department for Transport, 'Vehicle licensing statistics: 2018' (2019), Table 0131
391 'Car Registrations', Society of Motor Manufacturers and Traders, accessed 18 April 2019
392 Q127
393 Q125—see also Office for Low Emissions Vehicles, 'Tax benefits for ultra low emission vehicles' (2018), paras 4.1–4.7
394 Business, Energy and Industrial Strategy Committee, Fifteenth Special Report of Session 2017–2019, 'Electric vehicles: driving the transition: Government Response to the Committee's Fourteenth Report of Session 2017–19', HC 1881, p8
395 'Changes to the Plug-in Car Grant', Office for Low Emissions Vehicle, accessed 13 June 2019
396 Green Alliance, 'How the UK can lead the electric vehicle revolution' (2018), p7
397 Green Alliance, 'How the UK can lead the electric vehicle revolution' (2018), p8
398 Department for Transport, 'Road to Zero' (2018), p60
399 'Transport Secretary leads the way in transition to a zero-emission future', Department for Transport, accessed 17 June 2019

legislation regarding the proportion of low-emissions vehicles in publicly-procured fleets of vehicles.[400] This includes a range of measures to promote the public procurement of low-emissions vehicles including minimum proportions of vehicles procured to be low-emissions.[401] We asked the Government if it intended to adopt regulations at least as ambitious as any such regulations adopted by the EU post-Brexit, but it declined to comment.[402]

117. **Uptake of ultra-low emissions vehicles can potentially be driven in the fleet vehicle market more quickly than in the private consumer market. Options for supporting the uptake of ultra-low emissions vehicles in the fleet vehicle market include fiscal incentives and public procurement targets. *The Government should commit to adopting regulations on the public procurement of ultra-low emissions vehicles that are at least as ambitious as the EU's post-Brexit. It should further commit to having a 100% ultra-low emissions vehicle fleet by 2022 and to supporting local authorities in also having 100% ultra-low emissions fleets by 2030.***

118. Alongside cost as a barrier to consumer uptake, the Committee on Climate Change has reported "increasing evidence that production volumes [of electric vehicles] are insufficient, with demand outstripping supply for many models, resulting in long waiting times".[403] The European Federation for Transport and Environment, a sustainable transport advocacy group, has similarly argued that the low take-up of electric vehicles was partly due to manufacturers allocating insufficient resources to meeting demand as well as spending disproportionately little on marketing.[404] Evidence from elsewhere in Europe suggests that car dealers are also dismissive of electric vehicles, misinforming shoppers on vehicle specifications, omitting electric vehicles from the sales conversation and strongly orienting customers towards petrol and diesel vehicle options.[405] The Committee on Climate Change therefore recommended in 2018 that the Government reviewed the electric vehicle market, to "establish whether the willingness of manufacturers and dealers to sell electric vehicles is a barrier to uptake".[406]

119. The Environmental Defense Fund Europe, an environmental non-profit organisation, highlighted ultra-low emissions vehicles sales mandates in China and various US states and recommended that the UK adopt a similar approach.[407] The Green Alliance has also recommended that the UK adopt zero-emissions vehicle sales targets, using a tradeable credit scheme so that manufacturers could sell 'surplus' zero-emissions vehicle sales certificates to competitors.[408] Research in Canada suggested that a mandate on manufacturers to ensure that 30% of their sales were of ultra-low emissions models by 2030 would be achievable and reduce the cost to the Government compared to a consumer-

400 European Parliament, 'Results of Plenary votes', 18 April 2019
401 European Parliament, 'Review of the Clean Vehicles Directive' (2019)
402 Department for Transport (CGE0088)
403 Letter from Lord Deben to Rt Hon Chris Grayling MP and Rt Hon Greg Clark MP, 11 October 2018
404 European Federation for Transport and Environment, 'Carmakers still failing to hit their own goals for sales of electric cars' (2018)
405 G. Zarazua de Rubens *et al.*, 'Dismissive and deceptive car dealerships create barriers to electric vehicle adoption at the point of sale', Nature Energy vol 3 (2018)
406 Letter from Lord Deben to Rt Hon Chris Grayling MP and Rt Hon Greg Clark MP, 11 October 2018
407 Environmental Defense Fund Europe (CGE0042), para 4—see also Bloomberg, 'China Is About to Shake Up the World of Electric Cars', 14 November 2018 and Bloomberg, 'Colorado Joining California in Mandating Electric-Vehicle Sales', 17 January 2019
408 Green Alliance, 'How the UK can lead the electric vehicle revolution' (2018), p9

incentive driven strategy.[409] Although recently adopted EU regulations (see paragraph 97 of this Report) introduced ultra-low emissions sales targets on manufacturers, these targets are voluntary.[410]

120. **One current barrier to the uptake of ultra-low emissions vehicles in the UK is an insufficient supply to meet consumer demand, which has led to long waiting times. There is evidence in the UK and internationally suggesting that this could be partly due to inadequate support for the ultra-low emissions vehicle market from manufacturers and dealers. *The Government should review the functioning of the ultra-low emissions vehicles market annually, to determine if there are sufficient incentives for manufacturers and dealers to drive the adoption of ultra-low emissions vehicles, with the first review published by the time of the Spring Statement 2020. This should include consideration of the value of introducing minimum sales mandates on manufacturers, using tradeable sales certificate framework.***

Heavy goods vehicles

121. Heavy goods vehicles (HGVs) and buses are responsible for around 27% of all road transport emissions.[411] The Government has agreed a voluntary ambition with the HGV industry of reducing emissions across the sector by 15% by 2025, compared to 2015 levels.[412] This is intended to be achieved through a variety of measures such as driver training, the use of aerodynamic equipment and the adoption of more efficient tyres. The Government has not, however, set any longer-term targets for HGVs, in contrast to its targets for cars and vans. The National Infrastructure Commission has recommended that the Government should commit to decarbonising road freight by 2050, and announce plans by the end of 2021 to ban the sale of new diesel-powered HGVs no later than 2040.[413] It described this as a "challenging" but "possible" target, and indicated that a ban on sales of new diesel-powered HGVs by 2040 would be required in order for the whole fleet to be zero-emissions by 2050, in keeping with the Government's overall net-zero emissions targets.[414] This aligns with the average age of HGVs at scrappage, which has rarely fallen below 11 years since at least 2000.[415]

122. There are a variety of different potential technologies that could enable zero-emissions HGVs.[416] Whereas the Committee on Climate Change has said that "battery electric vehicles are now well placed to deliver the bulk of decarbonisation for cars and vans", it is less clear that electrification of HGVs is the optimal technological option.[417] The Royal Academy of Engineering and allied institutions explained that because "batteries have a relatively low power density and long charging time, battery electric heavy duty freight

409 J. Axsen and M. Wolinetz, 'Reaching 30% plug-in vehicle sales by 2030: Modeling incentive and sales mandate strategies in Canada', Transportation Research Part D vol 65 (2018)
410 Council and Parliament Regulation (EU) 2019/631—see also: European Parliament, 'CO2 standards for new cars and vans' (2019)
411 Department for Business, Energy and Industrial Strategy, '2017 UK greenhouse gas emissions: final figures–data tables' (2019)
412 Department for Transport, 'The Road to Zero' (2018), p62
413 National Infrastructure Commission, 'Better Delivery: The Challenge for Freight' (2019), pp29–36
414 National Infrastructure Commission, 'Better Delivery: The Challenge for Freight' (2019), p36
415 Society of Motor Manufacturers and Traders, '2018 UK Automotive Sustainability Report' (2018), p23
416 National Infrastructure Commission, 'Better Delivery: The Challenge for Freight' (2019), pp29–32
417 Committee on Climate Change, 'Hydrogen in a low-carbon economy' (2018), p8

is unlikely to be feasible".[418] However, Andy Eastlake, Managing Director of the Low Carbon Vehicle Partnership, told us that "we have not got to the point where we should be trying to pick a winner".[419]

123. In 2018, the Committee on Climate Change recommended that the Government develop a strategy for decarbonising heavy goods vehicles, which it said would "necessitate small-scale trial deployments of hydrogen HGVs in a variety of fleets prior to [the second half of the 2020s], in the UK or elsewhere".[420] The Government's 'Road to Zero' strategy said that the Government would conduct research into low-emissions technologies for HGVs "with a view to ultimately performing full-scale demonstrator trials on the UK road network if appropriate technologies are identified".[421] However, ULEMCo, a company that converts HGVs to run on hydrogen, told us that it "already supports a fleet of vehicles across a range of hydrogen hubs in the UK", suggesting that Government support could already go beyond early-stage research.[422] In addition to trials of different technologies, the National Infrastructure Commission has recommended that the Government should work with distribution and transmission network operators to "prepare detailed assessments of the infrastructure required to enable the uptake of battery electric or hydrogen HGVs, including the refuelling requirements at depots and key rest areas on major freight routes".[423]

124. **A ban on the sale of new diesel-powered heavy-goods vehicles will be needed by 2040 in order for the sector to achieve net-zero emissions by 2050. This will require policies now that will drive the development of alternative technologies and demonstrate the technical feasibility of such a ban.** ***The Government should introduce a ban on the sale of new diesel-powered heavy goods vehicles, for no later than 2040. It should additionally support trials of low-emissions HGV technologies on a timeframe that aligns with the proposed ban, and work with network operators and the delivery industry to plan for the potential charging infrastructure required for zero-emissions HGVs. Given that some HGVs are already being converted to run on hydrogen on a commercial basis, the Government should review the opportunity for market support mechanisms to drive higher rates of HGV conversion.***

The current and future transport system

125. Andy Eastlake, Managing Director of the Low Carbon Vehicle Partnership, noted that emissions were generated over the full lifecycle of a vehicle, not just as it travels.[424] Indeed, research for the European Parliament estimated that manufacturing accounts for around 23% of an internal combustion engine vehicle's lifetime emissions, and can account for as much as 80% of an electric vehicle's lifetime emissions depending upon the source of the electricity used to charge the vehicle.[425] In addition to the emissions associated with manufacturing, the availability of some of the materials required to make the batteries

418 Royal Academy of Engineering and allied institutions (CGE0055), para 53
419 Q151
420 Committee on Climate Change, 'Hydrogen in a low-carbon economy' (2018), p14
421 Department for Transport, 'The Road to Zero' (2018), p66
422 ULEMCo Ltd (CGE0005), paras 1.3 and 2.2
423 National Infrastructure Commission, 'Better Delivery: The Challenge for Freight' (2019), p36
424 Qq104–109
425 European Parliament, 'Research for TRAN Committee—Battery-powered electric vehicles: market development and lifecycle emissions' (2018), p43

used in electric vehicles has also raised concern (see also Box 4).[426] Mr Eastlake argued that in the long term, "we probably do not want 40 million very large electric cars circulating on our roads in the same way as we have 40 million vehicles currently":[427]

> Our objective is not to have a lot of zero-emission vehicles on the road, but to have zero-emission mobility. That can be delivered through a combination of buses, cars, small L-category vehicles—not the current type—rail and trams. We need to deliver a mobility system, not a fleet of vehicles.[428]

Box 4: Material resources required for electric batteries

Electric vehicle batteries typically require specific materials in their manufacturing, including lithium, cobalt, graphite and nickel. The United States Geological Survey reported in 2019 that, globally, there was an estimated 62m tonnes of lithium, 25m tonnes of cobalt, over 800m tonnes of graphite and at least 130m tonnes of nickel that could be economically extracted (continued resource exploration may well cause these figures to increase over time). Compared to the quantities of these materials used in an average electric vehicle battery, this would equate to the amounts needed for at least 2.3bn cars or around 30 years of the current global car production output. The European Commission has further noted that the recycling potential for electric vehicle batteries is "significant".

The Geological Society warned us, however, that "as it stands, there are no significant lithium or cobalt mines online anywhere in Europe", leaving "many long-term supply questions in the context of a booming industry, unanswered". The European Commission has said that "building up and strengthening EU activity in battery material supply is imperative to reduce the EU's future dependence on imported battery component materials for cell manufacturing".

Amnesty International has additionally noted that more than half of the world's cobalt sources are in the Democratic Republic of the Congo, where mining can be poorly regulated and dangerous, and is frequently carried out by children using hand tools. It has called for greater transparency in supply chains so that the origin of cobalt can be better traced.

Source: The Geological Society (CGE0051), para 6; European Commission, 'Report on Raw Materials for Battery Applications' (2018); United States Geological Survey, 'Mineral Commodity Summaries 2019' (2019); European Parliament, 'Research for TRAN Committee—Battery-powered electric vehicles: market development and lifecycle emissions' (2018), p23; Diekmann *et al.*, 'Ecological Recycling of Lithium-Ion Batteries from Electric Vehicles with Focus on Mechanical Processes', Journal of the Electrochemical Society vol 164 (2017); 'Estimated worldwide automobile production from 2000 to 2018', Statista, accessed 4 July 2019; Amnesty International, 'This Is What We Die For' (2016)

126. The Royal Automobile Club Foundation for Motoring has reported that the average car is parked 96.5% of the time and is in use only 3.5% of the time.[429] There is therefore significant scope to increase the proportion of the time that each vehicle is used, with consequent reductions in the total number of vehicles required and hence the emissions associated with their manufacture. This would require shared ownership or use of vehicles, which the Society of Motor Manufacturers and Traders told us was already how the automotive industry expected urban transport to develop:

426 The Geological Society (CGE0051), para 6
427 Q105
428 Q117
429 Royal Automobile Club Foundation for Motoring, 'Spaced Out: Perspectives on parking policy' (2012), p23

> In recent years, a clear shift from traditional vehicle ownership to usership has emerged. Individual access to vehicles is still generally the preferred option […] However, new technologies, linked to smart phones, etc. have led to a proliferation of pay-as-you-go schemes, such as car clubs or on-demand mobility services. Many automotive companies are recognising this shift and embracing the new opportunities offering their own services or partnering with other service providers.[430]

The Commission on Travel Demand, an independent working group funded by UK Research and Innovation, has also noted recent increases in car-sharing, but reported that this had "yet to lead to any transition away from personal car ownership".[431] Indeed, the number of vehicles per capita in Great Britain has increased by around 5% since the 2012 recession.[432] The Aldersgate Group, an alliance of multiple UK businesses across various sectors, has recommended that:

> The Government should update its procurement framework so that all departments, agencies, local authorities and public bodies investigate whether they can save money and reduce their transport emissions by replacing their fleets with membership of an existing car club scheme.[433]

It noted that Croydon Council had found that it could save on costs and emissions by doing this, with employees having exclusive use of cars in a shared fleet during working hours and the public able to use the cars as part of a car club outside of working hours.[434] The Minister of State for Transport, Michael Ellis MP, told us that reduced congestion through more efficient use of road space, including through ridesharing, was one of nine key principles identified by the Government's 'Future of Mobility Urban Strategy', and said that the Government was "considering whether setting shared mobility targets would be appropriate".[435]

127. One important factor in consumers' decisions to purchase a vehicle or not would be the availability, quality and cost of public transport, alternative options such as walking and cycling, and car share schemes. The Government's Clean Growth Strategy highlighted £37bn of investment in public transport between 2011 and 2016 and listed ambitions to make buses and trains more efficient, but did not specify any ambition or policies for encouraging greater use of public transport.[436] Campaign for Better Transport, a charitable transport campaign group, has noted that funding for supported bus services in England and Wales had fallen by around 45% since 2010.[437] The Government also published a 'Cycling and Walking Investment Strategy' in 2017,[438] and told us that "almost £2bn of investment is projected over this Spending Review period to 2020/21 to increase cycling and walking".[439] However, the Committee on Climate Change has argued that

430 Society of Motor Manufacturers and Traders (CGE0030), para 26
431 Commission on Travel Demand, 'All Change? The future of travel demand and the implications for policy and planning' (2018), p30
432 Department for Transport, 'Vehicle Licensing Statistics: 2013' (2014), p5 and Department for Transport, 'Vehicle Licensing Statistics: Annual 2018' (2019), p9
433 Aldersgate Group, 'Shifting Emissions into Reverse Gear: Priorities for Decarbonising Transport' (2019), pp19–21
434 See also: 'Croydon council cuts employee car usage in half with Zipcar', Zipcar, accessed 9 July 2019
435 Department for Transport (CGE0088)
436 Department for Business, Energy and Industrial Strategy, 'Clean Growth Strategy' (2017), pp83–92
437 'Buses in Crisis, 2018', Campaign for Better Transport, accessed 17 June 2019
438 Department for Transport, 'Cycling and Walking Investment Strategy' (2017)
439 Department for Transport (CGE0088)

"the continued rise in road transport emissions highlights the urgent need for stronger policies to reduce growth in demand for travel".[440] The Government admitted that the estimated impact of all sustainable travel interventions since 2009 was for a reduction in the number of car kilometres travelled per year of just 0.5% by 2021.[441]

128. With regards to influencing travel choices, the relative costs of private and public transport are important. On this front, Andy Eastlake told us that "fuel duty, which has been frozen for over 10 years, is another [policy] that sends a very strong message".[442] Whereas fuel duty has been frozen since 2009, rail prices and bus prices have risen every year over the same period.[443] Although the RAC has questioned whether or not increasing fuel duty would decrease demand given that some consumers might be unable to adapt their transport,[444] a 2014 evidence review found that there was a correlation between fuel duty and car use.[445] Together, the nine previous freezes in fuel duty are estimated to have increased traffic and carbon emissions by 4% (as well as costing the Treasury over £6bn per year).[446]

129. Andy Eastlake highlighted that because electric vehicles do not pay fuel duty, "there is no doubt that, if we deliver on our objectives, that will be a significant hole in Treasury finances", and said that the Government had not articulated how it would address this.[447] Fuel duties raised £27.9bn for the Government in 2017/18.[448] Policy Exchange, a think tank, has calculated that if the UK were to follow the Committee on Climate Change's recommended route to meeting its emissions reductions targets, fuel duty revenues in 2030 would be between £9bn and £23bn lower than the Office for Budget Responsibility has assumed.[449] Several stakeholders, such as the National Infrastructure Commission and the Aldersgate Group, have recommended the introduction of a 'road pricing' system that would use increased vehicle connectivity and other technological developments to monitor road users and charge them according to where and when they drove.[450] Both argued that such a system could help to reduce congestion, support a transition to car usership and incentivise more sustainable travel choices. The Centre for London has suggested that a similar system could be integrated with public transport such as buses and trains, and could promote as well as incentivise sustainable journey options.[451]

130. Tim Lord, Director of Clean Growth at the Department for Business, Energy and Industrial Strategy, told us that the Government understood that instead of replacing conventional cars with electric cars, it had to rethink "how we move around and mak[e]

440 Committee on Climate Change, '2018 Progress Report to Parliament' (2018), p153
441 Department for Transport (CGE0088)
442 Q99
443 Office of Rail and Road, 'Rail Fares Index (January 2019): Statistical Release' (2019), p1 and Department for Transport, 'Annual bus statistics: England 2017/18' (2019), p12
444 'RAC statement on 'The Unintended Consequences of Freezing Fuel Duty' report', RAC Media Centre, 1 June 2018
445 RAND Europe, 'Road traffic demand elasticities' (2014)
446 Greener Journeys, 'The Unintended Consequences of Freezing Fuel Duty' (2018), p7 and Institute for Fiscal Studies, 'Tax and benefit measures' (2017)
447 Q120
448 Office for Budget Responsibility, 'Economic and fiscal outlook: March 2019' (2019), p76
449 Policy Exchange, 'Driving Down Emissions' (2017), p85
450 National Infrastructure Commission, 'National Infrastructure Assessment' (2018), pp119–120 and Aldersgate Group, 'Shifting Emissions into Reverse Gear: Priorities for Decarbonising Transport' (2019), p35—see also Centre for London, 'Green Light: Next Generation Road User Charging for a Healthier, More Liveable, London' (2019)
451 Centre for London, 'Green Light: Next Generation Road User Charging for a Healthier, More Liveable, London' (2019)

sure that we are doing that much more efficiently",[452] highlighting the 'Future of Mobility' grand challenge in the Industrial Strategy.[453] However, the associated 'mission' addressed only the manufacturing and deployment of low-emissions vehicles, not wider changes to the transport system.[454] Furthermore, the Government's major targets for decarbonising transport—as set out in the 'Road to Zero' strategy—focus on tailpipe emissions and the sales of ultra-low emissions vehicles rather than lifecycle emissions or the emissions of the transport system as a whole.[455] Mr Eastlake therefore told us that the Government's "metrics certainly are not right for the very long term".[456]

131. **The Government's current long-term targets for decarbonising transport focus heavily on reducing exhaust emissions and increasing sales of low-emissions vehicles, rather than delivering a low-emissions transport system. In the long-term, widespread personal vehicle ownership does not appear to be compatible with significant decarbonisation.** ***The Government should not aim to achieve emissions reductions simply by replacing existing vehicles with lower-emission versions. Alongside the Government's existing targets and policies, it must develop a strategy to stimulate a low-emissions transport system, with the metrics and targets to match. This should aim to reduce the number of vehicles required, for example by: promoting and improving public transport; reducing its cost relative to private transport; encouraging vehicle usership in place of ownership; and encouraging and supporting increased levels of walking and cycling. The Government should commit to ensuring that the annual increase in fuel duty should never be lower than the average increase in rail or bus fares.***

132. ***Any move to electric vehicles must have an associated environmental impact assessment, including the potential for recycling lead, lithium, cobalt, nickel and graphite. Hydrogen technology may prove to be cheaper and less environmentally-damaging than battery-powered electric vehicles. The Government should not rely on a single technology.***

133. ***The Government should review the potential to reduce emissions and support shared car ownership by incorporating Government Department car fleets into car sharing schemes. It should encourage other public bodies and local authorities to do likewise.***

Last-mile deliveries

134. The growth in emissions from road transport has been driven by increases in miles travelled by vans as well as cars,[457] which has been attributed to the rise of online retail, economic growth in sectors that make most use of vans (such as construction, retail and food) and a shift from using heavy goods vehicles to vans instead.[458] The Aldersgate Group, an alliance of multiple UK businesses across various sectors, has highlighted the potential role for 'urban consolidation centres'—"warehouses located on the edge of urban areas where deliveries from a variety of retailers are consolidated by destination"—

452 Q490
453 HM Government, 'Industrial Strategy' (2017), pp48–51
454 'The Grand Challenge missions', Department for Business, Energy and Industrial Strategy, accessed 12 June 2019
455 Department for Transport, 'The Road to Zero' (2018), p2
456 Q104
457 Department for Transport, 'Transport Statistics: Great Britain 2018' (2018), p8
458 Committee on Climate Change, '2018 Progress Report to Parliament: Chapter 5 Annex—Growth in Van Demand' (2018)

in decarbonising freight, to improve the efficiency of 'last mile' freight deliveries.[459] The National Infrastructure Commission has also stated that "consolidation centres have shown that they can reduce freight trips into congested areas", but warned that "commercial viability and industry appetite remain challenges to roll out".[460] It recommended:

> Where the business case supports consolidation centres, authorities should use the planning system to make land available and consider the case for funding land and construction or subsidising operations in the short term. The case for consolidation centres can be made stronger by building incentives for operators to make use of them, through planning restrictions on new build properties and giving consolidated services preferential regulatory treatment such as reduced loading/unloading restrictions at the kerbside.[461]

We have also heard of the potential for electric-powered unmanned drones to provide last-mile deliveries, generating lower emissions than conventional land-based delivery modes.[462]

135. The Government has consulted on sustainable last-mile deliveries,[463] but its response focused heavily on low-carbon modes of transport such as e-cargo bikes and electric vans rather than approaches to adapt last-mile delivery systems, such as through the use of consolidation zones.[464] Nevertheless, in response to our enquiries, the Government told us that it would "seek to support the increased provision and availability of micro distribution hubs whilst recognising the importance of ensuring such facilities are supported by local bodies".[465] It referred to the National Planning Policy Framework, which stated that "planning policies and decisions should recognise and address the specific locational requirements of different sectors [including …] for storage and distribution operations at a variety of scales and in suitably accessible locations",[466] and said that it was exploring how the learning from two case studies in Southampton and Manchester could best be promoted.

136. **We commend the Government on its existing work to support the establishment and use of urban delivery consolidation zones. However, with just two major examples of completed projects to point to, there is clearly scope for a wider roll-out. *The Government should support the development of urban delivery consolidation centres, working with local authorities to assess the potential of such centres to reduce emissions and identify strategies to support their deployment and effective use.***

459 Aldersgate Group, 'Shifting Emissions into Reverse Gear: Priorities for Decarbonising Transport' (2019), pp13 and 15
460 National Infrastructure Commission, 'Better Delivery: The Challenge for Freight' (2019), p12
461 National Infrastructure Commission, 'Better Delivery: The Challenge for Freight' (2019), p13
462 Oral evidence taken before the Science and Technology Committee on 26 June 2019, HC 2021, Q281
463 Department for Transport, 'The Last Mile: A Call for Evidence on the opportunities available to deliver goods more sustainably' (2018)
464 Department for Transport, 'Government Response to Call for Evidence: The Last Mile—Delivering goods more sustainably' (2019)
465 Department for Transport (CGE0088)
466 Ministry of Housing, Communities and Local Government, 'National Planning Policy Framework' (2019), para 82

6 Decarbonising heating

137. Domestic, commercial and industrial heating is responsible for around a third of the UK's overall emissions,[467] which is unchanged from 2009.[468] Adjusting for environmental temperature, the UK's residential emissions have remained essentially unchanged since 2013.[469] There are two basic technical ways to reduce the carbon emissions associated with heating, either the reduction of demand through energy efficiency measures or the replacement of fossil fuel heating systems to less carbon-intensive versions. This Chapter examines what progress has been made so far, and what more could be done on each of those fronts.

A low-carbon heating strategy

138. There are a range of low-carbon heating technologies, including:

- heat pumps—these use electricity to transfer heat from the outside environment (either the air or the ground) into a building, using a similar process to a fridge in reverse. Heat pumps 'move' heat rather than generating it, offering high efficiencies in principle. Decarbonisation of electric power generation would then reduce the emissions associated with heating by heat pumps.[470]

- low-carbon gas—'biomethane' can be produced from waste, with emissions reductions compared to natural gas depending upon the waste used. Alternatively, hydrogen can be burned for heat, producing only water vapour (rather than carbon dioxide). However, it is not found naturally and therefore must be produced.[471]

- hybrid heat systems—which combine heat pumps, to be used for routine heating, with gas boilers to provide extra power at peak demand.[472]

- heat networks—which supply heat from a central source to consumers, via a network of underground pipes carrying hot water. The networks can span small clusters of buildings or whole cities. The heat can come from burning natural gas, use waste heat from industrial processes or use low-carbon generation technologies.[473]

Reviewing these different technological options, the Government said in its Clean Growth Strategy that "at present it is not certain which [low-carbon heat] approaches or combination of them will work best at scale and offers the most cost-effective long-term

467 Department for Business, Energy and Industrial Strategy, 'Clean Growth—Transforming Heating: Overview of Current Evidence' (2018), p3

468 Department for Business, Energy and Industrial Strategy, 'Clean Growth Strategy' (2017), p9 and Department of Energy and Climate Change, 'Emissions from Heat: Statistical Summary' (2012), p3

469 Department for Business, Energy and Industrial Strategy, 'Alternative Format 2018 UK greenhouse gas emissions: provisional figures—data tables' (2019), Table 4

470 For more information, see: 'Residential Heat Pumps', POSTnote 426, Parliamentary Office of Science and Technology, January 2013

471 For more information, see: 'Decarbonising the Gas Network', POSTnote 565, Parliamentary Office of Science and Technology, November 2017

472 For more information, see: National Grid System Operator, 'Future Energy Scenarios' (2018), pp70–71

473 For more information, see: Department for Business, Energy and Industrial Strategy, 'What is a heat network?' (2017)

answer".[474] Many submissions to our inquiry, such as those from Energy UK and the UK Energy Research Centre, agreed that it was not clear which low-carbon heating options would be most suitable in the longer-term, and several, including from National Grid, stressed that a balance of different technologies in different situations was likely to be the most effective solution.[475]

139. Amidst this technological uncertainty, Duncan Burt, Director of Operations, for National Grid System Operator, told us that the decarbonisation of heat was "the one big problem left to crack for the UK",[476] and said that there was a "need for a very clear pathway for decarbonised heat to be established".[477] He added that "the development of inter-seasonal storage [should be considered] alongside decarbonisation of the heat market" as "the two go intrinsically together".[478] Other witnesses agreed with the need for a heat decarbonisation strategy,[479] including Professor Tim Green of the Imperial College Energy Futures Lab, who emphasised that instead of "developing a strategy and then doing trial deployments […] the first plank of the strategy is that we have to try some of these things".[480] The Government has recognised this need for evidence-gathering, stating in its Clean Growth Strategy that it would "need to lay the groundwork this Parliament so we are ready to make decisions in the first half of the next decade about the long term future of how we heat our homes",[481] and stating in 2018 that its "initial next steps" for decarbonising heating in the UK would include:

- the development of "plans for a substantial new project to demonstrate modern electric heating solutions across a range of building types and consumers"; and
- collaboration with industry, academia and other key stakeholders to "progressively build up a comprehensive programme of work to demonstrate the technical and practical feasibility of using hydrogen in place of natural gas for heating".[482]

140. Despite these plans, the Committee on Climate Change argued in May 2019 that "over ten years after the Climate Change Act was passed, there is still no serious plan for decarbonising UK heating systems and no large-scale trials have begun for either heat pumps or hydrogen".[483] Reflecting the Committee on Climate Change's focus on large-scale trials, we heard repeatedly of the importance of trials at scale for potential low-carbon heating technologies.[484] Malcolm Brinded, representing the Royal Academy of Engineering and allied institutions, explained, for example, that "it is not about testing the technology but about testing a system":

474 Department for Business, Energy and Industrial Strategy, 'Clean Growth Strategy' (2017), p75
475 For example, see: National Grid (CGE0019), paras 3.5–3.6; Energy UK (CGE0024), para 9; Calor (CGE0027), para 11; SGN (CGE0040), para 1; UK Energy Research Centre (CGE0057), para 18—see also: National Infrastructure Commission, 'National Infrastructure Assessment' (2018), p44
476 Q336
477 Q312
478 Q312
479 Qq60 and 335–336—see also: Drax Group plc (CGE0025), para 7
480 Q336
481 Department for Business, Energy and Industrial Strategy, 'Clean Growth Strategy' (2017), p75
482 Department for Business, Energy and Industrial Strategy, 'Clean growth: transforming heating—overview of current evidence' (2018), pp 122–123
483 Committee on Climate Change 'Net Zero: The UK's contribution to stopping global warming' (2019), p175
484 For example, see: Greenpeace UK (CGE0022), para 7; Energy UK (CGE0024), para 9; Energy Systems Catapult (CGE0029), para 18; Royal Academy of Engineering and allied institutions (CGE0055), para 41; UK Energy Research Centre (CGE0057), para 18; and Qq209, 218 and 335–336

> The work to understand how those options would play out in the real world with consumer resistance, behaviour, price signals and all the other demand-side management measures that might go with it, has to be done in the period to 2025 to understand which trajectory we should be on. It is not an issue of saying that it will be about hydrogen, electrification or hybrid; it is about really understanding how those systems will work at scale, and the total system around that work.[485]

Professor Jim Watson, Director of the UK Energy Research Centre, similarly clarified that trials should involve "heating real homes in a real city".[486] Advocating greater Government willingness to support large-scale trials, the Aldersgate Group, an alliance of multiple UK businesses across various sectors, noted that the UK could install hybrid heat pumps in 1 million homes, heat networks in 1 million homes and hydrogen in 1 million homes and "there would still be 22m homes left to treat".[487]

141. Damitha Adikaari, Acting Director of Science and Innovation for Climate and Energy at the Department for Business, Energy and Industrial Strategy, conceded that the Government's trials so far had only involved up to around a hundred homes.[488] He acknowledged that large-scale demonstrations were "necessary" but said that they were "the most difficult" and explained that "the Government's push at the moment is to provide sufficient funds to de-risk some of those unknown technologies towards the demonstration phase".[489] The National Infrastructure Commission has commented, however, that "whilst there are incremental steps that can be taken to address some aspects of the challenge, an incremental approach on its own will not be enough".[490] Addressing hydrogen in particular, the Committee on Climate Change has similarly said that "continuation of an incremental approach that relies on isolated, piecemeal demonstration projects may lead to hydrogen continuing to remain forever an option 'for the future'".[491]

142. **Heating accounts for around a third of the UK's overall emissions, which has remained essentially unchanged since 2009. The decarbonisation of heating will be critical to the UK achieving its long-term emissions reductions targets, but there remains considerable uncertainty surrounding what mix of low-carbon heating technologies represents the best decarbonisation pathway for the UK, or what mix the Government will pursue. *The Government must urgently develop a clearer strategy for decarbonising heat. This will require large-scale trials of different heating technologies operating in homes and cities to build the evidence base required for long-term decisions. The Government must commit now to large-scale trials of low-carbon heating technologies, convening relevant stakeholders to determine what evidence must be gathered and to co-ordinate existing work.***

485 Qq51 and 60
486 Q50
487 Aldersgate Group, 'Zeroing In: Capturing the Opportunities from a UK Net Zero Emission Target' (2019), p19
488 Q449—see also: 'Smart Systems and Heat', Energy Systems Catapult, accessed 18 June 2019
489 Qq447–449
490 National Infrastructure Commission, 'National Infrastructure Assessment' (2018), p44
491 Committee on Climate Change, 'Hydrogen in a low-carbon economy' (2018), p123

Hydrogen trials

143. Professor Jim Watson, Director of the UK Energy Research Centre, noted that there was "an asymmetry of evidence about the heat pathway", with reasonable evidence gathered on electric heating but "hardly any real-world evidence of the hydrogen route".[492] He argued that this made trials of hydrogen a particular priority.[493] The Energy Systems Catapult told us that a large-scale trial of hydrogen "probably needs to take place by the early 2020s".[494] Malcolm Brinded and Duncan Burt similarly indicated that such trials would need to be complete by 2025,[495] while the National Infrastructure Commission has said that community-scale trials should be conducted by 2021 followed by trials involving at least 10,000 homes by 2023.[496]

144. The UK Hydrogen and Fuel Cell Association and Sam French, representing the Decarbonised Gas Alliance, noted that hydrogen could be used not only as a fuel for heating, but also for transport and industrial processing.[497] The Hydrogen Council, a coalition of over 50 international companies developing hydrogen technologies, has also highlighted that "hydrogen is exceptionally well suited to store large quantities of energy for long durations", which it said could aid in particular with the integration of increasing proportions of renewable power generation.[498] Anglo American, a company that mines platinum (a metal used in hydrogen generation and hydrogen-powered technologies), explained that 'surplus' renewable power generated at times of low demand could be used to generate hydrogen instead of going to waste.[499]

145. The UK Hydrogen and Fuel Cell Association acknowledged that there was growing recognition of the potential for hydrogen in the UK, and listed eight projects already underway.[500] One of these is the Hy4Heat project, which received £25m from the Government to "establish if it is technically possible, safe, and convenient to replace natural gas with hydrogen in residential and commercial buildings and gas appliances".[501] Sam French agreed that the Government had "at least five or six reasonably large programmes looking at all the key elements down the supply chain", and that "at this level, [the Government] does have a co-ordinated plan".[502] However, he said that it would be "the next step that will be critical", and argued that this would have to involve trials an order of magnitude larger than current projects.[503] The Energy Networks Association similarly told us that it "welcome[d] the approach being taken [by the Government] to build the evidence base around the options to decarbonise heat and transport, and would encourage increased activity in these areas".[504] Guy Newey, Director of Strategy and Performance at the Energy Systems Catapult, told us that although there were currently "dozens of projects going on", the key challenge would be how to "bring those together in

492 Q52
493 Q52
494 Energy Systems Catapult (CGE0029), para 18
495 Qq60 and 339
496 National Infrastructure Commission, 'National Infrastructure Assessment' (2018), p44
497 UK Hydrogen and Fuel Cell Association (CGE0034), paras 3 and 6; and Qq210–212 and 218
498 Hydrogen Council, 'Hydrogen Scaling Up: A sustainable pathway for the global energy transition' (2017), pp58–59
499 Anglo American (CGE0046), paras 4 and 7
500 UK Hydrogen and Fuel Cell Association (CGE0034), para 7
501 Department for Business, Energy and Industrial Strategy, 'Hy4Heat Progress Report' (2018)
502 Q218
503 Q218
504 Energy Networks Association (CGE0059), para 35

big demonstrations".[505] The Sustainable Gas Institute also stressed that "future projects should be coordinated to ensure findings from practical demonstrations inform modelling efforts, and vice versa".[506]

146. The Energy Systems Catapult told us that "it is unclear precisely what a comprehensive live trial(s) for the large-scale deployment of hydrogen might look like and what components are necessary or merely desirable", and argued that "consensus is needed to ensure a live trial(s) adequately provides sufficient information to enable Government to make a decision on hydrogen".[507] Professor Watson outlined a "number of aspects" that a trial of hydrogen would need to cover:

> One is the cost of producing the hydrogen […] There is the demonstration of converting your network to use hydrogen. Most networks can use some share of hydrogen, but another interesting question is how far you can go there. Then there is the demonstration of the end-user appliances, what you need to do in people's homes or businesses to be able to burn hydrogen rather than methane. Attached to that are questions about the financial model, consumer acceptability and whether, with that much change, it will still be as acceptable and whether the service will be as good.[508]

The Royal Society and EDF Energy listed similar areas for investigation, highlighting also the different potential methods for generating hydrogen as well as the storage and safety requirements that would need to be explored.[509] Given the different sectors in which hydrogen could be used as a fuel, the UK Hydrogen and Fuel Cell Association told us that the Government should take a "holistic approach" to developing hydrogen, with support for "whole system hydrogen energy demonstrations".[510]

147. Proposals for significant trials of hydrogen already exist. For example, Cadent, a gas distribution network operator, has proposed a 'Liverpool-Manchester hydrogen cluster' that would blend hydrogen at 10–20% into the gas supply and cost around £600m.[511] The H21 Leeds City Gate project has developed plans to incrementally convert the gas network in Leeds to 100% hydrogen over three years.[512] It said that this would use existing technologies and could support decarbonisation across heating, transport and power generation, with a total cost of around £2bn.[513] Both projects indicated that funding could potentially be secured through Ofgem's network price controls framework, depending upon the details of its next phase.[514] Sam French indicated that private investment could be pulled in to supplement public funding for hydrogen demonstration projects, with industry seeking "a provision for the next competition that is going to build some of these

505 Q52—Mr Newey was discussing demonstration projects for low-carbon heating, nuclear power and carbon capture and storage
506 Sustainable Gas Institute, 'A Greener Gas Grid: What Are the Options?' (2017), pix
507 Energy Systems Catapult (CGE0029), para 18
508 Q57
509 EDF Energy (CGE0020), para 24 and The Royal Society (CGE0056), paras 9–10—see also: The Geological Society (CGE0051), paras 11–12
510 UK Hydrogen and Fuel Cell Association (CGE0034), paras 9–10
511 Cadent, 'The Liverpool-Manchester Hydrogen Cluster: A Low Cost, Deliverable Project' (2017)
512 Northern Gas Networks, Wales and West Utilities, Kiwa and Amec Foster Wheeler, 'H21 Leeds City Gate' (2016)
513 Northern Gas Networks, Wales and West Utilities, Kiwa and Amec Foster Wheeler, 'H21 Leeds City Gate' (2016), pp6–8
514 Cadent, 'The Liverpool-Manchester Hydrogen Cluster: A Low Cost, Deliverable Project' (2017), p17 and Northern Gas Networks, Wales and West Utilities, Kiwa and Amec Foster Wheeler, 'H21 Leeds City Gate' (2016), p6

projects that are currently being designed".[515] Amanda Lyne, Chair of the UK Hydrogen and Fuel Cell Association, added that developing a hydrogen system at scale would help to make the costs more competitive.[516]

148. In a report examining potential options for decarbonising the UK's gas networks, the Sustainable Gas Institute noted that "choosing areas of the existing gas network to convert to hydrogen will be a significant policy consideration":

> Consumers in the area of conversion will not have the option to continue using natural gas. A number of policy considerations will arise as a result, including: who decides what areas are to be converted and how; who pays for appliance replacement; and what rights do consumers have if they do not want hydrogen?[517]

These are important considerations that must be included in any future trial of hydrogen. However, high levels of engagement and support from homeowners involved in the HyDeploy project near Stoke-on-Trent suggests that public support can be achieved.[518]

149. The Energy and Clean Growth Minister, Claire Perry MP, acknowledged that "there is a huge amount of enthusiasm for hydrogen heating", but warned that "there is a question about public perception and how much you can blend [hydrogen into the grid], and currently we do not have hydrogen-powered appliances".[519] Damitha Adikaari, Acting Director of Science and Innovation for Climate and Energy at the Department for Business, Energy and Industrial Strategy, correspondingly stated that the "Government's push at the moment is to provide sufficient funds to de-risk some of those unknown technologies towards the demonstration phase", focusing on the safety of hydrogen and the availability of appliances.[520] However, Sam French and the Energy and Utilities Alliance both told us that manufacturers were developing hydrogen boilers that were at the point of being ready for use.[521] The H21 Leeds City Gate project reported in 2016 that "there are already a few models [of appliances and equipment for domestic, commercial and industrial sectors] on the market, although sales are extremely low, due to an absence of piped hydrogen", but that "just with the knowledge of this study, several manufacturers are showing real enthusiasm for their development":

> A firm long-term plan and significant stimulus would be needed to provide the motivation to develop and produce the wide range of equipment required. This could potentially be in the form of a national heat policy.[522]

150. **The use of hydrogen as a fuel offers significant promise for low-carbon heating, transport and industrial processing, as well as for energy storage and to help manage intermittent renewable power generation. However, evidence from large-scale trials will be needed to allow the Government to make informed decisions on the UK's future energy system. Demonstrating the safety of hydrogen as a fuel is a critical first step,**

515 Q220
516 Q142
517 Sustainable Gas Institute, 'A Greener Gas Grid: What Are the Options?' (2017), p92
518 'HyDeploy: Safety', HyDeploy, accessed 20 June 2019
519 Q445
520 Q447
521 Energy and Utilities Alliance (CGE0031), para 20 and Q207
522 Northern Gas Networks, Wales and West Utilities, Kiwa and Amec Foster Wheeler, 'H21 Leeds City Gate' (2016), p4

and we commend the Government for its support of the Hy4Heat programme. ***The Government must complete the safety demonstration work for hydrogen as an urgent priority. The Government should also commit to completing at least one large-scale trial of hydrogen by 2025 conditional upon safety approval, and start developing now the terms for a competition to deliver such a trial. This should involve co-ordination of existing demonstration and modelling projects and should lead to the terms of a competition being announced no later than the end of 2020.***

151. The Committee on Climate Change has said that hydrogen faces a "chicken and egg" problem in the UK as it "does not currently produce significant amounts of low-carbon hydrogen, nor does it have technologies in place that would provide a market for that hydrogen".[523] As one solution to this challenge, the Decarbonised Gas Alliance told us that "simply allowing the hydrogen blend [in the gas grid] to be increased up to 2%, as a first step, would help to unlock [a new market in hydrogen]", suggesting for example that renewable energy produced at periods of surplus energy supply could be used to produce hydrogen if there were a market for it.[524] Currently, the concentration of hydrogen in the grid is limited to 0.1%,[525] although one trial project has received an exemption to demonstrate hydrogen concentrations of up to 20% on the Keele University campus.[526] Increasing proportions of hydrogen have been injected into some gas grids worldwide, reaching 10% concentration in Germany,[527] while Ofgem has stated that all gas appliances manufactured after 1993 have been required to operate with a hydrogen mix up to 23%.[528] Randolph Brazier, Head of Innovation and Development at the Energy Networks Association, told us that the Association believed that it could supply "up to 20% hydrogen into the gas networks without affecting consumer devices in the home".[529] The Minister indicated to us that "changing the regulations to allow us to introduce blended hydrogen into the system […] would be a really easy thing to do".[530]

152. The Sustainable Gas Institute indicated that, in addition to amendments to gas regulations, "there may also be a need for modifications to market arrangements to facilitate and encourage injection of biomethane or hydrogen".[531] The UK Hydrogen and Fuel Cell Association suggested that feed-in tariffs might be required to help build a market for hydrogen injection.[532] Alternative market support mechanisms could include a 'low-carbon gas obligation' similar to the Renewable Transport Fuel Obligation currently in place for suppliers of fuel used in transport.[533]

153. **Blending hydrogen into gas supplied via the gas grid could provide an initial market for early hydrogen production facilities.** ***Once clear evidence is obtained on the level at which it is safe to mix hydrogen into the existing gas grid, and which is compatible with existing appliances, the Government should amend regulations to raise the proportion of hydrogen permitted in the grid. With higher blends of hydrogen***

523 Committee on Climate Change, 'Hydrogen in a low-carbon economy' (2018), p123
524 Decarbonised Gas Alliance (CGE0032), para 19—see also: Qq207 and 339
525 Health and Safety Executive, 'A guide to the Gas Safety (Management) Regulations 1996' (2007), p49
526 'HyDeploy: Safety', HyDeploy, accessed 19 June 2019
527 Netherlands Enterprise Agency, 'The effects of hydrogen injection in natural gas networks for the Dutch underground storages: Final Report' (2017), p54
528 Ofgem, 'Project Summary: HyDeploy' (2016), p7
529 Q339
530 Q449
531 Sustainable Gas Institute, 'A Greener Gas Grid: What Are the Options?' (2017), p92
532 UK Hydrogen and Fuel Cell Association (CGE0034), para 11.2
533 Department for Transport, 'RTFO Guidance Part One: Process Guidance' (2019)

permitted, the Government should act to support the development of this as a market for hydrogen, perhaps through feed-in tariffs or low-carbon obligations analogous to the Renewable Transport Fuel Obligation.

Near-term measures for decarbonising heating

154. In addition to large-scale trials of different low-carbon heating options, David Weatherall, Head of Policy at the Energy Saving Trust, highlighted two actions that could be pursued immediately and which would be required whichever low-carbon heating technologies the Government pursued: improving energy efficiency in buildings; and raising public awareness of the need for decarbonising heat and what that might entail.[534] The Government listed a variety of measures that could improve energy efficiency in existing homes, including:

- changes to the 'fabric' of the building, such as loft, cavity wall and solid wall insulation, and double-glazing;
- upgrades to more efficient boiler or other heating systems; and
- systems for managing demand such as 'smart' heating controls.[535]

This section explores these options, as well as other measures that could contribute to the decarbonisation of heating in the UK in the near-term.

New buildings

155. Lord Deben, Chairman of the Committee on Climate Change, highlighted the inadequacy of energy standards for new homes currently being built as "the first and prime issue" for the UK's decarbonisation.[536] The Royal Academy of Engineering and allied institutions similarly told us that "building regulations (and their enforcement) should be strengthened", noting that "every home that is built to lower standards locks the occupants into excessive energy demands and costs that last for decades".[537] The Minister for Energy and Clean Growth argued that "in the past nine years the average energy performance standard for new homes has improved by 30%".[538] However, the Government's statistics on the average energy use of new homes demonstrates that almost all of this improvement occurred before 2014.[539] Jenny Holland, Senior Public Affairs and Policy Specialist for the UK Green Building Council, noted that "it is now six years since building regulations were last upgraded—the longest period without uplift since building regulations in their current form were introduced in 1984".[540]

534 Q215
535 Department for Business, Energy and Industrial Strategy, 'Call for Evidence: Building a Market for Energy Efficiency' (2017), p16
536 Q8
537 Royal Academy of Engineering and allied institutions (CGE0055), para 38
538 Q420
539 Ministry of Housing, Communities and Local Government, 'Live tables on Energy Performance of Buildings Certificates' (2019), Table NB7
540 Q169

156. Building regulations were due to be updated in 2016, through the introduction of the 'Zero Carbon Homes' policy.[541] This would have required all new homes to mitigate any carbon emissions produced on-site as a result of energy usage covered under building regulations (such as heating, cooling and lighting).[542] However, the 2015 Government decided not to pursue the zero carbon homes target in order to reduce regulations on homebuilders, arguing that regulations were one reason that the "UK has been incapable of building enough homes to keep up with growing demand".[543] This decision was criticised at the time in an open letter to the Chancellor with over 200 signatories, including major UK homebuilders.[544] The letter stated that:

> There was a broad consensus in support of the zero carbon policy, which was designed to give industry the confidence it needs to invest and innovate, in order to drive higher energy efficiency standards and low carbon energy solutions […] There is no evidence to suggest [ending the policy] will increase housing supply or boost productivity.[545]

Jenny Holland told us that the UK Green Building Council advocated a reinstatement of the Zero Carbon Homes Policy as a "modest start" for 2020, arguing that its "work with local authorities and developers up and down the country" suggested that this was "cost-effective and viable across a range of situations and geographical areas".[546] David Weatherall, Head of Policy at the Energy Saving Trust, told us that he supported this fully.[547] Lord Deben, Chairman of the Committee on Climate Change, argued that any costs involved with reaching higher standards would quickly fall due to economies of scale, and in any case be absorbed by reductions in land price.[548] Jenny Holland made the same argument.[549]

157. Graham Hazell, representing the Heat Pump Association, highlighted in particular the distorting impact of out-dated building regulations on homebuilders' actions to comply with current energy efficiency standards.[550] He explained that, as a result of failing to reflect significant recent reductions in the carbon intensity of the UK electricity supply, current building regulations were "more than doubling the carbon intensity of a heat pump completely artificially".[551] This erroneously incentivises homebuilders to meet building standards requirements through the installation of solar panels, which reduce electricity consumption, over heat pumps, which use electricity to efficiently move heat to inside a building.[552] Mr Hazell argued that rectifying the building regulations to better

541 HM Treasury, 'The Plan for Growth' (2011), paras 2.297–2.300
542 Zero Carbon Hub, 'Zero Carbon Homes and Nearly Zero Energy Buildings: UK Building Regulations and EU Directives' (2014)
543 HM Treasury, 'Fixing the foundations: Creating a more prosperous nation' (2015), paras 9.1 and 9.17
544 'Industry leaders urge chancellor to reconsider zero carbon homes 'U-turn'', Construction Manager, accessed 13 June 2019
545 'Industry leaders urge chancellor to reconsider zero carbon homes 'U-turn'', Construction Manager, accessed 13 June 2019
546 Qq169–170
547 Q170; reinstating the Zero Carbon Homes standard has been advocated by others too, such as the Energy Efficiency Infrastructure Group, a coalition of over twenty organisations—see Energy Efficiency Infrastructure Group, 'Affordable Warmth, Clean Growth: Action Plan for a Comprehensive Buildings Energy Infrastructure Programme' (2017)
548 Q8
549 Qq171–172
550 Qq166–169 and 206
551 Q167
552 Heat Pump Association (CGE0074)

reflect the actual carbon intensity of electricity would be "quite a small thing to do" but would represent a "massive step" for low-carbon heating systems.[553] The Heat Pump Association told us, however, that it did not expect changes to be made quickly "due to the process required which is a combination of the need to go to public consultation and the need to pass law within Parliament".[554]

158. In 2018, the Government said that it would consult on changes to Part L of the Building Regulations—the regulations that govern new building energy efficiency standards—in 2019, but no consultation has yet been launched.[555] The 2019 Spring Statement also announced a 'Future Homes Standard' to be developed by 2025, to "build on the Prime Minister's Industrial Strategy Grand Challenge mission to at least halve the energy use of new buildings by 2030" by "future-proofing new build homes with low carbon heating and world-leading levels of energy efficiency".[556] The Chancellor stated that this would include "mandating the end of fossil-fuel heating systems in all new houses from 2025".[557] The UK Green Building Council welcomed the announcement, but stressed that "it is vital that this is accompanied by truly world-leading energy efficiency standards".[558] Tim Lord, Director of Clean Growth at the Department for Business, Energy and Industrial Strategy, explained that the 2025 date was intended to give time for supply chains of technologies such as heat pumps to develop, but said that he expected homes to gradually meet the strengthened standards by 2025 rather than improving suddenly.[559]

159. The Energy Saving Trust has advocated moving towards a '2050-ready' set of standards so that homes built now are fit for a net-zero emissions future, and outlined what such standards should encompass.[560] It indicated that these could be based on the Zero Carbon Homes and London's current zero carbon homes policy, incorporating:

- energy and water efficiency standards;
- the installation of low-carbon energy generation technologies to account for the energy used to heat and light the home, and potentially the appliances run inside; and
- the offset of any 'surplus' emissions through investment in external emissions-saving measures.

Graham Hazell agreed that "we are building homes right now on a number of fronts that will either be very difficult or impossible to change in the future",[561] noting in particular the fact that new homes tended to use small-bore heating pipes and did not incorporate sufficient room for the installation of a hot water cylinder, both of which left them incompatible with the future installation of a heat pump system.[562] E.On argued that national adoption of tightened emissions standards modelled on London's zero carbon

553 Qq167 and 169
554 Heat Pump Association (CGE0074)
555 Department for Business, Energy and Industrial Strategy, 'Clean Growth—Transforming Heating: Overview of Current Evidence' (2018), p9
556 HM Treasury, 'Spring Statement 2019: Written Ministerial Statement' (2019), p4
557 Rt Hon Philip Hammond MP, Spring Statement 2019, 13 March 2019
558 'UKGBC responds to Spring Statement', UK Green Building Council, accessed 14 June 2019
559 Q471
560 Energy Saving Trust, 'The Clean Growth Plan: A "2050-ready" new-build homes policy' (2017)
561 Q205
562 Qq201–205

homes policy could "provide a stimulus, free from subsidy, for heat networks and heat pumps, providing scale and the ability of those technologies to be industrialised to realise cost reductions".[563]

160. **The Government's announced future homes standard is welcome. However, regulations requiring improvements to the efficiency of new buildings must be introduced before 2025.** ***The Government should re-introduce the zero-carbon homes standard as a matter of urgency, and no later than the end of 2019. It should additionally ensure that building regulations accurately reflect the current carbon intensity of electricity in Great Britain, and that this figure can be regularly updated (at least annually) in future.***

161. ***The Government should launch its consultation on Part L of the building regulations by the time of the Spring Statement 2020. Beyond that, it must ensure that homes built today are compatible with a net-zero emissions future and that the 'Future Homes Standard' reflects this.***

Existing buildings

162. The Royal Academy of Engineering and allied institutions noted that "most of the buildings that will exist in 2050 have already been built".[564] Lord Deben, Chairman of the Committee on Climate Change, told us that he focused on new buildings because that it "is the stupidest part of the whole situation", but agreed that "the biggest problem is all those houses that will still be there in 2050, when we are supposed to have reduced our emissions by 80%".[565]

Existing buildings—energy efficiency

163. The energy efficiency of a house is measured using the 'Standard Assessment Procedure', which assesses how much energy a building will consume when delivering a defined level of comfort and service provision, and awards the building a corresponding 'score' out of 100 determined by the associated energy costs per square metre.[566] Homes are awarded an Energy Performance Certificate on the basis of the score, which categorises them from Band A (least costly to run) to Band G (most costly to run).[567] The most recent breakdown of the proportion of homes in each EPC band is shown in Table 1.

Table 1: Proportion of English homes in each EPC Band

EPC Band	A/B	C	D	E	F	G
(%)	1.3	28.8	50.5	14.4	3.8	1.2

Source: Ministry of Housing, Communities and Local Government, 'English Housing Survey 2017 to 2018' (2019), Table AT2.7

563 E.ON (CGE0036), para 36
564 Royal Academy of Engineering and allied institutions (CGE0055), para 38
565 Q9
566 'Standard Assessment Procedure', Department for Business, Energy and Industrial Strategy, accessed 17 June 2019—see also Building Research Establishment, ' The Government's Standard Assessment Procedure for Energy Rating of Dwellings' (2014)
567 'Energy Performance Certificate', HM Government, accessed 8 February 2019

164. In its Clean Growth Strategy, the Government stated its ambition for:

- all fuel poor homes to be at least energy efficiency Band C by 2030; and
- as many homes as possible to reach Band C by 2035, where "practical, cost-effective and affordable".[568]

The Committee on Climate Change has concluded that achieving these goals would be compatible with the UK's emissions reductions targets, "provided that the limitations of 'practical' and 'affordable' do not significantly limit cost-effective uptake".[569] Tim Lord, Director of Clean Growth at the Department for Business, Energy and Industrial Strategy, told us that he "would not want to put a specific percentage number" on how many homes the Government's ambition would apply to, but indicated that he "would certainly expect to be able to improve cost-effectively a very significant majority of homes".[570]

165. ***The Government should set out, in its response to this Report, the criteria that will be used to determine 'practicality' and 'affordability' in its energy efficiency targets, and provide an indicative percentage of homes that it is intending to help reach Band C by 2035.***

166. David Weatherall, of the Energy Saving Trust, and Jenny Holland, of the UK Green Building Council, agreed with the Committee on Climate Change that the Government's targets were reasonable.[571] Instead, Ms Holland flagged that "it is the lack of policy rather than the targets being wrong".[572] Indeed, the most recent English Housing Survey reported a slowing in improvements in energy efficiency, with "no change in the average [energy efficiency] rating of homes between 2016 and 2017".[573] In its 2018 Progress Report to Parliament, the Committee on Climate Change noted that home insulation rates in 2017 were at just 5% of the peak rate achieved in 2012.[574]

167. David Weatherall told us that in the Energy Saving Trust's opinion, the Energy Company Obligation was "currently the only national funding scheme for energy efficiency in homes".[575] The Energy Company Obligation requires energy suppliers to deliver energy efficiency and heating measures to consumers' homes, typically by paying for part or all of the installation (although suppliers are allowed to trade achieved savings amongst themselves).[576] A national target of total home heating cost savings is periodically set in secondary legislation, and is allocated to be achieved by large energy suppliers through the installations they deliver, according to their market share. The most recent secondary legislation, made in 2018, set a target for 2018–2022 of £8.235bn.[577] Any supplier that has not accrued the necessary savings by the end of the required period can be fined

568 Department for Business, Energy and Industrial Strategy, 'Clean Growth Strategy' (2017), p77
569 Committee on Climate Change, 'An independent assessment of the UK's Clean Growth Strategy' (2018), p58
570 Qq469–470
571 Q173
572 Q173
573 Ministry of Housing, Communities and Local Government, 'English Housing Survey: Headline Report, 2017–18' (2019), para 2.24
574 Committee on Climate Change, '2018 Progress Report to Parliament' (2018), p85
575 Q177
576 'About the ECO scheme', Ofgem, accessed 17 June 2019; Ofgem, 'Energy Companies Obligation (ECO) 2012–2015: Guidance for Suppliers' (2012); and Ofgem, 'Energy Company Obligation (ECO3) Guidance: Supplier Administration' (2018)
577 The Electricity and Gas (Energy Company Obligation) Order 2018 (SI 2018/1183)

by the regulator.[578] The Government amended the Energy Company Obligation in November 2018 so that the scheme targeted only low-income and vulnerable households.[579] It explained that this re-focus was introduced to "[help] to meet the Government's fuel poverty commitments", but acknowledged that the change would "result in lower carbon emissions reductions being achieved under the scheme".[580] This is because fuel poor households are likely to benefit from improved efficiency by increasing the extent to which the house can be heated, rather than by reducing the amount of heating required.[581]

168. Noting that the Energy Company Obligation is "increasingly being focused on those most in need of support", the Government opened a call for evidence on driving energy efficiency measures in the 'able to pay' market in 2017.[582] The consultation outlined several potential options for Government action, including:

- developing new methods for financing energy efficiency;
- strengthening price signals tied to the efficiency of properties;
- improving awareness and advice available to consumers regarding the benefits of energy efficiency;
- creating the conditions for other beneficiaries, such as distribution network operators, Clinical Commissioning Groups (who stand to gain from the improved health of those living in more efficient homes) and mortgage lenders, to support the implementation of energy efficiency improvements;
- supplementing the £10m thermal efficiency innovation challenge fund with other mechanisms to support innovation in energy efficiency;
- making use of increasing amounts of consumer and network data to gauge actual building thermal performances and impacts of improvements; and
- supporting designers and installers in local supply chains.[583]

However, the Government has still not responded to the consultation submissions.[584] Tim Lord, Director of Clean Growth at the Department for Business, Energy and Industrial Strategy, told us that the Government would be "bringing forward [its] plans in response to that call for evidence and consultation later in the year".[585]

578 Ofgem, 'Energy Company Obligation (ECO3) Guidance: Supplier Administration' (2018), p43
579 Department for Business, Energy and Industrial Strategy, 'Energy Company Obligation 2018–2022' (2019), p10—more specifically, the households covered are fuel-poor households, families receiving certain benefits or social housing with poor energy efficiency
580 Department for Business, Energy and Industrial Strategy, 'Energy Company Obligation: ECO3, 2018 to 2022' (2018), p1 and para 42
581 Qq31, 41and 175
582 Department for Business, Energy and Industrial Strategy, 'Call for Evidence: Building a Market for Energy Efficiency' (2017)
583 Department for Business, Energy and Industrial Strategy, 'Call for Evidence: Building a Market for Energy Efficiency' (2017), para 56
584 'Building a market for energy efficiency: call for evidence', Department for Business, Energy and Industrial Strategy, accessed 17 June 2019
585 Q428

169. The last significant policy framework intended to encourage homeowners to improve their homes' energy efficiency was the Green Deal.[586] This was a scheme under which loans were made available to homeowners to finance improvements to the energy performance of their properties. Loans were available for a specific set of energy efficiency and renewable generation technologies,[587] and individual properties had to be assessed and cost-saving opportunities identified for the property to be eligible for that improvement. The debt was taken on by the property rather than the owner and was paid back, with interest, through the property's electricity bill. The Green Deal scheme was launched by the then Government in 2011 but was closed in 2015 due to "low take-up and concerns about industry standards".[588] The Government has since acknowledged that the Green Deal only addressed the financial aspect of energy efficiency improvements, which was not enough to drive widespread uptake.[589] Jenny Holland, Senior Public Affairs and Policy Specialist for the UK Green Building Council, explained that the Green Deal falsely assumed that "thousands and thousands of householders out there were dying to make energy efficiency improvements to their homes and the only thing stopping them was a lack of available finance", but "the results speak for themselves" in showing this not to be the case.[590] The National Audit Office similarly reported in 2016 that initial concerns that the Green Deal would attract insufficient householder interest were well-founded, and found that "even where there has been some interest in Green Deal loans, the complex process meant many people did not complete the process of arranging a finance plan".[591]

170. Reflecting these previously identified problems with a lack of homeowner demand, Energy UK, a trade association covering the whole UK energy sector, recommended that the "Government should help kick-start a sustainable able-to-pay energy efficiency market via a combination of incentives and funding mechanisms to engage with different consumer groups".[592] The Energy Efficiency Infrastructure Group, a coalition of over twenty relevant organisations, has recommended a range of options to support this.[593] In particular, it suggested that the Government incentivise homeowners to make energy efficiency improvements by adjusting Stamp Duty so that it would vary according to the property's energy performance as well as its selling price.[594] Jenny Holland, Senior Public Affairs and Policy Specialist for the UK Green Building Council, told us that she would be "extremely supportive" of such an initiative.[595] A similar idea has been advocated by other stakeholders too, such as the Sustainable Energy Association.[596] The Energy Efficiency Infrastructure Group specified that under such a scheme, homebuyers should be given

586 'Green Deal: energy saving for your home', HM Government, accessed 17 June 2019
587 Department of Energy and Climate Change, 'Green Deal: Energy saving home improvements' (2013)
588 'Green Deal Finance Company funding to end', Department of Energy and Climate Change, and Ministry of Housing, Communities and Local Government, accessed 17 June 2019—A new Green Deal scheme has since been launched by a private company, see 'Newly Acquired Green Deal Finance Company Recommences Loan Origination', Green Deal Finance Company, accessed 17 June 2019
589 Department for Business, Energy and Industrial Strategy, 'Call for Evidence: Building a Market for Energy Efficiency' (2017), para 44
590 Q187
591 National Audit Office, 'Green Deal and Energy Company Obligation' (2016), paras 3.4–3.5
592 Energy UK (CGE0024), para 28
593 Energy Efficiency Infrastructure Group, 'Affordable Warmth, Clean Growth: Action Plan for a Comprehensive Buildings Energy Infrastructure Programme' (2017)
594 Energy Efficiency Infrastructure Group, 'Affordable Warmth, Clean Growth: Action Plan for a Comprehensive Buildings Energy Infrastructure Programme' (2017), pp11 and 53–56
595 Qq188 and 190—see also: E.ON (CGE0036), para 30
596 Sustainable Energy Association, 'Energy Efficiency—A Policy Pathway: Addressing the Able to Pay Sector' (2017), pp11–14—see also: Aldersgate Group, 'Increasing investment for domestic energy efficiency' (2018), p8

a year after purchase to complete any improvement works and claim a retrospective reduction in Stamp Duty, as this "would allow improvements to be undertaken at the same time as general renovations that often take place shortly after purchase".[597]

171. **Previous initiatives to encourage the installation of energy efficiency improvements in the 'able-to-pay' market have failed because they have focused too narrowly on providing financial support for specific interventions.** ***The Government's new energy efficiency policy must provide all homeowners with the incentive to make energy efficiency improvements to their property, with particular thought given to lower income households. By the time of the Spring Statement 2020, the Government should consider adjusting Stamp Duty so that it varies according to the energy performance of the home as well as the price paid for it. Homebuyers should then be able to make energy efficiency improvements within a defined time after purchasing the property, and claim back corresponding reductions in the Stamp Duty paid retrospectively. The adjustments made to Stamp Duty could be designed in order to be revenue-neutral to the Government. Robust certification of energy efficiency will need to be put in place to ensure that such a scheme is not open to exploitation and the Government should consider how best to incentivise upgrades in council, housing association and rented homes.***

172. The Government's realisation that an energy efficiency policy cannot focus on finance alone does not mean that finance is unimportant. Although energy efficiency improvements can often save costs in the long-term by reducing energy demand, homeowners still need to be able meet the upfront costs of making the improvement. The Green Deal offered loans to cover installation costs, which were repaid through the occupiers' electricity bill (even if the original homeowner had sold the property).[598] However, under the scheme's 'golden rule', loans were only awarded for energy efficiency improvements that would deliver greater cost savings over their lifetime than total loan repayments over the same period.[599] Jenny Holland advised that any future scheme should not adopt this rule, as it "limited the number and type of installations that you could put in".[600] Indeed, the National Audit Office found that, of seven common energy efficiency improvement measures, "only easy-to-treat cavity wall insulation would qualify on its own, while other measures would require some form of subsidy to be installed at zero net cost for the householder".[601]

173. The purpose of the Green Deal was to enable homeowners to pay for energy efficiency improvements in their homes, with the 'golden rule' intended to protect these homeowners from paying for energy efficiency improvements that would not deliver net cost-savings. The Energy Saving Trust has highlighted, however, that although some "home energy efficiency [improvements] may not be cost-effective for individual households, [they] may be highly cost-effective for the UK as a whole in reducing our overall energy demand and in meeting our 2050 carbon targets", pointing out that energy efficiency improvements can be more cost-effective than other measures subsidised by the Government, such as nuclear and some renewable power generation technologies.[602]

597 Energy Efficiency Infrastructure Group, 'Affordable Warmth, Clean Growth: Action Plan for a Comprehensive Buildings Energy Infrastructure Programme' (2017), pp53–54
598 'Getting a Green Deal: information for householders and landlords', HM Government, accessed 18 June 2019
599 Department of Energy and Climate Change, 'The Green Deal: A summary of the Government's proposals' (2010), pp11–12
600 Q191
601 National Audit Office, 'Green Deal and Energy Company Obligation' (2016), p43
602 Energy Saving Trust, 'The Clean Growth Plan: An offer to all householders' (2017), p2

174. The Energy Saving Trust has suggested various potential components of a future scheme for financing energy efficiency improvements in the 'able-to-pay' market, such as zero- or reduced-rate loans, grants, mortgage-linked cashback schemes and equity release schemes.[603] Bright Blue, an independent liberal conservative think tank, recommended the introduction of a 'Help to Improve' finance scheme for energy efficiency,[604] in reference to the 'Help to Buy' scheme in place for first-time homebuyers and for purchases of new homes.[605] This would comprise two main elements:

- 'Help to Improve' loans available to finance energy efficiency improvements, with Government funding used to reduce interest rates (potentially to zero), and made available through commercial banks; and
- 'Help to Improve' ISAs into which homeowners can invest and receive a bonus, funded by the Government, proportional to the sum invested by the homeowner and subject to a maximum cap, provided that the funds are used to pay for legitimate energy efficiency improvements.[606]

The Sustainable Energy Association has also recommended a 'Help to Improve' loan scheme, which it said was already used in other countries including Germany and France.[607] Evidence from Germany suggests that, as a result of the tax revenue from the economic activity associated with delivering energy efficiency improvements combined with reduced welfare spending due to improved housing and employment, the Government received a net income from the scheme.[608]

175. **The Green Deal's 'golden rule' heavily restricted the energy efficiency improvements that could be paid for by the scheme. Although some energy efficiency improvements may not deliver net cost-savings to homeowners, they may still represent cost-effective options for the UK to meet its emissions reductions targets. *The Government's new energy efficiency policy must enable homeowners to access the finance needed to cover the upfront costs of energy efficiency improvements that offer a cost-effective contribution to the UK's decarbonisation, not just net cost-savings to individual homeowners. In analogy to the existing 'Help to Buy' scheme, the Government should establish a 'Help to Improve' scheme by July 2020 that offers matched funding and interest-free loans to homeowners, to cover the costs of making energy efficiency improvements.***

176. Tim Lord, Director of Clean Growth at the Department for Business, Energy and Industrial Strategy, highlighted the fact that measures to improve energy efficiency could benefit from financial services innovation as well as technological innovation, noting in particular a potential role for 'green mortgages'.[609] The Minister explained that "people who are moving into energy-efficient homes are less likely to default on rental payments", providing an incentive for banks to offer lower mortgage rates.[610] However, the London School of Economics and Political Science has warned that the evidence base for this was

603 Energy Saving Trust, 'The Clean Growth Plan: An offer to all householders' (2017)
604 Bright Blue (CGE0049), paras 6–8
605 'Help to Buy', HM Government, accessed 18 June 2019
606 Bright Blue, 'Better Homes: Incentivising Home Energy Improvements' (2016), pp72–75
607 Sustainable Energy Association, 'Energy Efficiency—A Policy Pathway: Addressing the Able to Pay Sector' (2017), p25
608 KfW Bankengruppe, 'Impact on Public Budgets of KfW Promotional Programmes in the Field of "Energy-Efficient Building and Rehabilitation"' (2012)
609 Q428
610 Q429

limited, and that it was not clear whether more reliable payments were caused by energy efficiency or simply correlated.[611] Indeed, the Government itself has acknowledged that "it can be difficult to untangle the role of the property from the homeowner in these calculations".[612] Nevertheless, the LENDERS group, a coalition of organisations including the UK Green Building Council, the Energy Saving Trust and the Nationwide Building Society—supported by the Government—has also noted the correlation between energy efficiency and homeowners' capacity for mortgage repayments, and recommended that the mortgage industry reviews its current affordability calculations to take this into account.[613] Increasing potential purchasers' ability to secure a mortgage for homes with greater energy efficiency could help to drive demand for more energy efficient properties. The London School of Economics and Political Science has argued that this could apply to all mortgages, not just those intended to be 'green', and said that "this could be a safer and more flexible alternative to offering more favourable interest rates for green mortgages".[614] The LENDERS group indicated that the Government could support the mortgage industry in accessing "larger datasets in compatible formats to provide more accurate estimation for household expenditure".[615]

177. **We commend the Government for supporting research into, and the development of, 'green mortgages'.** ***The Government should consider the case for encouraging mortgage lenders to take energy efficiency into account for all mortgage applications, and should support the industry in capturing any potential in such a system for driving a market in energy efficiency improvements.***

178. The Minister for Energy and Clean Growth, Claire Perry MP, highlighted the fact that, in addition to the Energy Company Obligation, the Government had recently passed legislation targeting the "least energy-efficient part of the private rented sector".[616] This refers to amendments made to energy efficiency regulations under the Energy Act 2011.[617] The amended regulations forbid private landlords from granting new tenancies to new or existing tenants in properties with energy efficiencies beneath EPC Band E, and from April 2020 landlords will not be able to continue letting a property that is already let if it falls beneath these standards (with certain exclusions, especially in the social housing sector).[618] However, with the impact being restricted to privately-rented properties with efficiencies beneath Band E, these measures will only affect 2.5% of all English homes.[619] Suggesting policies that could affect a wider range of households, Bright Blue recommended that "the building code could be amended to mandate builders to improve the overall energy performance of homes whenever renovations take place":

611 'What are green mortgages and could they increase the energy efficiency of UK homes?', London School of Economics and Political Science, accessed 18 June 2019

612 Department for Business, Energy and Industrial Strategy, 'Call for Evidence: Building a Market for Energy Efficiency' (2017), para 86

613 LENDERS, 'Improving energy costs in mortgages, promoting energy efficiency in homes' (2017)

614 'What are green mortgages and could they increase the energy efficiency of UK homes?', London School of Economics and Political Science, accessed 18 June 2019

615 LENDERS, 'Improving energy costs in mortgages, promoting energy efficiency in homes' (2017), p19

616 Q420

617 The Energy Efficiency (Private Rented Property) (England and Wales) (Amendment) Regulations 2019 (SI 2019/595); The Energy Efficiency (Private Rented Property) (England and Wales) Regulations 2015 (SI 2015/962); and Energy Act 2011, section 52

618 Department for Business, Energy and Industrial Strategy, 'The Domestic Private Rented Property Minimum Standard' (2019)

619 Ministry of Housing, Communities and Local Government, 'English Housing Survey 2017 to 2018' (2019), Table AT2.7; Committee analysis

> The cost of the home energy improvements could be capped so they do not exceed a certain proportion of the overall cost of the building works. This regulation would be enforced in the same way that the building code, the regulations that govern building works, is currently enforced.[620]

This aligns with the UK Energy Research Centre's findings that households are much more likely to consider making energy efficiency improvements as part of wider renovations than for efficiency improvements alone.[621]

179. **We commend the Government for strengthening the requirements on landlords to improve the energy efficiency of the least efficient homes in England and Wales. However, these measures will affect only 2.5% of the housing stock.** ***The Government should amend building regulations so that renovations to buildings must always result in an overall improvement in energy efficiency.***

Existing buildings—low-carbon heating

180. The Renewable Heat Incentive (RHI) is a Government financial incentive aimed at promoting the use of renewable heat systems.[622] The National Audit Office has reported that, as of December 2017, the RHI had delivered just 78,000 of the 513,000 that it was projected to deliver between 2014 and 2020.[623] The RHI scheme is due to close to new applicants in 2021, with the Government saying it "is now considering how to transition support for [low-carbon heating] technologies away from direct subsidy".[624] Tim Lord, Director of Clean Growth at the Department for Business, Energy and Industrial Strategy, told us that he could not yet say "what the successor to or the future for that scheme will be".[625] **The Renewable Heat Incentive has significantly underperformed on the Government's expectations.** ***With the Renewable Heat Incentive due to close to new applications in 2021, the Government must ensure that it avoids a repeat of the disruption caused by the closure of the feed-in tariff, and announces its plans for the successor scheme to the Renewable Heat Incentive no later than the Spring Statement 2020. The successor scheme must be far more effective than the Renewable Heat Incentive scheme has proven to be.***

181. The Minister for Energy and Clean Growth, Claire Perry MP, told us that, following the Government's announced intention to mandate the end of fossil-fuel heating systems in all new houses from 2025,[626] "the hope is that through the regulatory changes we make we will kickstart a real cost reduction" in heat pumps and other existing technologies not yet deployed at scale.[627] This echoed what we heard from E.On, who argued that "if there was sufficient confidence within the supply chain that the market [for heat pumps] could be scaled, the cost of heat pump production and installation could be reduced significantly".[628]

620 Bright Blue (CGE0049), para 5
621 UK Energy Research Centre, 'Understanding Homeowners' Renovation Decisions: Findings of the VERD Project' (2013), p8
622 'About the Domestic RHI', Ofgem and 'About the Non-Domestic RHI', Ofgem, both accessed 18 June 2019
623 National Audit Office, 'Low-carbon heating of homes and businesses and the Renewable Heat Incentive' (2018)
624 Department for Business Energy and Industrial Strategy, 'A Future Framework for Heat in Buildings: Call for Evidence' (2018), paras 1.6–1.8
625 Q477
626 Rt Hon Philip Hammond MP, Spring Statement 2019, 13 March 2019
627 Q445
628 E.ON (CGE0036), paras 22–23

182. The Committee on Climate Change has commented that "switching to heat pumps is made more costly by the fact that the carbon costs of gas are not reflected in its price" and said that "there remain important questions to be resolved around the current balance of tax and regulatory costs across fuels, which currently weaken the private economic case for electrification".[629] Graham Hazell, representing the Heat Pump Association, similarly told us that "the driver [for low-carbon heating] has to be to put a cost on carbon" given that currently "the price of the fuel does not relate to the carbon content".[630] A 2013 report by the Centre for Climate Change Economics and Policy and the Institute for Fiscal Studies compared the variety of 'upstream' and 'downstream' policies on electricity with the fact that there were "no policies imposing a carbon price on gas use by households", and estimated that, in 2013/14 prices, households faced a carbon price of £27/tCO2e for electricity compared to a negative cost (taking into account the VAT 'subsidy') on household energy consumption) of £29/tCO2e for gas.[631] The authors of that report supported the introduction of a carbon tax on gas for domestic heating but highlighted that it would be regressive (because low-income households devote a larger portion of their spending to energy than richer households) and unpopular.[632] They recommended that such a move be accompanied by a compensation package to address these issues, and pointed out that the tax itself would raise a significant amount of money to enable this.

183. **The Government's announcement that fossil-fuel heating systems will not be permitted in new builds after 2025 may support the growth of supply chains for low-carbon heating technologies and deliver consequent cost-reductions as well.** ***The Government should further support the deployment of low-carbon heating technologies by setting out a clear roadmap by the time of the Spring Statement 2020 for rebalancing levies on electricity and gas, to better reflect the emissions intensities of each fuel.***

629 Committee on Climate Change, 'Next steps for UK heat policy' (2016), p74 and Committee on Climate Change, '2018 Progress Report to Parliament' (2018), p86

630 Qq198 and 214—see also: E.ON (CGE0036), para 22

631 Centre for Climate Change Economics and Policy, Institute for Fiscal Studies, Esmée Fairbairn Foundation and Economic and Social Research Council, 'Energy use policies and carbon pricing in the UK' (2013), p8

632 Centre for Climate Change Economics and Policy, Institute for Fiscal Studies, Esmée Fairbairn Foundation and Economic and Social Research Council, 'Energy use policies and carbon pricing in the UK' (2013), p10

7 The UK energy system

184. National Grid reported in 2018 that "the three drivers of decarbonisation, decentralisation and digitalisation are transforming the energy landscape".[633] Although this Report has focused on decarbonisation, decentralisation (the increasing use of smaller scale power generation, storage or management technologies, often situated close to consumers) and digitalisation (the increasing use of digital technologies to monitor and manage energy use) are important trends that will impact upon, and potentially facilitate, the decarbonisation of the UK's energy system. An additional trend highlighted during our inquiry was the increasing interdependence of previously distinct sectors such as power generation, transport and heat.[634] This Chapter examines some of these trends, as well as discussing the roles of different stakeholders in the UK energy system.

A smart energy system

185. The UK energy system has historically been 'centralised', with electricity being generated by a small number of large power stations and supplied to consumers via transmission and distribution networks.[635] These power stations have mostly used fossil fuels and have been able to vary their output to match demand.[636] As the power sector decarbonises, renewable technologies such as wind and solar power (which we discussed in Chapter 4) are increasingly being deployed. The output from these renewable sources is typically weather- and time-dependent, with far less scope for control. Furthermore, these new sources of power are being deployed in smaller units and closer to consumers than traditional power stations. This increases the complexity of power flows around the distribution networks.[637] Ofgem, the energy markets regulator, told us that the reduced control of power generation output combined with the decentralisation of power supply "poses new challenges in making sure the electricity system efficiently balances supply and demand and manages network constraints".[638]

186. In response to these trends, the Government and Ofgem together published a '*Smart Systems and Flexibility Plan*' in 2017.[639] The Plan set out 29 proposed actions, including:

- amending network usage costs and final consumption levies to apply more fairly to storage facilities;
- giving storage a legal definition in primary legislation, to provide regulatory clarity;
- strengthening regulation to avoid giving network operators an unfair advantage in the storage market;
- providing support for innovation in storage technologies;

633 National Grid System Operator, 'Future Energy Scenarios' (2018), p8
634 For example, see: Energy Systems Catapult (CGE0029); Ofgem (CGE0033), para 35; Dr Jonathan Radcliffe (CGE0041), para 19
635 'Flexible Electricity Systems', POSTnote 587, Parliamentary Office of Science and Technology, September 2018
636 The output from fossil fuel power plants can be controlled by varying the fuel input, subject to certain constraints. Nuclear power can in principle be controlled in the same manner, but in practice nuclear reactors tend to be run at a continuous rate.
637 Energy Networks Association (CGE0059), para 13
638 Ofgem (CGE0033), para 6
639 HM Government and Ofgem, 'Upgrading Our Energy System: Smart Systems and Flexibility Plan' (2017)

- supporting large non-domestic consumers to participate in demand-side response schemes;
- delivering the roll-out of smart meters and introducing half-hourly smart metering across the market, potentially mandated for all suppliers;
- consulting on seeking powers to set standards for smart appliances and electric vehicles;
- ensuring that storage and demand flexibility can compete in markets for network stability; and
- adapting network charges to an energy system less focused on central power generation.[640]

Duncan Burt, Director of Operations for National Grid System Operator, told us that the plan was "the right measure at the right time".[641] Randolph Brazier, Head of Innovation and Development at the Energy Networks Association, similarly told us that the Association "very much supports the smart systems and flexibility plan".[642]

187. In a 2018 'progress update', the Government listed 15 of the actions in the plan as "in progress" and 15 as "implemented" (one new action was added to the original 29).[643] Reviewing the progress of the plan in 2019, the National Infrastructure Commission reported that the Government "has been supportive of smart power and has made good progress in many areas".[644] Randolph Brazier, representing the Energy Networks Association, similarly told us that his organisation believed the plan was "making good progress".[645] Nevertheless, the National Infrastructure Commission report identified a few areas for further attention including three "priorities for 2019":

- a reduction of barriers to the creation of new "interconnectors" connecting the electricity networks in Great Britain to international networks, in particular in the context of Brexit negotiations;
- the establishment of a deadline for the transition currently being undertaken by energy distribution network operators as they start to more actively manage their networks, along with support from the Government and the regulator to facilitate the transition; and
- amendment to the Electricity Act 1989 to explicitly define electricity storage as a subset of generation.[646]

640 HM Government and Ofgem, 'Upgrading Our Energy System: Smart Systems and Flexibility Plan' (2017), pp21–30
641 Q334
642 Q334
643 HM Government and Ofgem, 'Upgrading Our Energy System: Smart Systems and Flexibility Plan—Progress Update' (2018), pp25–45
644 National Infrastructure Commission, 'Annual Monitoring Report 2019' (2019), p26
645 Q334
646 National Infrastructure Commission, 'Annual Monitoring Report 2019' (2019), p28

Storage

188. Dr Jonathan Radcliffe, of the University of Birmingham (and Specialist Adviser for this inquiry), noted that "the transition to a decarbonised economy presents challenges to energy systems by reducing their flexibility as an increased proportion of energy comes from variable renewable energy sources".[647] Many other submissions, including from National Grid and Ofgem, similarly highlighted the growing proportion of power provided by intermittent sources, and the consequential need for flexibility.[648] Dr Radcliffe told us that "energy storage technologies are one option for adding flexibility back into an energy system and analysis has shown that they have the potential to be part of a cost-effective transition to a low carbon and secure energy system", clarifying that different storage capabilities would be needed to manage:

- imbalances in transmission and distribution networks in 'real-time';
- peaks and troughs in energy demand through the day;
- days with low supplies of energy (for example with poor wind power generation); and
- seasonal variation in demand (for example increased heating in cold weather).[649]

Dr Radcliffe said that his team's "analysis of the energy system through the 2020s suggests that technologies that can store large quantities of energy […] will be important".[650] Randolph Brazier, Head of Innovation and Development at the Energy Networks Association, and Professor Nick Eyre, Director of the Centre for Research into Energy Demand Solutions, similarly said that deployment of sufficient long-term inter-seasonal energy storage would be the greatest challenge (see also paragraph 140).[651]

189. Several witnesses argued that the Government should aim to support the development of long-term energy storage technologies.[652] For example, the Durham Energy Institute told us that "significant intervention at the state level and investment is needed to reach the scale of storage required to make our energy system truly resilient and low-carbon".[653] The Institute said that this "could be achieved through direct investment in research and development, subsidies or by indirect market mechanisms such as requiring energy suppliers to implement a certain level of storage and tax breaks for companies who introduce storage".[654] Dr Jonathan Radcliffe similarly told us:

> Our review of international energy storage policies […] suggests that direct technology support for energy storage has been effective at increasing deployment in a number of markets. Such support has taken a number of forms including direct support for capital investment in energy storage

647 Dr Jonathan Radcliffe (CGE0041), para 4
648 For example, see: Cadent (CGE0015), para 15; National Grid (CGE0019), para 2.3; EDF Energy (CGE0020), para 9; Ofgem (CGE0033), para 6; Highview Power (CGE0050), section 1
649 Dr Jonathan Radcliffe (CGE0041), paras 4–5
650 Dr Jonathan Radcliffe (CGE0041), para 16
651 Qq307–309
652 For example, see: Greenpeace UK (CGE0022), para 7; Durham Energy Institute (CGE0065), paras 8 and 29–30; and Q310
653 Durham Energy Institute (CGE0065), para 29
654 Durham Energy Institute (CGE0065), para 30

> devices, mandated targets, and co-subsidies for renewables with energy storage; forms of which have been seen in Germany, Japan, and states in the US.[655]

He highlighted the ARPA-E GRIDS programme in the USA, which recently launched to support the development of "storage technologies that can store renewable energy for use at any location on the grid at an investment cost less than $100 per kilowatt hour".[656] Randolph Brazier clarified that long-term energy storage technologies existed, but that "they have not been tested at scale".[657]

190. Dr Radcliffe told us that although "large-scale energy storage of electricity and heat could be a key component of the future energy system […] policy/market signals that would encourage investment are lacking".[658] In keeping with the National Infrastructure Commission's recommendations, Eaton, a global power management company, told us that "there is currently no statutory definition for storage, which has significant detrimental impact on the technology's bankability":

> The Government's current plan to classify storage as a subset of generation provides short-term certainty, but is sub-optimal in the long term. In order to unlock the full potential value of storage, it needs to be defined in law as a separate asset class from generation systems which have completely different economics.[659]

191. The lack of a suitable legal definition for storage was also identified to us as a major barrier to the deployment of energy storage technologies by the Solar Trade Association and Highview Power.[660] The view that storage should not be defined as a subset of generation is reportedly widespread, given the additional roles it can play in the energy system.[661] Although the Government acknowledged the need for electricity storage to be defined in primary legislation in its '*Smart Systems and Flexibility Plan*',[662] Tim Lord, Director of Clean Growth at the Department for Business, Energy and Industrial Strategy, told us that the Government had "already taken a range of steps to enable storage to participate more fairly in the market" and that he was "not sure about any specifics on further legislation that people are seeking or require".[663]

192. **The development and deployment of energy storage technologies will be critical to the UK's transition towards a flexible, low-carbon energy system. It is disappointing that the Government has not made the Parliamentary time available to define energy storage in primary legislation. *The Government must ensure sufficient support for the development and deployment of energy storage technologies. Large-scale, inter-seasonal storage currently appears to pose the greatest technical challenges, and should be supported through demonstration projects, including in future large-scale trials of low-carbon heating. The Government should provide a dedicated legal definition of***

655 Dr Jonathan Radcliffe (CGE0041), para 17
656 Dr Jonathan Radcliffe (CGE0041), para 24–see also: ARPA-E, 'GRIDS Program Overview'
657 Q310
658 Dr Jonathan Radcliffe (CGE0041), para 2
659 Eaton (CGE0052)
660 Highview Power (CGE0050), section 4 and Solar Trade Association (CGE0053), para 14
661 'Brexit to blame for slow energy storage progress admits BEIS', Current +/-, 24 May 2018—see also: Qq322–323
662 HM Government and Ofgem, 'Upgrading Our Energy System: Smart Systems and Flexibility Plan' (2017), p21
663 Q496

energy storage in primary legislation as soon as possible. Such a commitment should be included in the next Queen's Speech, if Parliamentary time is not found for such legislation before then.

Smart meters

193. Energy storage is not the only option for increasing flexibility and managing increased levels of intermittent renewable power generation in the energy system.[664] One alternative is to better match demand to supply so that power is used when it is available and is not required when it is not available, an approach known as 'demand-side management'.[665] Duncan Burt, Director of Operations for National Grid System Operator, told us that one "fundamental" element of a smart energy system that could provide such demand-side management was the replacement of traditional electricity and gas meters with smart meters.[666] Smart meters measure a property's electricity or gas consumption (or electricity generation, where applicable) in real-time and can periodically relay this information to the energy supplier.[667] Although consumers are expected to benefit immediately from the installation of a smart meter on their property by:

- receiving automatic, accurate bills in place of manual metering or estimated bills; and
- being able to monitor their energy consumption in real-time, allowing for better management of home energy usage;[668]

the main benefits of smart meters are expected to accrue to consumers and to the wider system by enabling demand-side management.[669] In order for consumers to use electricity when it is most abundant, and to be rewarded for doing so (with lower energy costs, for example), their appliances must be able to respond to information about the current availability of electricity and suppliers need to know exactly when energy was consumed—this requires smart metering.

194. The improved information on, and control over, energy consumption might also allow for greater innovation in the energy system.[670] For example, companies may start offering 'heat as a service', where consumers pay for a pre-agreed level of comfort rather than for each unit of energy that they consume to heat their homes (such contracts would incentivise energy suppliers to provide the energy for heating as efficiently as possible).[671] By supporting energy supply contracts that encourage consumers to use energy when it is cheapest, smart meters may also help to reduce the peak demand for energy. This would reduce the need for power generation capacity and grid reinforcement. A 2016 study conducted by Imperial College London and the Carbon Trust estimated that flexibility could yield net savings for the UK energy system of £17–40bn by 2050.[672]

664 National Infrastructure Commission, 'Smart Power' (2016)
665 'Flexible Electricity Systems', POSTnote 587, Parliamentary Office of Science and Technology, September 2018
666 Q319
667 Smart Energy GB, 'Smart Meters'—smart meters can relay the information to suppliers every month, every day or every half-hour, but only provide the total consumption over half-hour periods
668 Smart Energy GB, 'Smart Meter FAQs'
669 Delta-EE, 'Smart Meter Benefits: Role of Smart Meters in Responding to Climate Change' (2019)
670 Delta-EE, 'Smart Meter Benefits: Role of Smart Meters in Responding to Climate Change' (2019)
671 Energy Systems Catapult, 'Smart Energy Services for Low Carbon Heat' (2019)
672 Imperial College London and Energy Saving Trust, 'An analysis of electricity system flexibility for Great Britain' (2016)—this study considered all flexibility options deployed together, not just smart meters

195. The Government has said that it is "committed to all homes and small businesses being offered smart meters by the end of 2020".[673] As part of their licence to operate, energy suppliers in Great Britain must "take all reasonable steps to have installed a smart meter" by the end of 2020.[674] However, as of December 2018, 12.7m smart meters were in operation in domestic properties across Great Britain, compared to 37.1m traditional meters.[675] The National Audit Office has said that "there is no realistic prospect of installing smart meters in all eligible premises covered by the rollout obligation by 2020".[676] Energy suppliers have said that they are aiming for 70–75% of households to have a smart meter by the end of 2020, which Claire Perry MP told the Business, Energy and Industrial Strategy Committee in January 2019 was "achievable".[677] However, in 2018, 4.9m smart meters were installed and if this rate were sustained, the roll-out would achieve around only 46% coverage by the end of 2020.[678] Further, installations rates have fallen since peaking at the end of 2017.[679]

196. Duncan Burt, Director of Operations for National Grid System Operator, told us that although the roll-out was "taking time", National Grid System Operator believed that the "strategy will deliver".[680] Professor Nick Eyre, Director of the Centre for Research into Energy Demand Solutions, told us that he thought it was "much more important to do the smart meter roll-out well than to do it quickly".[681] Dhara Vyas, Head of Future Energy Services at Citizens Advice, expressed a similar opinion in oral evidence to the Business, Energy and Industrial Strategy Committee in January 2019.[682]

197. Although energy suppliers should make all reasonable efforts to install a smart meter, households and businesses are not required to accept one.[683] Indeed, the National Audit Office has reported that "consumer behaviour has proven to be more of a barrier to mass uptake of smart meters than the [Government] anticipated".[684] Under half of households offered a smart meter reportedly accepted one in 2017,[685] although the Centre on Innovation and Energy Demand noted that there was "very little data available about acceptance rates".[686] It recommended that energy suppliers collect and publish data on acceptance rates and the reasons for consumer rejection, in order to identify options for increasing consumer acceptance. Professor Eyre told us that the smart meter roll-out should be treated "not just as a technology problem but recognising that people's trust in this technology and their ability to use it effectively to reduce their costs is absolutely

673 Department for Business, Energy and Industrial Strategy, 'Smart Meters: Unlocking the Future' (2018)
674 Ofgem, 'Supply licence guide: Smart metering' (2019)
675 Department for Business, Energy and Industrial Strategy, 'Smart Meter Statistics: Quarterly Report to end December 2018' (2019), p11
676 National Audit Office, 'Rolling out smart meters' (2018), para 1.36
677 Oral evidence taken before the Business, Energy and Industrial Strategy Committee on 9 January 2019, HC 1851, Q93
678 Department for Business, Energy and Industrial Strategy, 'Smart Meter Statistics: Quarterly Report to end December 2018' (2019), p10
679 Department for Business, Energy and Industrial Strategy, 'Smart Meter Statistics: Quarterly Report to end December 2018' (2019), p11
680 Q320
681 Q328
682 Oral evidence taken before the Business, Energy and Industrial Strategy Committee on 9 January 2019, HC 1851, Q70
683 'Smart meters: A guide to your rights', Ofgem, accessed 3 July 2019
684 National Audit Office, 'Rolling out smart meters' (2018), para 1.19
685 'Smart meter roll-out in question as only a fraction of households sign up', Daily Telegraph, 26 August 2017
686 Centre on Innovation and Energy Demand, 'The smart meter rollout: Social questions and challenges' (2018)

critical".[687] One problem has been the functionality of the smart meters, with the first models ceasing to operate smartly if the consumer changed energy suppliers.[688] A new generation of smart meters unaffected by this fault has now been developed, however, and the old meters are starting to be updated remotely to overcome the problem.[689]

198. In order for large numbers of consumers with smart meters to adjust their energy consumption to better match supply, it is likely that they will need to be financially rewarded for doing so. Although some energy suppliers currently offer tariffs that charge consumers according to when they consume energy, these are uncommon.[690] One barrier is the current settlement framework for network charges, under which consumers' consumption is typically estimated rather than measured. Since their suppliers pay the estimated charges, based on average consumer profiles rather than actual usage, the suppliers are then not exposed to the true network usage cost of supplying that consumer, which provides no incentive for the supplier to offer tariffs rewarding consumers for using electricity when it is abundant and cheap.[691] Ofgem told us that it was currently considering the case for market-wide 'half-hourly' settlement,[692] under which all suppliers would be charged according to the actual use of their consumers over every half-hour period. Ofgem said that it would be making its final decision on market-wide settlement reform in the second half of 2019, but warned that "the implementation of market-wide half-hourly settlement depends on the rollout of smart meters":

> A critical mass of smart meters will be needed to realise the full benefits of market-wide half-hourly settlement. To manage consumers without a smart meter when market-wide half-hourly settlement is implemented, a proportion of the energy market may need to continue to operate through some form of profiled data. In these circumstances, there may be costs to maintain the non-half hourly arrangements, which constrains the potential benefits of half-hourly settlement.[693]

199. **The roll-out of smart meters is one important enabling component of a flexible energy system that can match demand to supply, allowing increased deployment of intermittent renewable power generation. However, the Government's roll-out is severely behind schedule, in part because the original scheme had fundamental design faults, as highlighted by our predecessor Committee and the then Energy and Climate Change Committee. *The Government must ensure that it takes all reasonable steps to achieve a national roll-out of smart meters as soon as possible. In order to reduce consumer resistance to smart meters, the Government should run public engagement initiatives to raise public awareness that by having a smart meter installed, consumers can contribute to long-term reductions in the UK's greenhouse gas emissions. Ofgem should require energy suppliers to collect and publish data on consumer acceptance***

687 Q328
688 Department for Business, Energy and Industrial Strategy, 'Smart Metering Implementation Programme' (2018), p12
689 Department for Business, Energy and Industrial Strategy, 'Smart Metering Implementation Programme' (2018), pp12–13 and 'Way clear for second cohort of first-generation smart meters to be enrolled on central network', Data Communications Company, accessed 15 July 2019
690 Imperial College London Energy Futures Lab, 'Unlocking the potential of residential electricity consumer engagement with Demand Response' (2018), p10
691 Imperial College London Energy Futures Lab, 'Unlocking the potential of residential electricity consumer engagement with Demand Response' (2018), p10
692 Ofgem (CGE0033), paras 28–29
693 Ofgem, 'Market-wide Half-Hourly Settlement: Strategic Outline Case' (2018), para 2.41

rates for smart meter installation, and the reasons given by consumers for rejecting a smart meter. The Government should then be ready to act on this information to drive greater installation rates of smart meters, for example by introducing a consumer incentive mechanism. It should also require installation of a smart meter in properties without one whenever the owner or renter changes.

200. **Market-wide half-hourly settlement of energy consumption costs will incentivise energy suppliers to offer tariffs that reward consumers for using energy when it is abundant, helping to enable higher levels of intermittent renewable power generation. However, Ofgem has highlighted the dependence of market-wide half-hourly settlement on widespread smart meter deployment. Given the low current uptake of smart meters, this indicates that there could be very significant delays in the introduction of market-wide half-hourly settlement and the benefits of widespread 'smart' tariff adoption.** ***Ofgem should clarify what it determines to be the critical mass of smart meters required for market-wide half-hourly settlement. Since the introduction of market-wide half-hourly settlement will help to catalyse smart meter take-up, Ofgem should not set an overly stringent critical mass, and should be prepared to recover the costs of incomplete smart meter deployment from the suppliers of those consumers who do not have smart meters (in a way that protects vulnerable consumers).***

The Capacity Market

201. The Capacity Market was established by the then Government in 2013,[694] to address its concerns that falling power generation capacity combined with increasing levels of intermittent renewable generation could weaken the reliability of the electricity network.[695] Under the Capacity Market framework, National Grid estimates future peak electricity demand and determines a corresponding quantity of 'back-up' capacity required to ensure sufficient supply.[696] It then holds a lowest-cost auction for those willing to offer capacity. Successful bidders commit to provide electricity when needed in return for steady capacity payments. Two auctions are held each year, one to source capacity for four years' time (the T4 auction) and one to source additional capacity for one years' time (the T1 auction).[697] All T1 contracts last one year, but T4 contracts are available for up to 15 years for new facilities, for up to three years for refurbished facilities and for one year for existing facilities.[698] If contracted capacity providers cannot deliver electricity when required, they face financial penalties.[699] The cost of the Capacity Market is shared among electricity suppliers.[700]

202. Generation (*i.e.* back-up power generation plants) and non-generation (*e.g.* voluntary demand reduction schemes) approaches are eligible to apply to supply capacity in the Capacity Market.[701] However, non-generation suppliers may only apply for year-long

694 Energy Act 2013, sections 27–43
695 Department of Energy and Climate Change, 'Planning our electric future: A White Paper for secure, affordable and low-carbon electricity' (2011), p59
696 Department of Energy and Climate Change, 'Roles and responsibilities under the Capacity Market' (2015)—National Grid's forecasts are subject to independent scrutiny and approval by the Secretary of State
697 The Electricity Capacity Regulations 2014 (SI 2014/2043), section 2
698 Ofgem, 'Consolidated version of the Capacity Market Rules' (2018), pp25–26
699 The Electricity Capacity Regulations 2014 (SI 2014/2043), sections 39–41 and schedule 1
700 Department of Energy and Climate Change, 'Electricity Market Reform: policy overview' (2012), para 49
701 Department of Energy and Climate Change, 'Electricity Market Reform: policy overview' (2012), para 49

contracts.[702] The first T4 auction took place in 2014 for delivery in 2018/19.[703] Although the majority of capacity was contracted to existing gas-powered plants as expected,[704] the auction also supported a significant increase in small-scale diesel generators.[705] Highview Power, a 'liquid air' energy storage company, told us that this effective support for diesel generators does "not align with the decarbonisation agenda".[706] Tim Lord, Director of Clean Growth at the Department for Business, Energy and Industrial Strategy, highlighted however that capacity contracted through the Capacity Market might be used relatively infrequently—only at specific periods of low supply or high demand—and argued that the Capacity Market's support for fossil fuel technologies was therefore "not necessarily quite as problematic" as a scenario in which such technologies were being operated continuously.[707] Nevertheless, the results of the first T-4 auction will lead to around £1.2bn being provided to fossil-fuel generators over the course of the contracts agreed.[708]

203. Duncan Burt, Director of Operations for National Grid System Operator (which administers the Capacity Market), suggested that there was no technical reason why the Capacity Market could not make greater use of technologies such as batteries, interconnectors and demand-side response systems, without the need for diesel-powered generators.[709] Professor Nick Eyre, Director of the Centre for Research into Energy Demand Solutions, told us, however, that "it is clear that the Capacity Market has not been constructed to be a level playing field" for all technologies.[710] Although the Capacity Market is open to generation and non-generation technologies, non-generation suppliers may only apply for year-long contracts.[711] Professor Eyre argued that "it would be sensible for a demand-side response to be able to get the same contract lengths […] as supply-side technologies" and noted that "there is also no allowance for energy efficiency and energy demand reduction" even though "it is done in a number of American markets".[712] Highview Power advocated "the introduction of a carbon emissions intensity limit" to the Capacity Market, as well as longer contract durations.[713]

204. In 2014, Tempus, a company that manages voluntary demand reduction projects to provide capacity, took the European Commission to court, claiming that it did not sufficiently consider the compatibility of the Capacity Market with internal market and State Aid rules.[714] The General Court of the European Union ruled in November 2018 that the European Commission did not examine with sufficient thoroughness the compatibility of the Capacity Market with State Aid rules.[715] This has put the Capacity Market into a standstill, with no new auctions or payments under existing contracts permitted.[716] The European Commission must now re-evaluate the compliance of the Capacity Market with

702 Ofgem, 'Consolidated version of the Capacity Market Rules' (2018), pp25–26
703 Ofgem, 'Annual Report on the Operation of the Capacity Market' (2015)
704 Ofgem, 'Annual Report on the Operation of the Capacity Market' (2015), p19—see also: Dieter Helm, 'Cost of Energy Review' (2017), p93
705 Q303
706 Highview Power (CGE0050), section 4
707 Q494
708 Ofgem, 'Annual Report on the Operation of the Capacity Market' (2015), pp17 and 19
709 Qq303–304
710 Q305
711 Ofgem, 'Consolidated version of the Capacity Market Rules' (2018), pp25–26
712 Q305
713 Highview Power (CGE0050), section 4.1
714 'Tempus CEO—Why we challenged the UK Capacity Market', Tempus Energy, accessed 4 July 2019
715 General Court of the European Union, 'The General Court annuls the Commission's decision not to raise objections to the aid scheme establishing a capacity market in the UK', 15 November 2018
716 National Grid System Operator, 'Tempus state aid judgment' (2018), p4

State Aid rules, from which the Government has said it expects an Opening Decision "early this year", with the final decision "following later in the year" (neither decision has yet been made).[717] The Government has stated that "the General Court judgment ruled on procedural grounds and did not challenge the fundamental nature of the Capacity Market", and that the ruling "does not change the Government's view that the Capacity Market is the right mechanism to deliver secure electricity supply at least cost".[718] The Energy and Clean Growth Minister, Claire Perry MP, told the Business, Energy and Industrial Strategy Committee in January 2019 that the Government was "working closely with the European Commission to ensure that the Capacity Market can be reinstated swiftly".[719]

205. In line with requirements under the Energy Act 2013, the Minister has said separately that the Government would review the Capacity Market and its first five years of operation. It launched a consultation on this in August 2018 and published a summary of responses in March 2019.[720] The Government's summary of the responses concluded that "the Capacity Market was working as intended" although "there was scope to improve its design in some respects", in particular to ensure that the technology mix acquired through the market minimised costs and achieved "a range of energy objectives" rather than security of supply alone.[721] The summary did not provide detail on specific proposals, but noted that the Government's formal response would be published in summer 2019.[722] The Government's response to a separate consultation has also signalled its intention to allow certain renewable power generation technologies (solar and wind power) to compete in Capacity Market auctions from 2020 onwards.[723]

206. **Energy capacity secured through the Capacity Market supplies energy to the grid relatively infrequently throughout the year, and supports the co-deployment of increasing levels of intermittent renewable power generation. Nevertheless, contracts awarded through the Capacity Market provide funding for energy capacity technologies. So far, this has mostly supported technologies such as gas-fired and diesel generators, which are not in line with the UK's ambition to reach net-zero emissions. *In keeping with the UK's ambition to move towards net-zero emissions, the Government should ensure that the Capacity Market supports low-carbon technologies as far as possible without detriment to the wider deployment of renewable power generation. As it reviews the success of the Capacity Market to date, the Government should consider introducing a minimum proportion of Capacity Market funding that must be awarded to low-carbon technologies.***

207. ***Non-generation suppliers bidding for Capacity Market contracts should be eligible to bid for contracts of up to fifteen years, in line with new generation facilities.***

717 Letter from Rt Hon Claire Perry MP to Rachel Reeves MP, 3 January 2019
718 Department for Business, Energy and Industrial Strategy, 'Proposals for Further Amendments to the Capacity Market' (2019), p4
719 Letter from Rt Hon Claire Perry MP to Rachel Reeves MP, 3 January 2019
720 Department for Business, Energy and Industrial Strategy, 'Capacity Market and Emissions Performance Standard Review: Summary of call for evidence responses' (2019)
721 Department for Business, Energy and Industrial Strategy, 'Capacity Market and Emissions Performance Standard Review: Summary of call for evidence responses' (2019), p6
722 Department for Business, Energy and Industrial Strategy, 'Capacity Market and Emissions Performance Standard Review: Summary of call for evidence responses' (2019), p7
723 Department for Business, Energy and Industrial Strategy, 'Proposals for further amendments to the Capacity Market: Response to consultation' (2019), pp16–17

Price control framework

208. The market regulator, Ofgem, sets what costs energy network operators can recover from consumers' energy bills through its 'RIIO' ('Revenues using Incentives to deliver Innovation and Outputs') framework.[724] Ofgem explained to us that "the RIIO model of price regulation encourages innovation by incentivising network operators to behave in particular ways, for example reducing the number of times electricity consumers experience power cuts".[725] Ofgem is currently reviewing this framework, ready to operate RIIO-2 from 2021 for gas distribution and gas and electricity transmission networks, and from 2023 for electricity distribution networks.[726] It has said that it will "retain an innovation stimulus package, limited to innovation projects that might not otherwise be delivered under the core RIIO-2 framework".[727]

209. The Energy Networks Association told us that the first RIIO framework had had "significant success in encouraging network companies to bring forward innovative projects and embed a culture of innovation within their organisations".[728] It said that it was "vital, therefore, that innovation in networks continues to be strongly incentivised under future price controls, as the networks deliver their crucial role in developing the complex future energy system".[729] SGN, a gas distribution company, similarly told us that "sufficient funding for innovation […] as part of the [RIIO-2 gas distribution] network price control period […] will be crucial to enable timely future heat policy decisions from Government",[730] while Sam French, representing the Decarbonised Gas Alliance, agreed that "RIIO-2 is going to be really important" for the decarbonisation of gas.[731] However, following publication of Ofgem's proposals for RIIO-2,[732] Randolph Brazier, Head of Innovation and Development at the Energy Networks Association, told us that the Association advocated "more support for innovation in RIIO-2 [than what was in Ofgem's proposals], along the lines of what we have in RIIO-1".[733] SSE, a gas and electricity distribution network operator, has also warned that "the proposals put forward by Ofgem in developing the RIIO-2 model now put [the first price control framework's] success at risk".[734] It suggested a series of technical amendments to Ofgem's proposed framework, including the retainment of the Network Innovation Allowance and the Network Innovation Competition from the first framework.[735] These two elements were recently highlighted by a cross-sector strategy as having been "key to driving success forward".[736]

210. In addition to some witnesses expressing their hope for the new price control framework to continue the success of the first, we also heard from stakeholders advocating greater change. For example, Ovo Energy, an energy technology company and supplier, told us that "current incentive structures ought to do much more to accelerate change

724 Ofgem, 'RIIO-2 Framework Decision' (2018), p10
725 Ofgem (CGE0033), para 32
726 Ofgem, 'RIIO-2 Framework Decision' (2018)
727 Ofgem, 'RIIO-2 Framework Decision' (2018), p30
728 Energy Networks Association (CGE0059), para 9
729 Energy Networks Association (CGE0059), para 9
730 SGN (CGE0040), para 4
731 Q214
732 Ofgem, 'RIIO-2 Framework Decision' (2018)
733 Q333
734 SSE, 'Response to National Infrastructure Commission: Future of Regulation Study call for evidence' (2019)
735 SSE, 'Response to National Infrastructure Commission: Future of Regulation Study call for evidence' (2019)
736 Energy Networks Association, 'Gas Network Innovation Strategy' (2018), p3

in the energy system" and should encourage companies to incorporate innovation into business-as-usual, "rather than simply conduct pilot projects with no follow-on".[737] It made specific recommendations for the new framework, including:

- ensuring that network operators could make "genuine financial gains and losses based on their performance on whole-system outcomes", such as contributing to emissions reductions;
- making the cost and availability of new connections for renewable power generation a metric against which network operators were judged; and
- rewarding network operators for using existing infrastructure more efficiently, by making the ratio between maximum capacity and the average load on a network (the 'load factor') a primary metric for adjusting network company revenues.[738]

Ovo Energy has highlighted the last point in particular, arguing that the current price control framework "fail[s] to recognise and prioritise the procurement of flexibility services over alternative options such as investment in new network infrastructure",[739] and advocating with other stakeholders that network operators be "obligated to tackle network constraints by procuring flexibility services as a first measure, rather than by building expensive new network infrastructure".[740]

211. The Energy Networks Association, representing Great Britain's energy distribution network operators, said that it "welcome[d] the recognition [that Ovo Energy's campaign] gives to the important and exciting role that energy networks have to play in delivering a smarter, cleaner energy system", and argued that "energy networks are already delivering [flexibility services] across the country".[741] In 2018, the Association made a 'flexibility commitment', with the six distribution operators in Great Britain committing to:

- consider smart flexibility service markets when building significant new electricity network infrastructure;
- transparently compare relevant reinforcement and market flexibility solutions for all new projects of any significant value; and
- work with Ofgem and other stakeholders to ensure that the incentives under RIIO-2 do not favour the building of new infrastructure where flexibility services are more efficient.[742]

The Energy Networks Association has since published six principles that the network operators will adhere to in order to fulfil their commitment, and included case studies of how operators have acted upon this so far.[743]

737 Ovo Energy (CGE0007), paras 2.3 and 6.2
738 Ovo Energy (CGE0007), para 6.2
739 'Flexibility First: How the UK's network companies can facilitate clean, affordable energy for all', Ovo Energy, accessed 24 June 2019
740 'OVO leads the charge in calling for 'Flexibility First' revolution', Ovo Energy, accessed 24 June 2019
741 ''Flexibility First': Industry calls for networks to procure flexibility over network upgrades', Current +/-, 17 July 2018
742 Energy Networks Association, 'Energy Networks Association's Flexibility Commitment' (2018)
743 Energy Networks Association, 'Our six steps for delivering flexibility services' (2019)

212. **Regulation of UK energy markets will play a key part in the development of a smart and flexible energy system. The RIIO price control framework has helped to support innovation in the gas and electricity networks, but it is vital that the second price control framework promotes even greater levels of innovation as the energy networks undergo a period of significant change.** ***Ofgem must ensure that its second price control framework does not dilute its support for innovation and that the framework should further enable and incentivise network operators to innovate as part of their core business, rather than through standalone projects. Ofgem should work with network operators, energy suppliers and flexibility services providers to ensure that flexibility systems are always considered and deployed ahead of infrastructure construction, where possible and affordable.***

The roles for different stakeholders

The regulator

213. As discussed in the previous section (see paragraphs 208 to 212), the energy markets regulator has a key role to play in the decarbonisation of the UK energy system. The powers and duties of the regulator are provided for by a variety of UK and EU legislation,[744] but its "principal objective" is to "protect the interests of existing and future consumers in relation to gas conveyed through pipes and electricity conveyed by distribution or transmission systems".[745] These interests are defined to be "taken as a whole" and explicitly include consumers' interests in the reduction of gas- and electricity-supply emissions of targeted greenhouse gases.[746] Ofgem told us that its role was to "to design and regulate markets and networks which incentivise the lowest cost transition to a low carbon energy system whilst remaining technology neutral".[747]

214. Despite this responsibility to consider consumers' interests in the reduction of gas- and electricity-supply emissions of targeted greenhouse gases, we heard concerns expressed that Ofgem's focus lay too strongly on lowering costs for current consumers. For example, Zenobe Energy, a battery storage operator, noted that the impact assessment for Ofgem's proposed network charging reforms did not include criteria relevant to the UK's emissions reductions targets.[748] Indeed, Zenobe Energy told us that it thought that the proposed reforms would "undermine the UK's position as a global leader in the development and deployment of storage and renewable technologies".[749] SSE, a gas and electricity distribution network operator, has similarly argued that Ofgem's proposals for the next price framework "put too much emphasis […] on the short-term aspiration to exert downward pressure on customer bills" relative to the longer-term need for, and costs of, decarbonisation.[750] These concerns about Ofgem's proposed network charging reforms aligned with other evidence to our inquiry (see paragraphs 77 to 79).

744 In particular, the Gas Act 1986, the Electricity Act 1989, the Utilities Act 2000, the Competition Act 1998, the Enterprise Act 2002 and the Energy Acts of 2004, 2008, 2010 and 2011

745 'Powers and duties of GEMA', Ofgem, accessed 17 May 2019—for more detail, see: the Electricity Act 1989, section 3A and the Gas Act 1986, section 4AA

746 'Powers and duties of GEMA', Ofgem, accessed 17 May 2019—for more detail, see: the Electricity Act 1989, section 3A and the Gas Act 1986, section 4AA

747 Ofgem (CGE0033), para 2

748 Zenobe Energy (CGE0080), para 10

749 Zenobe Energy (CGE0080), para 9

750 SSE, 'Response to National Infrastructure Commission: Future of Regulation Study call for evidence' (2019)

215. At the request of the Government, the National Infrastructure Commission has launched an inquiry into the regulation of the energy, telecommunications and water markets, examining "what changes might be necessary to the existing regulatory framework to facilitate future investment needs […] while promoting competition and innovation and meeting the needs of both current and future consumers".[751] This is due to report in autumn 2019.

216. **The energy markets regulator has an explicit duty to protect consumers' interests in the reduction of gas- and electricity-supply emissions of targeted greenhouse gases, alongside other considerations such as minimising costs. However, there is no specific link between the regulator's objectives and the UK's emissions reduction targets. In addition, some have expressed concerns that the regulator focuses too heavily on reducing costs for current consumers, at the expense of contributing to the UK's decarbonisation. *When the Government reviews the upcoming recommendations from the National Infrastructure Commission on the future regulation of the energy market, it should consider the case for amending the energy market regulator's principal objective so that it explicitly includes ensuring that regulations align with the emissions reduction targets set out in the Climate Change Act 2008.***

Local authorities

217. Dr Jonathan Radcliffe, who leads the Energy Systems and Policy Analysis Group at the University of Birmingham and acted as a Specialist Adviser for our inquiry, told us that the trend for decentralisation in the energy system would "increase the importance of policy and regulation at a local level".[752] This is apparent from the range of issues relevant to local authorities discussed in this Report, including:

- planning support for low-carbon power generation technologies such as onshore wind farms (see paragraphs 59 to 62 and 65 to 68);
- the impact of urban planning on transport options, such as the quality of walking and cycling infrastructure and of public transport, and the establishment of urban delivery consolidation centres (see paragraphs 127 and 134);
- the provision of electric vehicle chargepoints (see paragraph 106);
- the development and enforcement of local building regulations (see paragraphs 155 to 161);
- the co-ordination between companies, households and infrastructure stakeholders required at a local level to deploy heat networks, which are so far mostly restricted to a few supportive local authority areas (see paragraph 138);[753]
- the strategic oversight required to plan local electricity and gas distribution networks ready for low-carbon transport and heating options such as electric vehicles and heat pumps (see paragraphs 106 and 138); and

751 National Infrastructure Commission, 'The Future of Regulation Study: Call for Evidence' (2019), p3
752 Dr Jonathan Radcliffe (CGE0041), para 18
753 Q54

- opportunities for local authorities to partner with local taxi services to promote the uptake of electric taxis.[754]

218. Dr Radcliffe told us that "a number of cities/regions are implementing their own energy innovation initiatives", pointing to examples in the West Midlands, Aberdeen and the Humber,[755] but argued that "there has been little consideration of the governance framework through which a more decentralised system can be coordinated".[756] Although Professor Nick Eyre, Director of the Centre for Research into Energy Demand Solutions, noted that there were "some excellent initiatives coming out of local government", he indicated that this was far from universal.[757] The Town and Country Planning Association concluded in 2016 that "local plans in England are not dealing with carbon dioxide emissions reduction effectively" and that "since 2012 climate change has been de-prioritised as a policy objective in the spatial planning system".[758]

219. Local authorities have a duty to include policies designed to mitigate climate change in local development plans,[759] with 2019 guidance from the Government for English local authorities stating that their planning systems must aim to support "moving to a low carbon economy" alongside achieving "economic" and "social" objectives.[760] However, this guidance was arguably weakened in 2018, with guidance requiring local authorities to "recognise the responsibility on all communities to contribute to energy generation from renewable or low carbon sources" removed and guidance on "building a strong, competitive economy" no longer referencing decarbonisation.[761] Regen, a not-for-profit sustainable energy consultant, summarised:

> Overall, there are suggestions that local planning authorities should have positive strategies in place and consider energy in relation to new developments, but there is little to require a more proactive approach. As a result, only authorities with the capacity and political drive to plan positively for low carbon will do so.[762]

220. The Energy Systems Catapult has further argued that the new requirements were "primarily focused on enabling low carbon energy-related developments in spatial planning in which the focus is to balance demands for land use", which it said was "conceptually different from local area energy planning, in which the focus is on achieving a balanced energy system while meeting social, economic and environmental objectives".[763] In contrast, Scottish local authorities are explicitly required to act "in the way best calculated to contribute to delivery of the [emissions reductions] targets" set by Scotland's 2009

754 'Electric taxis could be about to hit the streets of Bristol', Bristol Live, 13 May 2019
755 '21st Century Energy', Energy Capital; 'H2 Aberdeen', Aberdeen City Council; and 'Energy Estuary' Humber Local Enterprise Partnership—all accessed 4 July 2019
756 Dr Jonathan Radcliffe (CGE0041), paras 18–19
757 Q345
758 Town and Country Planning Association, 'Planning for the climate challenge?' (2016), p2
759 Planning and Compulsory Purchase Act 2004, section 19
760 Ministry of Housing, Communities and Local Government, 'National Planning Policy Framework' (2019), para 8
761 Ministry of Housing, Communities and Local Government, 'National Planning Policy Framework' (2018) and Department for Communities and Local Government, 'National Planning Policy Framework' (2012), paras 18 and 97
762 'Revised National Planning Policy Framework published', Regen, accessed 21 June 2019—Regen was commenting on the changes to the National Planning Policy Framework made in 2018; although the framework has since been updated again, the relevant sections have not been changed
763 Energy Systems Catapult, 'Local Area Energy Planning: Supporting clean growth and low carbon transition' (2018), p52

Climate Change Act.[764] Randolph Brazier, Head of Innovation and Development at the Energy Networks Association, noted that Scottish local authorities have started to consider local whole energy system plans more than most English authorities.[765] Highlighting the "vaguer" obligations placed on English local authorities compared to Scottish authorities, Professor Nick Eyre argued that "the role of local authorities in the energy system in England" ought to be made more specific.[766]

221. With 115 councils in the UK, as well as the Local Government Association, having declared a 'climate emergency',[767] it is, however, clear that limited local action on decarbonisation is not purely the result of weak obligations dampening ambition. Professor Eyre explained that there was "in many cases, very limited capacity for local government to respond clearly".[768] UK100, a network of local government leaders who have pledged to work towards "100% clean energy by 2050", has similarly said that the ambition of local authorities is "stymied by a lack of capacity and capability when it comes to turning that ambition into reality".[769] With regards to local authorities' access to finance for developments intended to reduce emissions, the Minister of State for Energy and Clean Growth, Claire Perry MP, highlighted Salix Finance, which offers interest-free loans to local authorities to make energy efficiency improvements, and told us that the Government had committed £10m to local energy hubs.[770] Professor Jim Watson, Director of the UK Energy Research Council, told us, however, that "one problem with many local authorities, even those that are doing quite a lot, is that they are very dependent on specific income streams via specific programmes":

> We had a conversation with the Treasury about the mechanism that allows [local authorities] to build up a general capability in this area, whether it is about giving them obligations, or whatever, and the budget to match. When you talk to local authorities, you find that that is often the struggle—they get offices in place on the back of particular projects and programmes, but that does not necessarily mean that over a long term they will get the capability that enables them to make those sorts of planning decisions, unless they are very entrepreneurial and successful.[771]

The Local Government Association has similarly reported, from a survey of local authorities, that the main barriers to local authorities' investment in sustainable transport were a lack of revenue and capital funding and a lack of certainty over continued levels of funding.[772]

222. The Energy Systems Catapult told us that, beyond access to finance, "the problem [local authorities] face is how to decide which options are most appropriate for their local area and in what order they should be prioritised".[773] Tanya Sinclair, Policy Director

764 Climate Change (Scotland) Act 2009, section 44
765 Q355
766 Q356
767 'Declare a Climate Emergency', Climate Emergency, accessed 9 July 2019 and Local Government Association, 'Debate on tackling climate change, protecting the environment and securing global development: Briefing' (2019)
768 Q345
769 UK100, 'Financing the Transition: Harnessing UK Cities' Ambition for Clean Energy' (2019), p1
770 Q452
771 Q55
772 Local Government Association, 'Sustainable Travel: Survey Results' (2018), p9
773 Energy Systems Catapult (CGE0029), para 4

at ChargePoint, told us that many of the strategies adopted by local authorities were transferable and that there was "a need for greater sharing of information between them".[774] Identifying similar problems, the UK Energy Research Centre recommended in 2017 that the Government should "consider further the need for support agencies and shared services for local authority energy developments including national or regional energy agencies and specialist procurement organisations".[775] In an attempt to address both capacity and funding challenges, UK100 recently recommended that the Government launch a 'Clean Energy Action Partnership' programme under which local authorities would be invited to apply for competitive funding to support clean energy projects, with successful authorities provided with access to a new, central team of experts in addition to receiving the funding.[776] UK100 said that, if the programme focused on proposals that could later be transferred to other local authorities, the Government could subsequently "ensure that successful approaches are applied at the national scale and supported into export markets where applicable".[777] This multi-stage approach ties in with the "evolutionary approach" to local area energy planning recommended by the Energy Systems Catapult, which suggested that the Government pursue an "initial emphasis on encouragement, facilitation and supporting funding", moving towards "an obligatory approach in the mid-2020s" if this works well.[778]

223. **Local authorities have a vital role to play in the UK's decarbonisation. Many local authorities are pursuing emissions reductions projects, but the capacity and capability for decarbonisation at the local level varies.** ***The Government should introduce a statutory duty on local authorities in England and Wales, by Green Week 2020, to develop emissions reduction plans in line with the national targets set by the Climate Change Act 2008, and to report periodically on progress made against these plans. In preparation for this new obligation, the Government should establish centralised support to help local authorities develop decarbonisation strategies and deliver initiatives aimed at reducing greenhouse gas emissions. It should also support local authorities' access to low-cost, long-term finance in order to enable the delivery of such strategies. The Government should adopt UK100's proposals for 'Clean Energy Action Partnerships'.***

Consumers

224. Greenpeace UK pointed out that, so far, "most UK carbon emission reduction has happened in the power sector whilst having little impact on most peoples' day to day lives", but that the future impact on consumers would be greater as more consumer-facing sectors such as transport and heating started to decarbonise.[779] The Association for Decentralised Energy has argued that "it is simply not possible to decarbonise the energy system without the customer being central to the transition, because customers own so much of the equipment that causes emissions".[780] Indeed, the Committee on Climate Change has estimated that while 38% of the emissions reductions required for net-zero

774 Q127
775 UK Energy Research Centre, 'What We Know about Local Authority Engagement in UK Energy Systems' (2017), p3
776 UK100, 'Financing the Transition: Harnessing UK Cities' Ambition for Clean Energy' (2019), pp43–53
777 UK100, 'Financing the Transition: Harnessing UK Cities' Ambition for Clean Energy' (2019), p50
778 Energy Systems Catapult, 'Local Area Energy Planning: Supporting clean growth and low carbon transition' (2018), p13
779 Greenpeace UK (CGE0022), para 5
780 Association for Decentralised Energy, 'Solving the energy policy puzzle for users' (2019), p11

emissions by 2050 would likely be purely technological, 53% would require a combination of technological and societal change and 9% would largely entail societal or behavioural changes alone.[781] Many submissions to our inquiry made similar arguments.[782]

225. The most recent of the Government's periodic surveys on public opinion towards climate change reported that 80% of the population were either "fairly concerned" or "very concerned" about climate change.[783] The Government said that this was "the highest proportion of overall concern since the survey started and is driven by an increase in the proportion very concerned about climate change".[784] However, public awareness of how to take measures to support the UK's decarbonisation is not always as great as its apparent concern on the issue. For example, the same Government survey found that 48% of the public had "never heard" of renewable heating systems, with just 6% claiming to "know a lot".[785] UK Research and Innovation similarly told us that although there was "a relatively high level of public awareness of the need to transition to low carbon alternatives" in some areas, for example regarding the uptake of low-emissions vehicles, "in others such as domestic heat, there is very low awareness and insufficient societal acceptance of the degree of disruption that such a transition will entail".[786] It told us that it was working with the UK Energy Research Centre and other sector stakeholders to design a programme, called 'C3T', that would "help improve public awareness of these challenges", but stated that the programme:

> does not yet have the sufficient momentum or Government awareness to give any certainty that it will make a meaningful difference in addressing current low levels of public awareness, or in ensuring the necessary behavioural changes to deliver this transition to a low-carbon economy.[787]

226. With regard to raising consumer awareness, Graham Hazell, representing the Heat Pump Association, told us that "people would like to see an independent route for advice".[788] Many sources of information on emissions-reducing actions exist, from publicly-funded as well as private and third-sector organisations.[789] However, David Weatherall, Head of Policy at the Energy Saving Trust, told us that "one of the areas where there have been cuts in England is in that provision of advice and support".[790] He said that in Scotland, "you can call the Energy Saving Trust acting on behalf of the Scottish Government", who "would send an expert adviser to look at your home and help you to identify what you can do to take action", which nearly 4,000 consumers chose to do in Scotland in 2018, of which 85% went on to take some action.[791] These advisers are trained to deliver bespoke and locally-tailored advice on a range of low-carbon measures including energy efficiency,

781 Committee on Climate Change, 'Net Zero: The UK's contribution to stopping global warming' (2019), p155
782 For example, see: National Grid (CGE0019), para 3.4; Greenpeace UK (CGE0022), para 5; Energy UK (CGE0024), paras 17 and 27–28; Energy Systems Catapult (CGE0029); Royal Academy of Engineering and allied institutions (CGE0055), paras 5.1, 6.1, 25 and 46–48; UK Research and Innovation (CGE0058), para 23; Imperial College London (CGE0071), para 8
783 Department for Business, Energy and Industrial Strategy, 'BEIS Public Attitudes Tracker—Wave 29' (2019), p11
784 Department for Business, Energy and Industrial Strategy, 'BEIS Public Attitudes Tracker—Wave 29' (2019), p6
785 Department for Business, Energy and Industrial Strategy, 'BEIS Public Attitudes Tracker—Wave 28' (2019), p20
786 UK Research and Innovation (CGE0058), para 23
787 UK Research and Innovation (CGE0058), para 23
788 Q214
789 For example, see: 'Save energy at home', Energy Saving Trust; '120 Ways to save and conserve energy', Ovo Energy; 'How to save energy at home', Greener Scotland, all accessed 21 June 2019, and Energy Systems Catapult, 'Living Carbon Free' (2019)
790 Q189
791 Q189

renewable power generation and electric vehicle use, and can act as the initial point of contact for applying for financial support from the Scottish Government for adopting such measures.[792] In contrast, in England, the Government closed the energy saving advice service so that now there is only a website, which offers only generic advice.[793]

227. **Emissions reductions in the transport and heating sectors will involve greater impact on, and require greater involvement of, consumers than the decarbonisation of the power generation sector, which is where the UK has achieved the bulk of its emissions reductions so far. Although public support for measures to reduce emissions appears high, this is not always matched with awareness of what actions consumers can take to support decarbonisation. *In co-ordination with existing organisations, such as the Energy Saving Trust, who work to raise consumer awareness of available emissions-reduction measures, the Government should publish an easily-accessible, central guide for members of the public explaining what measures individuals and households can take to support the UK's decarbonisation.***

228. ***The Government should re-introduce a telephone and visiting advice service in England which offers bespoke advice on measures such as residential energy efficiency and low-carbon heating and transport.***

229. Researchers from Imperial College London noted that some consumers already used their "spending power" to support 'ethical' goods such as organic or fair trade products, and argued that if consumer goods were labelled with clear information regarding the emissions involved in their manufacturing and transport, the market could reward and incentivise lower-emissions products.[794] Addressing the complexity of modern supply chains and hence the potential difficulty of tracking emissions, the research group further added that it had "devised a method to calculate the carbon footprints of all consumer goods" using machine-learning.[795]

230. **Product labelling already helps consumers choose products based on qualities such as healthiness, environmental impact and employee or animal welfare. *The Government should explore the feasibility and potential benefits of establishing a standard for the emissions associated with the manufacturing and transportation of consumer goods, to enable retailers to label their products with emissions information and to enable consumers to factor this into their purchasing decisions.***

Equity

231. The Committee on Climate Change has estimated that achieving net-zero emissions could cost around 1–2% of GDP by 2050.[796] Professor Jim Watson, Director of the UK Energy Research Centre, highlighted "the need to implement this [lower-emissions] transition in a way that pays attention to equity, particularly to the fuel poor", and to "address some of the arguments sometimes made that we are spending too much money and that there is a disproportionate burden on poorer consumers and citizens".[797] He suggested that this could involve "thinking about things like implementing upgrades to

792 'Grants and Loans', Energy Saving Trust, accessed 9 July 2019
793 Q189—see also: 'Simple Energy Advice', accessed 9 July 2019
794 Imperial College London (CGE0071)
795 Imperial College London (CGE0071), para 2
796 Committee on Climate Change, 'Net Zero: The UK's contribution to stopping global warming' (2019), pp212–255
797 Q41—see also: Durham Energy Institute (CGE0065), paras 15–18

homes and targeting [the fuel poor] first".[798] Several stakeholders have pointed out that policies that ultimately derived funding from energy bills were more regressive than using general taxation.[799] For example, Energy UK told us that supplier obligations like the Energy Company Obligation were "financially regressive as the costs are distributed among energy consumers regardless of their ability to pay" and said that it "strongly believes that the fairest and most progressive method of funding energy efficiency programmes is through general taxation".[800]

232. Professor Watson added that the Government should also consider "the industrial strategy benefits and jobs benefits [of decarbonisation], thinking about the regional economies and spread of those benefits in the way we implement those strategies", adding that he did not think the Government was doing enough on this front.[801] Menter Môn, a marine energy developer, similarly argued that "supply chain improvements and bringing jobs to the extremities of the UK, where unemployment is higher, and prospects are lower, should be a result of investment in clean growth".[802] Several submissions highlighted technological opportunities for low-carbon growth that would align with economic regeneration in disadvantaged communities, for example:

- the Durham Energy Institute told us that geothermal heating could make use of water in flooded coal mines, potentially bringing "employment and inward investment" to regions with disused coal mines;[803]
- Johnson Matthey highlighted that "brown field sites in the North East and North West, South Wales, Grangemouth, Humber and Aberdeen" would be "obvious locations for hydrogen production at large scale";[804] and
- Marine Energy Wales told us that "50–60% of the economic benefit of both gross value added and jobs expected to be generated" by marine energy would be "in coastal areas in need of economic regeneration".[805]

The Renewable Energy Association also flagged the "regional nature of both marine and geothermal technologies, which include Cornwall, Wales and Scotland", and said that this "means they could be essential components of regional sector deals, crucial to growth in these areas".[806]

798 Q41—see also: 'About the ECO scheme', Ofgem, accessed 17 June 2019
799 For example, see: Energy UK (CGE0024), para 25; UK Energy Research Centre, 'Review of Energy Policy: 2018' (2018), p7; 'How can we make sure the low carbon energy transition is fair?', Green Alliance, accessed 4 July 2019
800 Energy UK (CGE0024), para 25
801 Q41
802 Menter Môn (CGE0002)
803 Durham Energy Institute (CGE0065), para 28
804 Johnson Matthey (CGE0066), para 13
805 Marine Energy Wales (CGE0047), para 1.6
806 Renewable Energy Association (CGE0026), para 16

233. **The decarbonisation of the UK's economy is critical for the environment and is a legally-binding target for the Government. Although decarbonisation offers opportunity for economic growth, it will inevitably also entail costs. The Committee on Climate Change has estimated that achieving net-zero emissions could cost around 1–2% of GDP by 2050. It is important that these costs are shared fairly among citizens.** ***The Government must ensure that its policies for achieving net-zero emissions consider the economic impacts on individuals. The Government should aim to cover the costs of measures through progressive means rather than through energy bills.***

234. ***In line with the Government's focus on 'place' in its Industrial Strategy, the Government should include the potential for supporting economic growth in disadvantaged regions in its determination of where to locate demonstration projects and other initiatives.***

8 Carbon capture and storage

235. In addition to minimising the extent of global warming by reducing greenhouse gas emissions—by reducing demand for carbon-intensive processes or by making those processes less carbon intensive—technologies can also be used to directly capture carbon dioxide, either at the point of emission from an industrial process or from the ambient atmosphere. Depending upon the technique used, this can significantly reduce overall emissions or even deliver a net reduction in the quantity of carbon dioxide in the Earth's atmosphere. This Chapter examines some of these techniques and what the Government should be doing to provide the appropriate level of support for their development and deployment.

Carbon capture, usage and storage

236. Carbon capture and storage (CCS) entails collecting the carbon dioxide released during a process and storing it so that it is not released into the atmosphere. CCS could, for example, significantly reduce or potentially eliminate emissions from a range of processes including power generation, hydrogen production or industrial processing.[807] Carbon capture, usage and storage (CCUS) is a related term incorporating the possible use of captured carbon dioxide, for example as an ingredient for construction materials or to produce biofuels.[808] The Carbon Capture and Storage Association warned us, however, that carbon usage has "limited potential for climate mitigation due to the limited overall volumes of CO_2 that can be utilised".[809]

237. The Committee on Climate Change has stressed "the importance of carbon capture and storage to achieving the current 2050 target at lowest cost and being an enabler of deeper reductions beyond that".[810] In 2014 (prior to the UK strengthening its 2050 emissions reduction targets), the Energy Technologies Institute estimated that the cost of meeting the UK's then target for 2050 would be around £30bn greater without the use of carbon capture and storage.[811] Malcolm Brinded, representing the Royal Academy of Engineering and allied institutions, told us that "CCS is going to be an essential component of any negative emissions strategy for the world to get to 2°C and certainly to 1.5°C", and that large-scale demonstrations of CCS would provide "an opportunity for the UK to be at the front of that".[812] Several other submissions to our inquiry, including from Energy UK and the Energy Systems Catapult, also described CCS as a key technology for the decarbonisation of multiple sectors, and emphasised the importance of Government support for further development.[813]

238. In 2018, the Government published an "action plan" for CCUS, stating an overall ambition for the UK to deploy a first CCUS facility in the 2020s and to "have the option to deploy CCUS at scale during the 2030s, subject to the costs coming down sufficiently".[814]

807 Scottish Carbon Capture and Storage (CGE0021), section 3
808 Global CCS Institute, 'The Global Status of CCS: 2017' (2017), p9
809 Carbon Capture and Storage Association (CGE0023), para 6
810 Committee on Climate Change, 'Reducing UK emissions: 2018 Progress Report to Parliament' (2018), pp44–45
811 Energy Technologies Institute, 'Carbon Capture and Storage: Potential for CCS in the UK' (2014), p23
812 Q49
813 For example, see: Cadent (CGE0015), para 3; Energy UK (CGE0024), paras 19–22; Drax Group plc (CGE0025), paras 36–38; Energy Systems Catapult (CGE0029), para 5; Decarbonised Gas Alliance (CGE0032), para 25; The Geological Society (CGE0051), paras 7–9
814 HM Government, 'The UK Carbon Capture Usage and Storage deployment pathway: An Action Plan' (2018)

The action plan highlighted the £315m 'Industrial Energy Transformation Fund' as a potential source of funding for CCUS projects,[815] and stated the Government's intention to:

- provide £40m for innovation programmes focused on CCUS and collaborate with industry and academia on further innovation;
- work with industry to identify investable commercial models and establish market-based frameworks for bringing forward CCUS;
- review barriers to deployment and consult on findings;
- identify opportunities to re-use existing infrastructure and share existing or new infrastructure;
- assess delivery capability required for projects during the 2020s; and
- work with international partners to accelerate the global deployment of CCUS and support global cost reductions.[816]

The Government has since allocated £170m to support the development of the world's first 'net-zero carbon' industrial cluster by 2040, with carbon capture and storage expected to play a prominent role.[817]

239. Professor Gibbins told us that "if it is carried through", the Government's CCUS plan made the large-scale deployment of carbon capture and storage "eminently viable",[818] adding that the Minister had "done an awful lot to accelerate [the deployment of CCS] and make it clear that things need to happen".[819] The Committee on Climate Change welcomed the action plan as a sign of the Government's "recommitment" to carbon capture and storage, but cautioned that "the Government has not yet proposed concrete approaches to tackle the challenges in deploying CCS in the UK", noting that "many of these have been well understood for some time and should progress more quickly than proposed in the action plan".[820] The Carbon Capture and Storage Association, representing a variety of companies working on CCS, similarly told us that the "Government's recognition of the need to develop the first project by the mid-2020s as an enabler towards having the ability to deploy CCUS at scale in the 2030s" was "an important element" of the plan, but highlighted several "limitations and missing aspects" in the plan:

- it said that the plan lacked a "clear framework", which left industry unsure of "how and on what terms it can invest in CCUS", and that it also lacked clarity in the Government's definition of deployment "at scale", its criteria for sufficient cost-reduction and its proposed balance of cost-sharing with industry;

815 HM Government, 'The UK Carbon Capture Usage and Storage deployment pathway: An Action Plan' (2018), p33—see also: Department for Business, Energy and Industrial Strategy, 'Designing the Industrial Energy Transformational Fund' (2019)

816 HM Government, 'The UK Carbon Capture Usage and Storage deployment pathway: An Action Plan' (2018), pp6–11

817 'World-first carbon 'net-zero' hub of heavy industry to help UK seize global economic opportunities of clean growth', Department for Business, Energy and Industrial Strategy, accessed 4 July 2019

818 Q403

819 Q404

820 'CCC welcomes Government's recommitment to Carbon Capture and Storage technology', Committee on Climate Change, accessed 4 July 2019

- it contrasted the Government's ambition to have the option to deploy CCUS in the 2030s, subject to cost-reductions, with the importance of CCUS to the UK's future decarbonisation as described by the Committee on Climate Change; and
- it argued that the Government should aim to develop at least two to three CCUS clusters during the 2020s, rather than just one individual facility.[821]

The Carbon Capture and Storage Association consequently told us that "further commitments and early actions from both Government and industry are required to ensure the progression of a pipeline of multiple projects in the near-term".[822]

240. The UK Government has already twice run competitions to develop CCS plants, both without success. The first was launched in 2007 and closed in 2011,[823] while the second was launched in 2012 and ended in 2015.[824] The National Audit Office estimated that the first and second CCS projects cost the Government £64m and £100m respectively prior to their cancellation.[825] Professor Gibbins explained that these projects combined carbon capture and storage with coal or gas-fired electricity generation, and failed due to a combination of the recession dampening demand for electricity, shale gas and renewable power developments competing with coal and gas-fired power generation, and insufficient scale.[826] He told us that, learning from these previous projects, it was now "important that the Government aim to develop a number of these clusters […] because if you aim to do one it is very easy to end up doing nothing", whereas "if you get ready to do several, at least one will happen first and, since we need the others anyway, they will follow on".[827] He also highlighted the importance of "open access development" of Government-supported demonstration projects, arguing that learning generated through such projects should be made public rather than commercially protected, so that "commercial readiness and expertise [builds up] more quickly than would normally happen".[828]

241. **Carbon capture and storage has been widely identified as a key technology for decarbonisation in several sectors. The Energy Technologies Institute estimated, prior to the UK's net-zero emissions ambition, that meeting the UK's original 2050 emissions targets without the use of carbon capture and storage would incur an additional £30bn in costs. This puts the Government's desire for value-for-money in context. We commend the Government for recapturing lost momentum in the development of carbon capture and storage. However, there are concerns that its action plan lacks clarity and ambition.**

242. ***Industry must have clarity on the framework through which it can invest in carbon capture, usage and storage (CCUS), as well as the timetable for the Government's CCUS Action Plan. The Government must provide greater clarity on the details of its action plan, and should set out in its response to this Report: what it considers to be deployment at scale; what constitutes cost-effectiveness or sufficient cost-reduction; how it expects***

821 Carbon Capture and Storage Association (CGE0079), paras 4–9
822 Carbon Capture and Storage Association (CGE0079), para 8
823 'Longannet carbon capture scheme scrapped', BBC News, 19 October 2011
824 'UK government carbon capture £1bn grant dropped', BBC News, 25 November 2015
825 National Audit Office, 'Carbon capture and storage: lessons from the competition for the first UK demonstration' (2012), p4 and National Audit Office, 'Carbon capture and storage: the second competition for government support' (2017), p4
826 Q396
827 Q403
828 Q393

to share costs with industry; and what the major milestones for the plan are, as well as when they are expected to be achieved. The Government should learn from previous carbon capture and storage projects and ensure that a sufficient number of projects, of sufficient scale, are undertaken to optimise the chance of successful deployment, and that the knowledge gained from publicly-funded work is publicly accessible.

A greenhouse gas removal strategy

243. A variety of techniques exist whose overall effect is to reduce the level of greenhouse gases in the atmosphere.[829] The Royal Society and the Royal Academy of Engineering have set out the major examples of these greenhouse gas removal technologies, as well as the maximum quantity of greenhouse gases they estimated these technologies could plausibly remove in 2050 (reproduced in Table 2).

Table 2: Major greenhouse gas removal techniques

Technique	Maximum 2050 greenhouse gas removal capacity (MtCO2)	Description
Bioenergy with carbon capture and storage (BECCS)	50	Capturing and storing the emissions produced as sustainably sourced biomass (e.g. wood) is burnt to produce energy, to remove the carbon extracted from the atmosphere by the biomass as it grew
Direct air carbon capture and storage (DACCS)	25	Deploying technologies that extract carbon dioxide directly from the air, for example through chemical reactions that convert carbon dioxide into a different chemical
Forestation	15	Growing new forests, whose trees absorb carbon dioxide as they grow
Enhanced terrestrial weathering	15	Accelerating the natural decomposition processes of certain minerals that extract carbon dioxide from the air as they decompose, for example by milling the minerals into a fine powder that can be spread over crops
Soil carbon sequestration	10	Changing land management practices to promote the capture and retention of carbon by soil, for example by using certain crops or fertilisers

829 'Negative Emissions Technologies', POSTnote 447, Parliamentary Office of Science and Technology, October 2013

Technique	Maximum 2050 greenhouse gas removal capacity (MtCO2)	Description
Biochar production and use	5	Converting biomass into 'biochar' products such as charcoal can significantly slow the rate at which carbon dioxide is released as it decomposes, as well as improving the fertility of soil it is spread on (which can further enhance carbon dioxide capture)
Habitat restoration	5	Restoring ecosystems that absorb high quantities of carbon dioxide, such as wetland, peatland or certain coastal habitats
Low-carbon building methods	5	Using sustainable wood or low-carbon concrete increases the carbon dioxide stored in building materials

Source: Royal Society and Royal Academy of Engineering, 'Greenhouse Gas Removal' (2018), pp25–65 and 95–103

Greenhouse gas removal projections

244. The Committee on Climate Change has stated that, even with the deployment of emissions reductions options "towards the maximum limits that are likely to be feasible, acceptable and sustainable", it expects the UK to emit greenhouse gases with the equivalent warming impact of around 130 million tonnes of carbon dioxide ($130MtCO_2e$) in 2050.[830] In order to meet the Government's target of net-zero emissions by 2050, this will therefore require the annual removal of $130MtCO_2e$ by 2050. Comparing this quantity with the total estimated greenhouse gas removal capacity of all plausible technologies combined (see Table 2), the Royal Society and the Royal Academy of Engineering concluded that the Committee on Climate Change's estimated removal requirement was "possible, but very challenging", and would involve "many methods [of greenhouse gas removal] deployed at the limit of their maximum deployment".[831]

245. In contrast to these projections, none of the Government's three "illustrative" pathways to meeting the UK's existing 2050 emissions reduction target involves any more than $20MtCO_2$ removal (despite one being labelled the "emissions removal" pathway).[832] Dr Naomi Vaughan, of the Tyndall Centre for Climate Change Research, highlighted that the Government's new target of net-zero emissions by 2050 would make greenhouse gas removal "even more necessary" given the difficulty of eliminating emissions from certain processes in aviation, agriculture and industry.[833]

246. Reviewing the technological readiness of greenhouse gas removal technologies, the Royal Society and Royal Academy of Engineering reported that "some greenhouse gas removal methods are already in use today, while others require significant development and demonstration before they can remove emissions at scale", but qualified that "when

830 Committee on Climate Change, 'UK Climate Action following the Paris Agreement' (2016), pp35–39
831 Royal Society and Royal Academy of Engineering, 'Greenhouse Gas Removal' (2018), p9
832 HM Government, 'The Clean Growth Strategy' (2017), pp151–152
833 Q362

considered at the scale required, none of the methods have been fully evaluated across their life cycle".[834] In order to meet the scale of removal necessary for 2050, Dr Naomi Vaughan, of the Tyndall Centre for Climate Change Research, told us that most of these technologies would need to start being deployed during the 2030s in order to contribute fully to the greenhouse gas removal required by 2050.[835] Professor Gideon Henderson, representing the Royal Society, said that the technologies could be broadly broken down into three categories of readiness:

- those that can be rolled out now, including forestation, habitat restoration, soil carbon sequestration and low-carbon building methods;
- those that still require substantial research and development, including biochar production and use, and enhanced terrestrial weathering; and
- technologies that will need to be deployed in conjunction with carbon storage, namely bioenergy and carbon capture and storage and direct air carbon capture and storage.[836]

He warned that there was an "urgent need to do research and development" on the second category of technologies, because it "would take some time, in order for us then to be able to roll them out to achieve net zero in 2050", while Professor Jonathan Gibbins, Director of the UK Carbon Capture and Storage Research Centre, told us that technologies requiring carbon capture and storage needed to start being deployed at scale "very quickly".[837]

Frameworks for the deployment of greenhouse gas removal technologies

247. Professor Henderson flagged that technological readiness would not be the only consideration relevant to the deployment of greenhouse gas removal technologies.[838] For example, Professor Jim Skea, of Imperial College London, highlighted that "transmitting a carbon price in some form is absolutely essential" because "people need to be rewarded" if they are to deploy greenhouse gas removal technologies.[839] Professor Henderson told us that there were a range of ways to incentivise the deployment of greenhouse gas removal technologies, including direct payments, tax credits or obligations on certain stakeholders.[840] In addition to requiring a system for incentivising or mandating greenhouse gas removal, he indicated that it would also probably be necessary to determine a price associated with emissions:

> Normally, the way in which we judge whether [greenhouse gas removal technologies] are worthwhile is to look at what you might call the social cost of carbon. You work out how much you think a tonne of CO_2 in the atmosphere is doing damage to the planet and societies, value that and then work out whether the cost of your technologies to remove the carbon dioxide is lower than that social cost of carbon. The Stern-Stiglitz report, for

834 Royal Society and Royal Academy of Engineering, 'Greenhouse Gas Removal' (2018), p8
835 Q366
836 Q367
837 Q367
838 Q372
839 Q376
840 Q380

> instance, values the social cost of carbon currently at something like US$30 per tonne of CO_2, with that escalating into the future. It rapidly gets to $50 and $100.[841]

Professor Gibbins argued that "a better measure of cost is what it would cost to get carbon neutrality by other means", saying that net-zero emissions would have to be achieved one way or another.[842]

248. As well as a framework for determining a suitable incentive or requirement for greenhouse gas removal, Professor Skea said that "one of the prerequisites would be better measurement and estimate of emissions [removals]" achieved by deployments of such technologies, explaining that "you need to be able to measure it, so that you can reward it properly".[843] Professor Henderson noted that a framework for greenhouse gas removal would require systems for reporting and verification as well as measuring and monitoring.[844] Dr Vaughan further noted that different frameworks would probably be required for technologies related to land management, which typically involve large numbers of landowners and farmers, compared to those that require significant infrastructure, which might involve networks of industries.[845]

249. Dr Vaughan also highlighted the wider environmental impacts of different greenhouse gas removal technologies.[846] In particular, she emphasised that "it is essential that […] bioenergy is sustainably sourced":

> You could have biomass energy with carbon capture with storage of a megaton of CO_2 underground, but the net effect is not to remove anything if you get wrong how you get that bioenergy. If you deforest a primary rain forest or interfere with a high-carbon ecosystem, you can make all that effort but the planet will see no benefit.[847]

Dr Vaughan said that the governance and regulation of bioenergy was therefore critical, and would have to be assured for international imports as well as domestic produce. Beyond the importance of ensuring that bioenergy with carbon capture and storage yields net greenhouse gas removal, Professor Henderson told us that "in many cases we do not really know the environmental impact" of greenhouse gas removal technologies, which could relate to impacts on biodiversity, environmental toxicity or food security, and that this was "another reason why doing things at field scale and demonstrating them is really important to see how the impact plays out".[848]

841 Q383
842 Q385
843 Q376
844 Q390
845 Q390
846 Q397
847 Q397
848 Q401

The Government's support for greenhouse gas removal

250. In its Clean Growth Strategy, the Government stated that its "strategic approach to greenhouse gas removal" had two main elements:

- a research and development programme, to "help overcome the uncertainties around their costs, deployment potential, and impacts on the environment"; and
- consideration of "the scope for removing barriers and strengthening incentives to support the deployment of greenhouse gas removal".[849]

The research and development programme received £8.6m of funding over four years until 2021.[850] Professor Henderson told us that although the UK's greenhouse gas removal research programme was "the first of its type internationally", "there is an urgent need for more", in particular for demonstration trials and lifecycle assessment.[851] Professor Skea agreed that "what is needed is a real demonstration to the commercial sector".[852] Discussing direct air carbon capture and storage and bioenergy with carbon capture and storage specifically, UK Research and Innovation—the body responsible for overseeing the Government's research and innovation programme—told us that "with some notable exceptions […] more needs to be done to demonstrate the potential of these technologies".[853]

251. Regarding the Government's consideration of the barriers and incentives for greenhouse gas removal technologies, the Government recently said that it "has no current policies to deploy specific greenhouse gas removal technologies beyond existing commitments made in the Clean Growth Strategy to plant 11 million trees in England, to restore peatland, and to increase the amount of UK timber used in construction".[854] Professor Henderson told us, however, that as far as he knew, "currently there are very few, if any, approaches in the UK that financially incentivise removal of CO_2":

> In fact, many of the greenhouse gas removal technologies are not formally factored into global carbon accounting at the moment. Forestation is an exception. Most other technologies are not factored in.[855]

Dr Vaughan highlighted that the Government was not meeting its targets for forestation, and that there was "a basket of things that we can do now", including coastal habitat restoration as well as a greater level of forestation and peatland restoration.[856] Professor Skea added that land management practices could also contribute to greenhouse gas removal already, and noted that he had had "many complaints from the National Farmers Union that farmers are punished for their livestock emissions, but not rewarded for the way in which they manage the land and the soil".[857] Professor Henderson flagged that the Government had recognised the potential for an improved incentives framework for land use management in its 25-year environment plan, and that this would "probably be

849 HM Government, 'The Clean Growth Strategy' (2017), p57
850 '£8.6 million UK research programme on greenhouse gas removal', Natural Environment Research Council, accessed 20 June 2019 and PQ HL15075, 16 April 2019
851 Q390
852 Q390
853 UK Research and Innovation (CGE0058), para 7
854 Department for Business, Energy and Industrial Strategy, 'The UK Government's View on Greenhouse Gas Removal Technologies and Solar Radiation Management ("Geoengineering")' (201)
855 Q388
856 Qq383–384 and 390
857 Qq376 and 387

recognised in the Environment Bill".[858] The '25 Year Plan' did state the Government's intention to work with stakeholders to design a new woodland creation grant scheme to "incentivise larger scale afforestation to meet carbon goals and wider environmental benefits at a landscape scale".[859] However, the draft Environment Bill does not reference forestation, and the draft Agriculture Bill includes powers for the Secretary of State to "give financial assistance for or in connection with the purpose of starting, or improving the productivity of, an agricultural, horticultural or forestry activity" but only in the context of improving the quality of forestry products or the resource efficiency of these activities.[860]

252. **The Government's new ambition, to reach net-zero emissions by 2050, will probably require the active removal of at least 130 million tonnes of carbon dioxide from the atmosphere annually by 2050. This is significantly greater than the extent of greenhouse gas removal envisioned in any of the Government's previous 'illustrative pathways' to meeting its original 2050 target, and is also at the limit of what is expected to be reasonably deliverable.** ***The Government should plan for the deployment of greenhouse gas removal technologies capable of removing around 130 million tonnes of carbon dioxide by 2050. It should develop and publish, within six months of this Report's publication, an illustrative pathway detailing the full extent of greenhouse gas removal that it projects to be possible from each major technology option by 2050, as well as a strategy for ensuring this pathway is feasible, including any policy decisions required now.***

253. ***The Government should launch a consultation to inform the development of a future framework for managing and incentivising greenhouse gas removal, and to provide greater certainty to encourage private investment in the development of these technologies. The consultation should examine potential frameworks for valuing, incentivising, measuring, reporting and validating greenhouse gas removal by different technologies.***

254. **The step-change in greenhouse gas removal required by the Government's new ambition to reach net-zero emissions by 2050 will require a significant increase in current support for greenhouse gas removal technologies. Some urgently require research and development, whereas others could be deployed at scale now with the correct support.** ***In line with its future strategy for greenhouse gas removal, the Government should be ready to increase funding for research, development and demonstration of greenhouse gas removal technologies. It must also ensure that it is seizing currently available opportunities for greenhouse gas removal, and should develop an effective framework for managing and incentivising forestation and land use management to achieve net emissions removals.***

Geoengineering

255. In addition to technologies for removing carbon dioxide from the atmosphere, there are some proposed technologies that could potentially control global warming in other ways. The main technologies aim to do this by managing the solar radiation entering the Earth's atmosphere and striking its surface, for example by:

858 Q377
859 HM Government, 'A Green Future: Our 25 Year Plan to Improve the Environment' (2018), pp49–50
860 Draft Environment (Principles and Governance) Bill and Draft Agriculture Bill, section 1

- releasing reflective aerosol particles high in the Earth's atmosphere;
- spraying saltwater into the sky above seas, to precipitate increased, brighter cloud cover;
- using ships to churn up microbubbles on the ocean surface, increasing the reflectivity;
- distributing particles via aircraft or drones to dissipate high-altitude cirrus clouds, which absorb heat from the Sun; or
- putting a fleet of mirrors into orbit.[861]

256. Dr Naomi Vaughan, of the Tyndall Centre for Climate Change Research, told us that "modelling studies have shown that some [solar radiation management] technologies could lower the temperature", but said that this would only last as long as the intervention was maintained, and would not address the underlying problem of excess greenhouse gases in the atmosphere.[862] Professor Gideon Henderson, representing the Royal Society, further warned that "the cooling is also not uniform, so radiation management would not lead to the same cooling level across the world; you would get patchiness and, therefore, different countries would benefit differently".[863]

257. Professor Gibbins agreed that "solar radiation management is a very dangerous thing to do", but noted that "globally there would be a strong incentive to do it if it seemed like the alternatives were worse—for example, destabilisation of the Greenland ice cap or uncontrolled release of methane from thawing permafrost".[864] He argued that it was "very much in the UK's interest to research solar radiation management to show how dangerous it is and all the effects you will get:

> It does not reverse CO_2 emissions, but, bearing in mind that we may face suggestions to use it even within our lifetime, we need to be prepared. Wilfully closing our eyes to studying it because it is very unattractive and dangerous is not a responsible attitude.[865]

Professor Jim Skea, of Imperial College London, told us that his personal opinion was that "it would be worthwhile doing desk studies of solar radiation management", but that he would be "far less convinced of the case for doing demonstration".[866] Professor Henderson similarly told us that he thought that the "dominant research spending should be on greenhouse gas removal" compared to solar radiation management.[867]

258. **Solar radiation management does not address the fundamental problem of excess concentrations of greenhouse gases in the Earth's atmosphere, and does not appear to be a long-term solution to global warming. Nevertheless, it may be considered as a short-term solution if global greenhouse gas emissions are not reduced quickly enough to avoid significant global warming. In this scenario, detailed understanding of the wider effects of solar radiation management will be vital. *UK Research and Innovation***

861 'Explainer: Six ideas to limit global warming with solar geoengineering', Carbon Brief, accessed 4 July 2019
862 Q409
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should review the current state of research into solar radiation management, the likely timeframes that would be required for detailed research and potential testing of such technologies, and the case for any increased research now. It should ensure that research into solar radiation management is sufficient to allow for any potential future decisions to be made on the deployment of such technology to be sufficiently well-informed.

Conclusions and recommendations

UK Greenhouse Gas Emissions

1. The UK has achieved world-leading emissions reductions for over two decades. However, this has not been exclusively the result of Government policies. The Government has decided to carry forward the equivalent of 88 million tonnes of carbon dioxide from the second carbon budget to the third, as permitted by the Climate Change Act 2008, pending advice from the Committee on Climate Change on technical changes to how the UK calculates and reports its emissions. *The Government must not use outperformance of the second carbon budget to weaken its targets for subsequent carbon budgets. As soon as possible after the Committee on Climate Change's advice on technical changes to the UK's emissions baseline, the Government should unambiguously declare its commitment to follow that advice.* (Paragraph 12)

2. Progress against the UK's emissions reductions targets must not be achieved by 'offshoring' UK industry and displacing the UK's territorial emissions to be counted instead in its consumption emissions. The Government should do more to meet its commitment to increase the prominence of consumption emissions statistics in its publications. *The Government should include consumption emissions alongside territorial emissions in all future publications on UK emissions. It should consider the impact of all policies on consumption emissions as well as territorial emissions, and ensure that progress is not achieved by 'offshoring' emissions to other countries to the detriment of the global environment. We do not accept that territorial emissions should be the sole basis for international negotiations. The United Kingdom's decarbonisation targets should also include consumption emissions.* (Paragraph 16)

3. We commend the Government for adopting a net-zero emissions target, in line with the 2015 Paris Agreement. It is vital now that this ambition is backed up with policies to ensure that the UK meets its targets. *The Government must develop and act on policies to ensure that the UK is on track to meet a 2050 net-zero emissions target. It must seek to achieve this through, wherever possible, domestic emissions reductions. However, it should also work to develop robust international frameworks for carbon units trading, to ensure that effective and efficient methods for reducing global emissions are supported where available.* (Paragraph 19)

4. We commend the Government on responding promptly to the Intergovernmental Panel on Climate Change's 2018 report on 1.5˚C global warming, by asking the Committee on Climate Change (CCC) for advice on net-zero emissions. However, it is disappointing that the Government excluded existing carbon budgets from the scope of this advice. *The Government should explicitly state, in advance of the CCC's advice on the sixth carbon budget, its willingness to amend the fourth and fifth carbon budgets in line with the CCC's cost-effective path to net-zero emissions by 2050 if recommended to do so.* (Paragraph 21)

5. Lord Deben, the Chairman of the Committee on Climate Change, gave evidence to our Committee. He did not declare his interest as the Chair of Sancroft International. This company has had amongst its clients Drax, the largest recipient of renewable

energy subsidies in the country, and Johnson Matthey, who are about to make a huge investment in electric vehicles. These should have been declared to the Science and Technology Committee. (Paragraph 23)

The Clean Growth Strategy

6. The Government's own projections suggest that the UK is not currently on track to meet its existing emission targets, although we note that there are several significant policies and ambitions that have not yet been included in these calculations. Nevertheless, the rate of deployment of several key low-carbon technologies is significantly lower than what is required to meet the Government's ambitions, and various stakeholders—including the Committee on Climate Change—have expressed concern at the current and projected rate of progress of the UK's decarbonisation. In order to meet the fourth and fifth carbon budgets, emissions reductions cannot continue only in sectors that have decarbonised successfully so far, and must be significantly accelerated in sectors such as transport, heating and agriculture that have made little progress. The step-change in decarbonisation required will need policies to support the deployment and roll-out of existing technologies alongside, and co-ordinated with, significant research, development and demonstration of less mature technologies. (Paragraph 36)

7. The UK can simultaneously achieve economic growth and global emissions reductions through the export of low-carbon technologies to other countries. This potentially offers global emissions reduction at lower cost than the same level of reduction in the UK. However, opportunities for delivering emissions reductions outside of the UK were not included in the 50 key policies and proposals of the Government's Clean Growth Strategy. When it laid legislation strengthening the UK's long-term emissions reduction targets, the Government said that it would review the net-zero target within five years, to review the extent to which other countries had followed the UK's lead in setting and acting upon decarbonisation targets. (Paragraph 40)

8. *Ahead of its review of international reaction to the UK's net-zero target, the Government should actively encourage other countries to take similarly ambitious action. It should develop a strategy by the end of 2020, identifying opportunities for the UK to encourage and support decarbonisation in other countries, and prioritising action that will achieve the greatest global emissions reduction. This should include cross-Government action to support British companies exporting technologies that can deliver emission reductions abroad.* (Paragraph 41)

9. *The Government should increase the number of Ministers across Government Departments working on climate change, including a new Ministerial role at the Foreign and Commonwealth Office with explicit responsibility for delivering multi-lateral action internationally on climate change. Reflecting the critical importance of mitigating climate change, and to improve cross-Government co-ordination, the Minister charged with co-ordinating the UK's action on national and international decarbonisation should be a full Cabinet Minister.* (Paragraph 43)

Decarbonising power generation

10. We commend National Grid Electricity System Operator for its ambition to be able to manage a 'zero carbon' electricity grid by 2025. This goes significantly beyond the Government's projections for possible renewable power deployment by 2032, and indicates that any 'over-delivery' on the deployment of low-carbon power generation in the 2020s will not be incompatible with the electricity transmission system. *We urge distribution network operators to adopt a similar ambition to National Grid System Operator, of operating a zero carbon grid by 2025. Ofgem should work with distribution network operators to ensure that the regulatory framework required to allow this is in place. If sufficient progress is not made we urge the Government to consider strengthening Ofgem's mandate to require the distribution network operators to speed up the investment and upgrading of the distribution networks required.* (Paragraph 53)

11. The Government has indicated that it expects requirements for new power generation capacity to be met through offshore wind power, nuclear power and gas-fired power with carbon capture and storage. There is considerable risk that these technologies may not provide the generation capacity required. *The Government must set out in its response to this Report how it intends to monitor and address any potential shortfall in power generation capacity, and ensure that this can be achieved with low emissions and costs.* (Paragraph 54)

12. Although onshore wind power and large-scale solar power are low-cost and low-carbon, the deployment of new installations of these technologies has fallen drastically since 2015. Onshore wind power in particular could lower costs to energy consumers as well as contributing to the UK's decarbonisation, and there is widespread support for increased Government support for such projects across Great Britain. *The Government must ensure that there is strong policy support for new onshore wind power and large-scale solar power projects for which there is local support and projected cost-savings for consumers over the long-term. The Government should actively encourage and support local authorities to adopt planning practices that promote local support for such renewable energy projects. The Government must additionally develop mechanisms to promote community ownership and profit-sharing of low-carbon projects, such as joint ventures, split ownership or shared revenue.* (Paragraph 62)

13. The marine energy sector has come together to propose market support mechanisms to support marine and other less-established renewable power technologies through technology development and commercialisation. *The Government should examine the case for supporting 'Innovation Power Purchase Agreements' and setting minimum allocations of future contract for difference auctions to specific technologies, to support the development and commercialisation of renewable power technologies that are less-established than offshore wind power.* (Paragraph 64)

14. *The Government should develop, by the end of 2020, a clear planning permission framework for re-powering existing onshore wind farms, and ensure that national planning policy facilitates re-powering with the most efficient technology and does not block proposals that attract local support. It must also monitor the proportion*

of onshore wind power sites that apply for permission to repower, and be ready to provide market support (for example through eligibility for contracts for difference) if this is not close to 100%. (Paragraph 68)

15. The delay between the end of the feed-in tariff scheme and the start of the Smart Export Guarantee scheme has caused unnecessary disruption to the smart energy and small-scale generation market. Nonetheless, the move towards a framework that facilitates greater flexibility and innovation in these markets is welcome, provided it offers a fair and sufficient means of compensation for owners of small-scale renewable generation capacity and a sufficient incentive for people to make the initial investment in such technologies. *The Government must ensure that it reviews the functioning of the Smart Export Guarantee scheme by the end of 2020, and should be ready to include a minimum price floor if there is evidence of a lack of market competitivity—for example, if uptake of tariffs is not significantly greater than the current number of tariffs or if the tariffs offered are significantly lower than wholesale electricity prices.* (Paragraph 74)

16. The Government must make sure that business rates incentivise embedded low-carbon generation and do not cause existing embedded generation to be disconnected. *The Government should reduce business rates for organisations that consume the majority of the power they generate to match the rates of organisations that sell the majority of their generation—and stop the administrative burden of loopholes that are being used to counter the discrepancy in rates. The Government should also reinstate the microgeneration exemption from business rates for renewable energy installations producing no more than 50kW. In its response to this Report, the Government should set out why combined heat and power units have been classed as excepted plant and machinery under the business rate regulations, but such a provision is not applied to solar panels and energy storage systems.* (Paragraph 76)

17. Ofgem must consider the interests of future consumers as well as current consumers in its decisions, including the need for decarbonisation. The projected increases in network costs for consumers and businesses that have installed on-site generation and flexibility technologies, arising from Ofgem's proposed network charging reforms, will act as a disincentive for further consumers or enterprises to install similar technologies. This is not conducive to the overall goal of decarbonisation. However, Ofgem is right to seek to avoid the costs of network usage falling increasingly on vulnerable consumers. *Ofgem must revise its proposed network charging reforms to ensure that they do not disincentivise the deployment of technologies that will contribute to the decarbonisation of the UK's energy system. The Government must ensure that vulnerable consumers do not pay an increasing proportion of network costs, and that all households have the ability to deploy technologies that will reduce their cost of energy and help to decarbonise the economy.* (Paragraph 79)

18. Although it is not possible to directly compare the costs of different power generation technologies, the Government is right to support nuclear power subject to it representing value for money, because full lifecycle emissions from nuclear power will help the UK to achieve its emissions reduction targets. *The Government must make a decision on implementing a regulated asset base framework for nuclear power by the end of this year. Subject to value for money, the Government should seek to support new nuclear power generation so as to sustain, but not grow, the UK's*

nuclear power industry. It must anticipate any gap in future generation capacity such a policy would cause, and support sufficient renewable power alternatives to fill the gap. (Paragraph 84)

19. The Government's support for small modular nuclear reactors in the Nuclear Sector Deal is welcome. *The Government must ensure that it delivers on the recommendations from the Expert Finance Working Group on Small Nuclear Reactors, including on regulatory developments, without undue delay. The Government should set out, in its response to this Report, what steps it has taken since the publication of the Group's report and propose a pathway—with indicative dates for key milestones—for the deployment of a first-of-a-kind small modular nuclear reactor by 203*0. (Paragraph 88)

20. Nuclear fusion is unlikely to make a substantial contribution to the UK's net-zero target for 2050. Nevertheless, it could ultimately provide significant quantities of energy from abundant fuels and without radioactive waste. *The Government must ensure that, whatever the terms of the UK's departure from the European Union, the long-term future of nuclear fusion research in the UK is not disrupted. It should additionally review the case for providing support for the nuclear fusion industry similar to the measures introduced recently by the US Government*. (Paragraph 92)

Decarbonising transport

21. There is significant scope for emissions reductions in the transport sector as a result of the purchase of more efficient vehicle models, without requiring technological developments or alternative fuel sources. However, the current fiscal incentives for cars are not sufficient to encourage consumers to purchase lower-emissions vehicles, given that most of the increase in average new car emissions in 2017 was caused by consumers choosing more emitting models. *The Government must reconsider the fiscal incentives for consumers to purchase both new and used vehicle models with lower emissions, and develop a strategy by the time of the Spring Statement 2020 to use vehicle excise duty and other incentives to drive the purchase of vehicle models with lower average emissions. This must include consideration of post-sales vehicle excise duty and the second-hand market*. (Paragraph 96)

22. *The Government must commit, prior to the UK's withdrawal from the European Union, to adopting transport emissions regulations that are, as a minimum, in line with current and future EU regulations on transport emissions. This should include legislation regarding emissions reductions requirements for heavy duty vehicles, regardless of the terms of the UK's departure from the EU.* (Paragraph 98)

23. The Government has said that a 2040 ban on the sale of conventional cars and vans is consistent with the UK's current emissions reductions targets for 2050, but this has been disputed by independent organisations such as the UK Energy Research Centre and the Committee on Climate Change. There is a strong case for bringing the date for a future ban forward, given that several manufacturers already have more ambitious commitments in place. *The Government should act on the advice of the Committee on Climate Change and bring forward the proposed ban on sales of new conventional cars and vans to 2035 at the latest. This ban should explicitly cover hybrid as well as internal combustion engines.* (Paragraph 102)

24. The availability of chargepoints is a significant factor in consumer uptake of electric vehicles. Although the extent of the UK's charging infrastructure is growing, it is not expanding at a pace to match the roll-out of electric vehicles. Interoperability of different chargepoint networks will be required to avoid the need for a roll-out of multiple extensive networks. Widespread adoption of electric vehicles will not necessarily require an unmanageable increase in power generation requirements, but in order for the electricity demand from widespread electric vehicles to be more comfortably met, and in order for electric vehicles to contribute to increased grid flexibility, smart charging will have to be commonplace. (Paragraph 109)

25. *The Government must ensure sufficient roll-out of rapid chargepoints along the strategic road network, and smart chargepoints at domestic, destination (such as places of work or shopping centres) and local sites. It should work with public services and owners of public land, such as schools and hospitals, to accelerate the deployment of chargepoints. The Government's forthcoming consultation on the regulation of charging infrastructure must determine measures to deliver interoperability, compatibility with a smart energy system, public availability of real-time information on the current functionality of chargepoints, and enforcement powers to ensure that chargepoints are reliable.* (Paragraph 110)

26. It is disappointing that the Government cut back the plug-in grant with electric vehicle sales below the indicative target set by the Committee on Climate Change. *The Government should set out, by the time of the Spring Statement 2020, how it intends to adjust the plug-in grant scheme in the future, using a transparent framework linked to ultra-low emissions vehicles sales.* (Paragraph 112)

27. *The Government should evaluate the impact of the free charging offered by the ChargePlace Scotland charging network as well as other potential incentive schemes for electric vehicle use.* (Paragraph 114)

28. Uptake of ultra-low emissions vehicles can potentially be driven in the fleet vehicle market more quickly than in the private consumer market. Options for supporting the uptake of ultra-low emissions vehicles in the fleet vehicle market include fiscal incentives and public procurement targets. *The Government should commit to adopting regulations on the public procurement of ultra-low emissions vehicles that are at least as ambitious as the EU's post-Brexit. It should further commit to having a 100% ultra-low emissions vehicle fleet by 2022 and to supporting local authorities in also having 100% ultra-low emissions fleets by 2030.* (Paragraph 117)

29. One current barrier to the uptake of ultra-low emissions vehicles in the UK is an insufficient supply to meet consumer demand, which has led to long waiting times. There is evidence in the UK and internationally suggesting that this could be partly due to inadequate support for the ultra-low emissions vehicle market from manufacturers and dealers. *The Government should review the functioning of the ultra-low emissions vehicles market annually, to determine if there are sufficient incentives for manufacturers and dealers to drive the adoption of ultra-low emissions vehicles, with the first review published by the time of the Spring Statement 2020. This should include consideration of the value of introducing minimum sales mandates on manufacturers, using tradeable sales certificate framework.* (Paragraph 120)

30. A ban on the sale of new diesel-powered heavy-goods vehicles will be needed by 2040 in order for the sector to achieve net-zero emissions by 2050. This will require policies now that will drive the development of alternative technologies and demonstrate the technical feasibility of such a ban. *The Government should introduce a ban on the sale of new diesel-powered heavy goods vehicles, for no later than 2040. It should additionally support trials of low-emissions HGV technologies on a timeframe that aligns with the proposed ban, and work with network operators and the delivery industry to plan for the potential charging infrastructure required for zero-emissions HGVs. Given that some HGVs are already being converted to run on hydrogen on a commercial basis, the Government should review the opportunity for market support mechanisms to drive higher rates of HGV conversion.* (Paragraph 124)

31. The Government's current long-term targets for decarbonising transport focus heavily on reducing exhaust emissions and increasing sales of low-emissions vehicles, rather than delivering a low-emissions transport system. In the long-term, widespread personal vehicle ownership does not appear to be compatible with significant decarbonisation. The Government should not aim to achieve emissions reductions simply by replacing existing vehicles with lower-emission versions. *The Government should not aim to achieve emissions reductions simply by replacing existing vehicles with lower-emissions versions. Alongside the Government's existing targets and policies, it must develop a strategy to stimulate a low-emissions transport system, with the metrics and targets to match. This should aim to reduce the number of vehicles required, for example by: promoting and improving public transport; reducing its cost relative to private transport; encouraging vehicle usership in place of ownership; and encouraging and supporting increased levels of walking and cycling. The Government should commit to ensuring that the annual increase in fuel duty should never be lower than the average increase in rail or bus fares.* (Paragraph 131)

32. *Any move to electric vehicles must have an associated environmental impact assessment, including the potential for recycling lead, lithium, cobalt, nickel and graphite. Hydrogen technology may prove to be cheaper and less environmentally-damaging than battery-powered electric vehicles. The Government should not rely on a single technology.* (Paragraph 132)

33. *The Government should review the potential to reduce emissions and support shared car ownership by incorporating Government Department car fleets into car sharing schemes. It should encourage other public bodies and local authorities to do likewise.* (Paragraph 133)

34. We commend the Government on its existing work to support the establishment and use of urban delivery consolidation zones. However, with just two major examples of completed projects to point to, there is clearly scope for a wider roll-out. *The Government should support the development of urban delivery consolidation centres, working with local authorities to assess the potential of such centres to reduce emissions and identify strategies to support their deployment and effective use.* (Paragraph 136)

Decarbonising heating

35. Heating accounts for around a third of the UK's overall emissions, which has remained essentially unchanged since 2009. The decarbonisation of heating will be

critical to the UK achieving its long-term emissions reductions targets, but there remains considerable uncertainty surrounding what mix of low-carbon heating technologies represents the best decarbonisation pathway for the UK, or what mix the Government will pursue. *The Government must urgently develop a clearer strategy for decarbonising heat. This will require large-scale trials of different heating technologies operating in homes and cities to build the evidence base required for long-term decisions. The Government must commit now to large-scale trials of low-carbon heating technologies, convening relevant stakeholders to determine what evidence must be gathered and to co-ordinate existing work.* (Paragraph 142)

36. The use of hydrogen as a fuel offers significant promise for low-carbon heating, transport and industrial processing, as well as for energy storage and to help manage intermittent renewable power generation. However, evidence from large-scale trials will be needed to allow the Government to make informed decisions on the UK's future energy system. Demonstrating the safety of hydrogen as a fuel is a critical first step, and we commend the Government for its support of the Hy4Heat programme. *The Government must complete the safety demonstration work for hydrogen as an urgent priority. The Government should also commit to completing at least one large-scale trial of hydrogen by 2025 conditional upon safety approval, and start developing now the terms for a competition to deliver such a trial. This should involve co-ordination of existing demonstration and modelling projects and should lead to the terms of a competition being announced no later than the end of 2020. (Paragraph 150)*

37. Blending hydrogen into gas supplied via the gas grid could provide an initial market for early hydrogen production facilities. *Once clear evidence is obtained on the level at which it is safe to mix hydrogen into the existing gas grid, and which is compatible with existing appliances, the Government should amend regulations to raise the proportion of hydrogen permitted in the grid. With higher blends of hydrogen permitted, the Government should act to support the development of this as a market for hydrogen, perhaps through feed-in tariffs or low-carbon obligations analogous to the Renewable Transport Fuel Obligation.* (Paragraph 153)

38. The Government's announced future homes standard is welcome. However, regulations requiring improvements to the efficiency of new buildings must be introduced before 2025. *The Government should re-introduce the zero-carbon homes standard as a matter of urgency, and no later than the end of 2019. It should additionally ensure that building regulations accurately reflect the current carbon intensity of electricity in Great Britain, and that this figure can be regularly updated (at least annually) in future.* (Paragraph 160)

39. *The Government should launch its consultation on Part L of the building regulations by the time of the Spring Statement 2020. Beyond that, it must ensure that homes built today are compatible with a net-zero emissions future and that the 'Future Homes Standard' reflects this.* (Paragraph 161)

40. *The Government should set out, in its response to this Report, the criteria that will be used to determine 'practicality' and 'affordability' in its energy efficiency targets, and provide an indicative percentage of homes that it is intending to help reach Band C by 2035.* (Paragraph 165)

41. Previous initiatives to encourage the installation of energy efficiency improvements in the 'able-to-pay' market have failed because they have focused too narrowly on providing financial support for specific interventions. *The Government's new energy efficiency policy must provide all homeowners with the incentive to make energy efficiency improvements to their property, with particular thought given to lower income households. By the time of the Spring Statement 2020, the Government should consider adjusting Stamp Duty so that it varies according to the energy performance of the home as well as the price paid for it. Homebuyers should then be able to make energy efficiency improvements within a defined time after purchasing the property, and claim back corresponding reductions in the Stamp Duty paid retrospectively. The adjustments made to Stamp Duty could be designed in order to be revenue-neutral to the Government. Robust certification of energy efficiency will need to be put in place to ensure that such a scheme is not open to exploitation and the Government should consider how best to incentivise upgrades in council, housing association and rented homes.* (Paragraph 171)

42. The Green Deal's 'golden rule' heavily restricted the energy efficiency improvements that could be paid for by the scheme. Although some energy efficiency improvements may not deliver net cost-savings to homeowners, they may still represent cost-effective options for the UK to meet its emissions reductions targets. *The Government's new energy efficiency policy must enable homeowners to access the finance needed to cover the upfront costs of energy efficiency improvements that offer a cost-effective contribution to the UK's decarbonisation, not just net cost-savings to individual homeowners. In analogy to the existing 'Help to Buy' scheme, the Government should establish a 'Help to Improve' scheme by July 2020 that offers matched funding and interest-free loans to homeowners, to cover the costs of making energy efficiency improvements.* (Paragraph 175)

43. We commend the Government for supporting research into, and the development of, 'green mortgages'. *The Government should consider the case for encouraging mortgage lenders to take energy efficiency into account for all mortgage applications, and should support the industry in capturing any potential in such a system for driving a market in energy efficiency improvements.* (Paragraph 177)

44. We commend the Government for strengthening the requirements on landlords to improve the energy efficiency of the least efficient homes in England and Wales. However, these measures will affect only 2.5% of the housing stock. *The Government should amend building regulations so that renovations to buildings must always result in an overall improvement in energy efficiency.* (Paragraph 179)

45. The Renewable Heat Incentive has significantly underperformed on the Government's expectations. *With the Renewable Heat Incentive due to close to new applications in 2021, the Government must ensure that it avoids a repeat of the disruption caused by the closure of the feed-in tariff, and announces its plans for the successor scheme to the Renewable Heat Incentive no later than the Spring Statement 2020. The successor scheme must be far more effective than the Renewable Heat Incentive scheme has proven to be.* (Paragraph 180)

46. The Government's announcement that fossil-fuel heating systems will not be permitted in new builds after 2025 may support the growth of supply chains for

low-carbon heating technologies and deliver consequent cost-reductions as well. *The Government should further support the deployment of low-carbon heating technologies by setting out a clear roadmap by the time of the Spring Statement 2020 for rebalancing levies on electricity and gas, to better reflect the emissions intensities of each fuel.* (Paragraph 183)

The UK energy system

47. The development and deployment of energy storage technologies will be critical to the UK's transition towards a flexible, low-carbon energy system. It is disappointing that the Government has not made the Parliamentary time available to define energy storage in primary legislation. *The Government must ensure sufficient support for the development and deployment of energy storage technologies. Large-scale, inter-seasonal storage currently appears to pose the greatest technical challenges, and should be supported through demonstration projects, including in future large-scale trials of low-carbon heating. The Government should provide a dedicated legal definition of energy storage in primary legislation as soon as possible. Such a commitment should be included in the next Queen's Speech, if Parliamentary time is not found for such legislation before then.* (Paragraph 192)

48. The roll-out of smart meters is one important enabling component of a flexible energy system that can match demand to supply, allowing increased deployment of intermittent renewable power generation. However, the Government's roll-out is severely behind schedule, in part because the original scheme had fundamental design faults, as highlighted by our predecessor Committee and the then Energy and Climate Change Committee. *The Government must ensure that it takes all reasonable steps to achieve a national roll-out of smart meters as soon as possible. In order to reduce consumer resistance to smart meters, the Government should run public engagement initiatives to raise public awareness that by having a smart meter installed, consumers can contribute to long-term reductions in the UK's greenhouse gas emissions. Ofgem should require energy suppliers to collect and publish data on consumer acceptance rates for smart meter installation, and the reasons given by consumers for rejecting a smart meter. The Government should then be ready to act on this information to drive greater installation rates of smart meters, for example by introducing a consumer incentive mechanism. It should also require installation of a smart meter in properties without one whenever the owner or renter changes.* (Paragraph 199)

49. Market-wide half-hourly settlement of energy consumption costs will incentivise energy suppliers to offer tariffs that reward consumers for using energy when it is abundant, helping to enable higher levels of intermittent renewable power generation. However, Ofgem has highlighted the dependence of market-wide half-hourly settlement on widespread smart meter deployment. Given the low current uptake of smart meters, this indicates that there could be very significant delays in the introduction of market-wide half-hourly settlement and the benefits of widespread 'smart' tariff adoption. *Ofgem should clarify what it determines to be the critical mass of smart meters required for market-wide half-hourly settlement. Since the introduction of market-wide half-hourly settlement will help to catalyse smart meter take-up, Ofgem should not set an overly stringent critical mass, and should be*

prepared to recover the costs of incomplete smart meter deployment from the suppliers of those consumers who do not have smart meters (in a way that protects vulnerable consumers). (Paragraph 200)

50. Energy capacity secured through the Capacity Market supplies energy to the grid relatively infrequently throughout the year, and supports the co-deployment of increasing levels of intermittent renewable power generation. Nevertheless, contracts awarded through the Capacity Market provide funding for energy capacity technologies. So far, this has mostly supported technologies such as gas-fired and diesel generators, which are not in line with the UK's ambition to reach net-zero emissions. *In keeping with the UK's ambition to move towards net-zero emissions, the Government should ensure that the Capacity Market supports low-carbon technologies as far as possible without detriment to the wider deployment of renewable power generation. As it reviews the success of the Capacity Market to date, the Government should consider introducing a minimum proportion of Capacity Market funding that must be awarded to low-carbon technologies.* (Paragraph 206)

51. *Non-generation suppliers bidding for Capacity Market contracts should be eligible to bid for contracts of up to fifteen years, in line with new generation facilities.* (Paragraph 207)

52. Regulation of UK energy markets will play a key part in the development of a smart and flexible energy system. The RIIO price control framework has helped to support innovation in the gas and electricity networks, but it is vital that the second price control framework promotes even greater levels of innovation as the energy networks undergo a period of significant change. *Ofgem must ensure that its second price control framework does not dilute its support for innovation and that the framework should further enable and incentivise network operators to innovate as part of their core business, rather than through standalone projects. Ofgem should work with network operators, energy suppliers and flexibility services providers to ensure that flexibility systems are always considered and deployed ahead of infrastructure construction, where possible and affordable.* (Paragraph 212)

53. The energy markets regulator has an explicit duty to protect consumers' interests in the reduction of gas- and electricity-supply emissions of targeted greenhouse gases, alongside other considerations such as minimising costs. However, there is no specific link between the regulator's objectives and the UK's emissions reduction targets. In addition, some have expressed concerns that the regulator focuses too heavily on reducing costs for current consumers, at the expense of contributing to the UK's decarbonisation. *When the Government reviews the upcoming recommendations from the National Infrastructure Commission on the future regulation of the energy market, it should consider the case for amending the energy market regulator's principal objective so that it explicitly includes ensuring that regulations align with the emissions reduction targets set out in the Climate Change Act 2008.* (Paragraph 216)

54. Local authorities have a vital role to play in the UK's decarbonisation. Many local authorities are pursuing emissions reductions projects, but the capacity and capability for decarbonisation at the local level varies. *The Government should introduce a statutory duty on local authorities in England and Wales, by Green Week 2020, to develop emissions reduction plans in line with the national targets set by*

the Climate Change Act 2008, and to report periodically on progress made against these plans. In preparation for this new obligation, the Government should establish centralised support to help local authorities develop decarbonisation strategies and deliver initiatives aimed at reducing greenhouse gas emissions. It should also support local authorities' access to low-cost, long-term finance in order to enable the delivery of such strategies. The Government should adopt UK100's proposals for 'Clean Energy Action Partnerships'. (Paragraph 223)

55. Emissions reductions in the transport and heating sectors will involve greater impact on, and require greater involvement of, consumers than the decarbonisation of the power generation sector, which is where the UK has achieved the bulk of its emissions reductions so far. Although public support for measures to reduce emissions appears high, this is not always matched with awareness of what actions consumers can take to support decarbonisation. *In co-ordination with existing organisations, such as the Energy Saving Trust, who work to raise consumer awareness of available emissions-reduction measures, the Government should publish an easily-accessible, central guide for members of the public explaining what measures individuals and households can take to support the UK's decarbonisation.* (Paragraph 227)

56. *The Government should re-introduce a telephone and visiting advice service in England which offers bespoke advice on measures such as residential energy efficiency and low-carbon heating and transport.* (Paragraph 228)

57. Product labelling already helps consumers choose products based on qualities such as healthiness, environmental impact and employee or animal welfare. *The Government should explore the feasibility and potential benefits of establishing a standard for the emissions associated with the manufacturing and transportation of consumer goods, to enable retailers to label their products with emissions information and to enable consumers to factor this into their purchasing decisions.* (Paragraph 230)

58. The decarbonisation of the UK's economy is critical for the environment and is a legally-binding target for the Government. Although decarbonisation offers opportunity for economic growth, it will inevitably also entail costs. The Committee on Climate Change has estimated that achieving net-zero emissions could cost around 1–2% of GDP by 2050. It is important that these costs are shared fairly among citizens. *The Government must ensure that its policies for achieving net-zero emissions consider the economic impacts on individuals. The Government should aim to cover the costs of measures through progressive means rather than through energy bills.* (Paragraph 233)

59. *In line with the Government's focus on 'place' in its Industrial Strategy, the Government should include the potential for supporting economic growth in disadvantaged regions in its determination of where to locate demonstration projects and other initiatives.* (Paragraph 234)

Carbon capture and storage

60. Carbon capture and storage has been widely identified as a key technology for decarbonisation in several sectors. The Energy Technologies Institute estimated, prior to the UK's net-zero emissions ambition, that meeting the UK's original 2050

emissions targets without the use of carbon capture and storage would incur an additional £30bn in costs. This puts the Government's desire for value-for-money in context. We commend the Government for recapturing lost momentum in the development of carbon capture and storage. However, there are concerns that its action plan lacks clarity and ambition. (Paragraph 241)

61. *Industry must have clarity on the framework through which it can invest in carbon capture, usage and storage (CCUS), as well as the timetable for the Government's CCUS Action Plan. The Government must provide greater clarity on the details of its action plan, and should set out in its response to this Report: what it considers to be deployment at scale; what constitutes cost-effectiveness or sufficient cost-reduction; how it expects to share costs with industry; and what the major milestones for the plan are, as well as when they are expected to be achieved. The Government should learn from previous carbon capture and storage projects and ensure that a sufficient number of projects, of sufficient scale, are undertaken to optimise the chance of successful deployment, and that the knowledge gained from publicly-funded work is publicly accessible.* (Paragraph 242)

62. The Government's new ambition, to reach net-zero emissions by 2050, will probably require the active removal of at least 130 million tonnes of carbon dioxide from the atmosphere annually by 2050. This is significantly greater than the extent of greenhouse gas removal envisioned in any of the Government's previous 'illustrative pathways' to meeting its original 2050 target, and is also at the limit of what is expected to be reasonably deliverable. *The Government should plan for the deployment of greenhouse gas removal technologies capable of removing around 130 million tonnes of carbon dioxide by 2050. It should develop and publish, within six months of this Report's publication, an illustrative pathway detailing the full extent of greenhouse gas removal that it projects to be possible from each major technology option by 2050, as well as a strategy for ensuring this pathway is feasible, including any policy decisions required now.* (Paragraph 252)

63. *The Government should launch a consultation to inform the development of a future framework for managing and incentivising greenhouse gas removal, and to provide greater certainty to encourage private investment in the development of these technologies. The consultation should examine potential frameworks for valuing, incentivising, measuring, reporting and validating greenhouse gas removal by different technologies.* (Paragraph 253)

64. The step-change in greenhouse gas removal required by the Government's new ambition to reach net-zero emissions by 2050 will require a significant increase in current support for greenhouse gas removal technologies. Some urgently require research and development, whereas others could be deployed at scale now with the correct support. *In line with its future strategy for greenhouse gas removal, the Government should be ready to increase funding for research, development and demonstration of greenhouse gas removal technologies. It must also ensure that it is seizing currently available opportunities for greenhouse gas removal, and should develop an effective framework for managing and incentivising forestation and land use management to achieve net emissions removals.* (Paragraph 254)

65. Solar radiation management does not address the fundamental problem of excess concentrations of greenhouse gases in the Earth's atmosphere, and does not appear to be a long-term solution to global warming. Nevertheless, it may be considered as a short-term solution if global greenhouse gas emissions are not reduced quickly enough to avoid significant global warming. In this scenario, detailed understanding of the wider effects of solar radiation management will be vital. *UK Research and Innovation should review the current state of research into solar radiation management, the likely timeframes that would be required for detailed research and potential testing of such technologies, and the case for any increased research now. It should ensure that research into solar radiation management is sufficient to allow for any potential future decisions to be made on the deployment of such technology to be sufficiently well-informed.* (Paragraph 258)

Annex 1: Units used in the Report

tCO_2e, $MtCO_2e$: The greenhouse effect varies according to the quantity of greenhouse gases in the Earth's atmosphere. One tonne of CO_2-equivalent (tCO_2e) refers to one tonne of carbon dioxide, or a quantity of another greenhouse gas that would contribute to global warming to an equivalent degree as one tonne of carbon dioxide. One megatonne of CO_2-equivalent (M tCO_2e) is equal to one million tonnes of CO_2-equivalent.

W, MW, GW: A Watt (W) is a unit of *power*, that is the rate of energy produced or consumed at a certain point in time. One Megawatt (MW) is equal to a million Watts and one Gigawatt (GW) is equal to a billion Watts. Power generation capacity can also be measured in Watts, in which case it represents the average or maximum power output that the generation plant can provide. A typical rooftop solar panel might generate a few thousand Watts in the middle of a sunny day, while a nuclear power station might generate a few billion Watts.

Wh, kWh, MWh: One watt-hour (Wh) is a unit of *energy*, equivalent to the total energy generated or consumed by a 1W device over the course of an hour. One kilowatt-hour (kWh) is equal to one thousand watt-hours and one megawatt-hour (MWh) is equal to one million watt-hours. Since there are 8,760 hours in a year, a 1MW power station would generate 8,760MWh of energy in a year. The average UK household uses around 10kWh of electricity a day, or around 4MWh of electricity each year.

Formal minutes

Wednesday 17 July 2019

Members present:

Norman Lamb in the Chair

Vicky Ford	Carol Monaghan
Bill Grant	Graham Stringer
Darren Jones	Martin Whitfield
Stephen Metcalfe	

Draft Report (*Clean Growth: Technologies for meeting the UK's emissions reduction targets*), proposed by the Chair, brought up and read.

Ordered, That the draft Report be read a second time, paragraph by paragraph.

Paragraphs 1 to 18 read and agreed to.

Paragraph 19 read.

Motion made, to leave out paragraph 19 and insert the following new paragraphs:

Professor Dieter Helm's October 2017 Cost of Energy Review: Independent Report was highly critical of the Government's response to the Climate Change Act:

1. This review has two main findings. The first is that the cost of energy is significantly higher than it needs to be to meet the government's objectives and, in particular, to be consistent with the Climate Change Act (CCA) and to ensure security of supply. The second is that energy policy, regulation and market design are not fit for the purposes of the emerging low-carbon energy market, as it undergoes profound technical change.

2. Since late-2014, the prices of oil, gas and coal have fallen significantly, contrary to the modelling and forecasting of both the Department of Energy & Climate Change (DECC) and the Committee on Climate Change (CCC). Since then, the price of renewables has been coming down fast too, as have the costs of addressing intermittency, as a host of new battery and other storage and demand-side options become available. Productivity increases should have been putting further downward pressure on the costs of transmission, distribution and supply. New technologies should mean lower, not higher, costs and much greater scope for energy efficiency. Margins should be falling as competition should be increasing. Yet in this period, households and industry have seen limited benefits from these cost reductions. Prices have gone up, not down, for many customers.

3. These excessive costs are not only an unnecessary burden on households and businesses, they also risk undermining the broader democratic support for decarbonisation. In electricity, the costs of decarbonisation are already estimated

by the CCC to be around 20% of typical electricity bills. These legacy costs will amount to well over £100 billion by 2030. Much more decarbonisation could have been achieved for less; costs should be lower, and they should be falling further.

4. Many of these excessive costs are locked in for a decade or more, given the contractual and other legal commitments governments have made. These include Renewables Obligation Certificates (ROCs), feed-in tariffs (FiTs), and low-carbon contracts for difference (CfDs) granted to early-stage wind and solar, larger-scale nuclear, biomass, and offshore wind. Since the ROCs, FiTs and low-carbon CfDs are formal contracts, they are taken as given in this review. The task is to find ways of minimising the burden these impose, and making them transparent, ring-fenced, and separated out from the market, where costs should be coming down.

5. The burden on households and businesses would have been even greater had there not been a financial crisis in 2007/08 which held down demand, and a parallel continued decline of the energy-intensive industries. Had the crash not happened, GDP would be perhaps 20–25% higher in 2017 (assuming no sharp fall in GDP in the immediate aftermath of the crash and 2–3% GDP growth since then). There would then have been a serious capacity crunch and much higher prices. As it is, the UK has flirted with dangerously low capacity margins despite the GDP effect, and this drives up prices as the more expensive marginal plant is drawn onto the system to match demand.

6. In the current decade, the government has moved from mainly market-determined investments to a new context in which almost all new electricity investments are determined by the state through direct and often technology-specific contracts. Government has got into the business of 'picking winners'. Unfortunately, losers are good at picking governments, and inevitably – as in most such picking-winners strategies – the results end up being vulnerable to lobbying, to the general detriment of household and industrial customers.

7.As a consequence of Electricity Market Reform (EMR), the government now determines the level and mix of generation to a degree not witnessed since these were determined by the nationalised industries – notably the Central Electricity Generating Board (CEGB). Investment decision-making has been effectively quasi-renationalised. This is a direct consequence of EMR. The government, not the customer, has become the client.

8. In determining not just the level of new capacity, but also the composition of the low-carbon portfolio, the government started out with some of the most expensive technologies first, and it could be argued that since then it has at times been exploring even more expensive options. The result is that British households and businesses are locked into higher renewables and other low-carbon generation costs than they need be to achieve the decarbonisation objectives for decades to come.

9. These state-backed contracts have been supported by the return to formal modelling and forecasting by DECC (now BEIS, the Department for Business, Energy & Industrial Strategy) and the CCC. In the case of DECC, the results have at times been spectacularly bad. In particular, in the first half of this decade, DECC

focused on its forecasts of high, rising and volatile gas prices, and therefore it could conclude that the wholesale price of electricity would rise to over £92/MWh by the early 2020s. It was confident that because fossil fuel prices (and particularly gas) were going up, households would be relatively better off as a result of its policies by around 7% by 2020.

10. The EU Renewables Directive and its particular definition of renewables has been a major contributor to raising the costs above those necessary to reduce carbon emissions to meet the CCA. A further contributor is the inefficient way in which the carbon budgets have been addressed, notably by not moving against coal earlier.

11. The overwhelming focus on electricity rather than agriculture, buildings and transport has added to the cost. Agriculture in particular contributes 10% greenhouse gas (GHG) emissions, and the costs of reducing these emissions are much lower than many of the chosen options because the economic consequences of a loss of output in agriculture are small. Agriculture comprises just 0.7% GDP and at least half its output is uneconomic in the absence of subsidies. With the development of electric vehicles (EVs) it is apparent that transport can contribute more. The CCC could have paid more attention to the lower marginal cost of abatement in these sectors.

12. Keeping costs down is all the more important as the electricity system faces a series of major challenges over the next decade. Not only does it need to meet the carbon budgets, it needs to do this in the context of major retirement of existing capacity, the investment requirements to handle the intermittent renewables, the coming of electric transport, and the wider demands of a digitalising economy. These challenges are on a scale and magnitude not witnessed since the reconstruction of the electricity industry immediately after the Second World War.

13. The energy sector is going through a technological transformation as electricity becomes an increasingly dominant form of energy. Previous structural breaks have come from single technologies, like the coal-fired power station, the gas turbine, and the civil nuclear power stations. This time there are structural breaks which span the whole economy as it digitalises, the transport sector as it electrifies, and the generation, transmission, distribution, supply and the demand for electricity. We are moving towards a decarbonised, digital, smart electric energy world, offering the prospect of ever-lower costs from cleaner energy.

14. The CCC neglects some of the opportunities of these technology impacts in its time horizon to 2050, arguing that any new technologies will have to be deployed before 2030 if they are to make much impact before 2050. This, together with the assumption that gas prices will rise by 30% by 2030, is a key rationale for the roughly linear profile of emissions reductions from now through to 2030. If the objective is limited to the CCA 2050 target, then the carbon budgets overegg the early stages, and make the trajectory between now and 2050 more expensive than it needs to be. Indeed, with such early action in the linear trajectory, it may turn out that decarbonisation is achieved much faster.

15. Tempting though it is to many observers to predict how this transformation is going to take place, and profitable to many lobbyists to persuade government that their specific technologies and projects are the right answers, the design of energy policy and the interventions to achieve the objectives should be driven by the uncertainty about the detailed shape of the decarbonisation path. In order to achieve the prize, it is important not to try to pick winners, and to focus on the framework within which the private sector brings new ideas, new technologies and new products to the end-user. Avoiding detailed intervention is a key to keeping down the cost of energy.

16. Since 2015, a number of reforms have begun to reverse some of the more grossly inefficient dimensions of current policies. The greater use of auctions has begun to bear down on excessive costs, but there is a long way to go. The decision to exit coal by 2025 is a belated but welcome step to recognise that switching away from coal is the cheapest way to decarbonise. It should have been the first option.

17. Notwithstanding the significant cost reductions from the auctions so far, existing energy policy is not fit for these new purposes. It remains complex and expensive, and it is slowing down the transition to a decarbonised economy.

18. The measures necessary to reduce the costs include: the unification of the capacity and FiTs and CfDs auctions on the basis of equivalent firm power (EFP); the gradual reforms of the structure of FiTs and CfDs in the transition to their eventual abolition; and further enhancements to competition in the wholesale and balancing markets. There should be significant reforms of the regulation of transmission and distribution focused on the role of system operators at the national and local levels, and the replacement of the specific licences for distribution, supply and decentralised generation with a general licence. A default supply tariff should be required and the margins published. Finally, carbon prices and energy taxes should be harmonised.

19. This package of measures is a major shift from the original market design and regulation model at privatisation, and moves on from EMR. It would create a simpler, more competitive structure fit for the new purposes. Instead of low-carbon technologies being grafted onto the fossil fuel-based system, the new world is radically different, backed up by new smart technologies, data and smart energy networks and services. A common carbon price would significantly lower the cost of decarbonisation and greatly enhance incentives.

20. As the fixed system costs gain an increased share of total costs, it will be government that ultimately decides the allocation between customer classes of these fixed costs. The legacy costs are also fixed. The scope for protecting the poorest customers will be increased, and the government should consider a universal basic allocation of fixed costs.

21. The fixed costs also permit a more efficient allocation to the industrial sector, and particularly to those companies facing international competition. In addition to exemptions from the legacy costs, consideration should be given to the relative burdens on industry and households from the rising proportion of fixed costs. However, neither should be exempt from the carbon price.

22. These measures require significant institutional reform. The system operator model should be further developed, with an independent national system operator (NSO) and a series of regional system operators (RSOs) playing a bigger part.

23. Ofgem's role in regulation should be significantly reduced as the NSO and RSOs assume some of the duties currently placed on distribution network operators (DNOs) and Ofgem, with much greater use being made of competitive tenders and auctions. The licensing regime at the local level should be simplified, abolishing the increasingly anachronistic distinctions between generation, supply and distribution, which are being overtaken by the new technologies that are emerging.

24. The comprehensive long-term framework set out in this review is a practical and evolutionary package, and will deliver benefits not only over the coming decades, but in the immediate future too. Immediate benefits would come from revisiting the transmission and distribution price reviews, introducing a default tariff for supply focused on the margins, and reforms to the FiTs to capture the refinancing gains after existing commitments have been fully met.

25. This long-term framework, coupled with these immediate measures, is the least-cost way of achieving the objectives, with the prospect that the 2050 carbon target could be met at lower cost, and could even be met early, to the benefit of households and industry.

26. Not to implement these recommendations is likely to perpetuate the crisis mentality of the industry, and these crises are likely to get worse, challenging the security of supply, undermining the transition to electric transport, and weakening the delivery of the carbon budgets. It will continue the unnecessary high costs of the British energy system, and as a result perpetuate fuel poverty, weaken industrial competitiveness, and undermine public support for decarbonisation. We can, and should, do much better, and open up a period of falling prices as households and industry benefit from the great technological opportunities over the coming decades.

The Government must change its response to the Climate Change Act so that the burden of implementation does not fall unfairly on the poorest members of society. There can be little confidence in this as when the government introduced its target of net zero emissions by 2050 it failed to produce an impact assessment.—(*Graham Stringer.*)

The Committee divided.

Ayes, 1	Noes, 5
Graham Stringer	Vicky Ford
	Darren Jones
	Stephen Metcalfe
	Carol Monaghan
	Martin Whitfield

Question accordingly negatived.

Paragraph 19 agreed to.

Paragraph 20 read and agreed to.

Paragraphs—(*Graham Stringer*)—brought up and read, as follows:

> Climate models are an imperfect way of understanding global warming. A number of academic reports have questioned their accuracy. The IPCC Synthesis Report 2012, page 43, found 111 of 114 climate models predicted higher temperatures than were observed between 1998 and 2012. Warming in the troposphere was found to be less than half that predicted in the Asia-Pacific Atmospheric Journal, reference 53/4 2017.
>
> With only partial information the Government has moved to a zero emissions policy for 2050. It does not know the cost of this policy and there is no evidence that the major emitters of carbon dioxide are following. In fact, India has cancelled its nuclear programme and China is building 700 coal fired power stations. On its own, if successful, the UK's greenhouse gas reduction policy would delay global warming by 8 months. Unilateralism is an expensive and ineffective policy for tackling climate change.

Question put, That the paragraphs be read a second time.

The Committee divided.

Ayes, 1	Noes, 5
Graham Stringer	Vicky Ford
	Darren Jones
	Stephen Metcalfe
	Carol Monaghan
	Martin Whitfield

Question accordingly negatived.

Paragraphs 21 and 22 read and agreed to.

Paragraph 23 read.

Amendment proposed, in line 18, after "Science and Technology Committee.", to insert "It also creates a major conflict of interest for Lord Deben as the Chair of the Climate Change Committee. He should not continue as Chair of that committee."—(*Graham Stringer.*)

The Committee divided.

Ayes, 1	Noes, 5
Graham Stringer	Vicky Ford
	Darren Jones
	Stephen Metcalfe
	Carol Monaghan
	Martin Whitfield

Question accordingly negatived.

Paragraph 23 agreed to.

Paragraphs 24 to 258 read and agreed to.

Annex and Summary agreed to.

Resolved, That the Report be the Twentieth Report of the Committee to the House.

Ordered, That the Chair make the Report to the House.

Ordered, That embargoed copies of the Report be made available (Standing Order No. 134).

[Adjourned till Wednesday 4 September at 9.00am

Witnesses

The following witnesses gave evidence. Transcripts can be viewed on the inquiry publications page of the Committee's website.

Tuesday 15 January 2019

Lord Deben, Chairman, and **Chris Stark**, Chief Executive, Committee on Climate Change — Q1–38

Malcolm Brinded, Fellow, Royal Academy of Engineering and allied institutions, **Guy Newey**, Director of Strategy and Performance, Energy Systems Catapult, and **Professor Jim Watson**, Director, UK Energy Research Centre — Q39–91

Tuesday 26 February 2019

Amanda Lyne, Chair, UK Hydrogen and Fuel Cell Association, **Andy Eastlake**, Managing Director, Low Carbon Vehicle Partnership, and **Tanya Sinclair**, Policy Director UK & Ireland, ChargePoint — Q92–164

David Weatherall, Head of Policy, Energy Saving Trust, **Jenny Holland**, Senior Public Affairs & Policy Specialist, UK Green Building Council, **Sam French**, Decarbonised Gas Alliance, and **Graham Hazell**, Consultant, Heat Pump Association — Q165–229

Tuesday 2 April 2019

Professor Keith Bell, University of Strathclyde, **Dr Robert Gross**, Imperial College London, **Dr Nina Skorupska**, Chief Executive, Renewable Energy Association, and **Tom Greatrex**, Chief Executive, Nuclear Industry Association — Q230–294

Professor Nick Eyre, Director, Centre for Research into Energy Demand Solutions, **Professor Tim Green**, Co-Director, Imperial College Energy Futures Lab, **Randolph Brazier**, Head of Innovation and Development, Energy Networks Association, and **Duncan Burt**, Director of Operations, National Grid System Operator — Q295–356

Tuesday 23 April 2019

Professor Jim Skea, Imperial College London, **Professor Gideon Henderson**, Royal Society, **Professor Jon Gibbins**, Centre Director, UK Carbon Capture and Storage Research Centre, and **Dr Naomi Vaughan**, Tyndall Centre for Climate Change Research — Q357–413

Rt Hon Claire Perry MP, Minster of State for Energy and Clean Growth, **Tim Lord**, Director, Clean Growth, and **Damitha Adikaari**, Acting Director, Science and Innovation for Climate and Energy, Department for Business, Energy and Industrial Strategy — Q414–504

Published written evidence

The following written evidence was received and can be viewed on the inquiry publications page of the Committee's website.

CGE numbers are generated by the evidence processing system and so may not be complete.

1 ABB (CGE0010)
2 Amir Eilon (CGE0078)
3 Anglian Water Services (CGE0017)
4 Anglo American (CGE0046)
5 Bright Blue (CGE0049)
6 Cadent (CGE0015)
7 Calor (CGE0027)
8 Carbon Capture and Storage Association (CGE0023), (CGE0079)
9 CBMNet (CGE0003)
10 Centre for Research into Energy Demand Solutions (CGE0070)
11 ChargePoint (CGE0054)
12 Decarbonised Gas Alliance (CGE0032)
13 Department for Business, Energy and Industrial Strategy (CGE0016), (CGE0089)
14 Department for Transport (CGE0088)
15 Dolphin N2 (CGE0069)
16 Dr Duncan Connors (CGE0060)
17 Dr Jonathan Radcliffe (CGE0041)
18 Drax Group plc (CGE0025)
19 Durham Energy Institute (CGE0065)
20 E.ON (CGE0036)
21 Eaton (CGE0052)
22 EDF Energy (CGE0020)
23 Energy and Utilities Alliance (CGE0031)
24 Energy Networks Association (CGE0059)
25 Energy Systems Catapult (CGE0029)
26 Energy Technologies Institute (CGE0061)
27 Energy UK (CGE0024)
28 Enertek International Ltd (CGE0063)
29 Environmental Defense Fund Europe (CGE0042)
30 Federation of Petroleum Suppliers (CGE0028)
31 Greenpeace UK (CGE0022)
32 Heat Pump Association (CGE0074)
33 Highview Power (CGE0050)

34 Imperial College London (CGE0071)
35 Johnson Matthey (CGE0066)
36 Marine Energy Wales (CGE0047)
37 Menter Mon (CGE0002)
38 Michael Pilling (CGE0087)
39 Mr Andrew Lewis (CGE0008)
40 Mr Colin Megson (CGE0082)
41 Mr George Busby (CGE0072)
42 Mr Timothy Kingham (CGE0064)
43 National Franchised Dealers Association (CGE0073)
44 National Grid (CGE0019)
45 National Physical Laboratory (CGE0014)
46 Network/Utility Week (CGE0086)
47 Nova Innovation Ltd (CGE0044)
48 Nuclear Industry Association (CGE0018)
49 Offshore Renewable Energy Catapult (CGE0081)
50 Ofgem (CGE0033)
51 OVO Energy (CGE0007)
52 Policy Connect (CGE0011)
53 Professor Jonathan Gibbins (CGE0045)
54 Pupils 2 Parliament (CGE0012)
55 Renewable Energy Association (CGE0026)
56 Renewable Thermal Systems Limited (CGE0077)
57 RenewableUK (CGE0067)
58 Rolls-Royce Plc (CGE0039)
59 Royal Academy of Engineering (cross-engineering sector response) (CGE0055)
60 Scottish Carbon Capture and Storage (CGE0021)
61 SGN (CGE0040)
62 Society of Motor Manufacturers and Traders (CGE0030)
63 Solar Trade Association (CGE0053)
64 Sustainable Marine Energy (CGE0013)
65 The Geological Society (CGE0051)
66 The Royal Society (CGE0056)
67 Tokamak Energy Ltd (CGE0004), (CGE0075)
68 UCL Green Innovation Policy Commission (CGE0009)
69 UK Energy Research Centre (CGE0057)
70 UK Hydrogen and Fuel Cell Association (CGE0034)
71 UK Research and Innovation (CGE0058)

72 UKLPG (CGE0062)

73 ULEMCo Ltd (CGE0005)

74 Victor Harman (CGE0068)

75 Zenobe Energy (CGE0080)

List of Reports from the Committee during the current Parliament

All publications from the Committee are available on the publications page of the Committee's website. The reference number of the Government's response to each Report is printed in brackets after the HC printing number.

Session 2017–19

First Report	Pre-appointment hearing: chair of UK Research & Innovation and executive chair of the Medical Research Council	HC 747
Second Report	Brexit, science and innovation	HC 705
Third Report	Genomics and genome editing in the NHS	HC 349
Fourth Report	Algorithms in decision-making	HC 351
Fifth Report	Biometrics strategy and forensic services	HC 800
Sixth Report	Research integrity	HC 350
Seventh Report	E-cigarettes	HC 505
Eighth Report	An immigration system that works for science and innovation	HC 1061
Ninth Report	Flu vaccination programme in England	HC 853
Tenth Report	Research integrity: clinical trials transparency	HC 1480
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Twelfth Report	Quantum technologies	HC 820
Thirteenth Report	Energy drinks and children	HC 821
Fourteenth Report	Impact of social media and screen-use on young people's health	HC 822
Fifteenth Report	Evidence-based early years intervention: Government's Response to the Committee's Eleventh Report of Session 2017–19	HC 1898
Sixteenth Report	'My Science Inquiry'	HC 1716
Seventeenth Report	Japanese knotweed and the built environment	HC 1702
Eighteenth Report	Digital Government	HC 1455
Nineteenth Report	The work of the Biometrics Commissioner and the Forensic Science Regulator	HC 1970
First Special Report	Science communication and engagement: Government Response to the Committee's Eleventh Report of Session 2016–17	HC 319
Second Special Report	Managing intellectual property and technology transfer: Government Response to the Committee's Tenth Report of Session 2016–17	HC 318
Third Special Report	Industrial Strategy: science and STEM skills: Government Response to the Committee's Thirteenth Report of Session 2016–17	HC 335

Fourth Special Report	Science in emergencies: chemical, biological, radiological or nuclear incidents: Government Response to the Committee's Twelfth Report of Session 2016–17	HC 561
Fifth Special Report	Brexit, science and innovation: Government Response to the Committee's Second Report	HC 1008
Sixth Special Report	Algorithms in decision-making: Government Response to the Committee's Fourth Report	HC 1544
Seventh Special Report	Research integrity: Government and UK Research and Innovation Responses to the Committee's Sixth Report	HC 1562
Eighth Special Report	Biometrics strategy and forensic services: Government's Response to the Committee's Fifth Report	HC 1613
Ninth Special Report	An immigration system that works for science and innovation: Government's Response to the Committee's Eighth Report	HC 1661
Tenth Special Report	Research integrity: clinical trials transparency: Health Research Authority Response to the Committee's Tenth Report	HC 1961
Eleventh Special Report	Quantum technologies: Government Response to the Committee's Twelfth Report	HC 2030
Twelfth Special Report	Impact of social media and screen-use on young people's health: Government Response to the Committee's Fourteenth Report	HC 2120