Part 1: The Government's approach to energy and climate change

Introduction

1.1 The UK, in common with other countries, faces two great risks over the coming decades:

- First, if we are not able to constrain global greenhouse gas emissions, the world faces the prospect of dangerous **climate change**, which will have unprecedented impacts on global security and prosperity.
- Second, the UK faces challenges to its **energy security** as our current generation of power stations closes and we must ensure supplies of energy which are resilient to volatile fossil fuel prices.

The threat of climate change

1.2 Climate change is one of the greatest threats facing the world today. There is an overwhelming scientific consensus that climate change is happening, and that it is primarily the result of human activity. There is now almost 40% more carbon dioxide in the atmosphere than there was before the industrial revolution, the highest level seen in at least the last 800,000 years. As a consequence, global average temperatures continue to rise. 2000–09 was the warmest decade on record, and 2010 matched 2005 and 1998 as the equal warmest year.[8]

1.3 The UK accounts for less than 1.5% of global greenhouse gas emissions,[9] so we have a clear national interest in ensuring that the world tackles climate change together. Climate change is a global problem, and it requires a global solution. Therefore the UK's international approach focuses on:

- encouraging the European Union to demonstrate leadership on climate change;
- influencing global political and economic conditions to secure action from other countries to limit greenhouse gas emissions;
- helping developing countries to build the climate resilience of their economies and move towards low carbon growth in the future; and
- working for a comprehensive global climate change agreement.

1.4 At the same time as mitigating climate change, the Government is committed to ensuring that the UK is resilient to the effects of a changing climate. The Climate Change Risk Assessment to be published next year will provide an assessment of climate change risks and opportunities for the UK. The assessment will underpin the development of a National Adaptation Programme establishing priorities for UK adaptation policy over the next five years.

[8] For further information on climate science see: Royal Society (2010) *Climate Change: A summary of the science*. Available at: http://royalsociety.org/climate-change-summary-of-science/

[9] Climate Analysis Indicators Tool. Available at: http://cait.wri.org/

Maintaining our energy security

1.5 We face three challenges to our energy security. First, by 2020, the UK could be importing nearly 50% of its oil and 55% or more of its gas. At a time of rising global demand, and continued geopolitical instability, the risk of high and volatile energy prices, and physical disruptions will remain. Second, we will lose a fifth of our electricity generating capacity due to the closure of coal and nuclear plants over the coming decade. Third, in the long term, while dependence on imported energy is expected to fall, we will face a new challenge in balancing more intermittent supply of energy from renewables with more variable electricity demand from electric cars, or electric heating. Our system will need to be resilient to mid-winter peaks in heating demand due to cold weather, and troughs in supply due to low wind speeds.

1.6 To meet our energy security needs, gas and oil will continue to play a valuable role as we make the transition to a low carbon economy. Gas will be needed over the coming decades both for heating and for electricity generation. Even in 2050, gas will contribute to electricity supply in the form of power stations fitted with carbon capture and storage (CCS) technology or as back-up to intermittent renewable generation. Our energy strategy seeks to underpin secure and diverse energy supplies, both domestically and internationally. This involves encouraging investment in oil and gas production; promoting reliable supply through more efficient markets and strengthened bilateral trading relations; and enhancing price stability through improved transparency and dialogue.

Our principles

1.7 The Government is determined that we should address the twin challenges of tackling climate change and maintaining our energy security in a way that **minimises costs and maximises benefits to our economy**.

1.8 To achieve this, we will follow a clear set of principles:

- **We should always aim for the most cost effective means to achieve our aims.** This necessitates using less energy across the economy. And it requires using the most cost effective technologies to drive further efficiencies and meet remaining demand.

- **A diverse portfolio of technologies, competing against each other for market share, can drive innovation and cost reduction.** While our principle is to choose the most cost effective mix of technologies in any sector, the reality is that we do not yet know how these technologies will develop, how their costs will change, or what other technologies may yet emerge. In transport this could mean electric, plug-in hybrid or hydrogen cars, or the use of biofuels. In heating this could mean building-level technologies such as air- and ground-source heat pumps or network-level options such as district heating. For that reason, the Government aims to encourage a portfolio of technologies and create competitive market conditions in which the most cost effective succeed over time.

- **Clear long-term signals about the regulatory framework can support cost reduction.** There is a role for the Government in providing clear, unambiguous signals to the market and a stable long-term regulatory framework to create the conditions for the investment that is fundamental to economic growth and the move to a low carbon economy.

- **The Government should help to tackle market failures and unblock barriers to investment to encourage growth in newer technologies.** While competition between technologies and businesses is the best way to ensure that we find the most cost effective mix, there is a role for the Government in identifying where it can constructively enable the market, particularly where technology deployment relies on the creation of new infrastructure.

- **Costs must be distributed fairly.** The Government will continue to focus on the distributional impacts of the low carbon transition. We are supporting consumers by

providing subsidised insulation, delivered by energy companies, to the most vulnerable households, as well as bill rebates to more than 600,000 vulnerable pensioners. The Government also recognises the challenges confronting energy-intensive industries, including the difficulties some face in remaining internationally competitive while driving down domestic emissions. We are taking active steps to support these industries through the transition, recognising the future role these sectors will play in delivering economic growth.

1.9 Reducing emissions will have wider impacts. Creating a low carbon and resource efficient economy means making major structural changes to the way in which we work and live, including how we source, manage and use our energy. The Government is committed to identifying a sustainable route for making that transition by balancing greenhouse gas benefits, cost, energy security and impacts on the natural environment. By adopting these principles, we seek to maximise the potential economic benefits to the UK from making the transition to a low carbon economy, as well as to minimise adverse impacts for the environment and public.[10] Doing this in the most cost effective way will help to enable us to:

- **use our resources more efficiently.** Managing energy and resource demand reduces costs to businesses and consumers, releasing spending power that can increase growth and productivity elsewhere. Lower demand for energy reduces risks to the security of our energy supplies;
- **reduce our exposure to fossil fuel price volatility.** According to the Office for Budget Responsibility, a temporary 20% increase in the oil price (adjusted to remove inflation) would lead to a loss of potential output in the UK of over 0.3% in the following year;[11] and
- **create long-term comparative advantages.** Being an early mover in technologies such as renewables and CCS could give the UK a long-term comparative advantage in growing global markets for these technologies.

The vision for 2050

1.10 These principles will underpin our vision for a long-term transition to a low carbon economy. By 2050 we will have transformed our buildings, transport and industry, the way in which we generate electricity and our agriculture and forestry.

1.11 **Low carbon buildings:** Heating and powering buildings produced 38% of the UK's emissions in 2009. Those emissions are a result of burning fossil fuels to heat buildings, and generating the electricity that powers our lighting and appliances. Buildings will need to be much better insulated and make use of Smart Meters and heating controls, and more efficient lighting and appliances, to reduce their demand for energy. At the same time, we will move away from the use of fossil fuels for heating and hot water and towards low carbon alternatives such as heat pumps or heating networks. By 2050, emissions from heating and powering our buildings will be virtually zero.

1.12 **Low carbon transport:** Transport is a major contributor to the UK's energy demand and greenhouse gas emissions, creating 24% of the UK total in 2009. Most of those emissions come from the oil-based fuels we rely upon for road transport. A step-change is needed to move away from fossil fuels and towards ultra-low carbon alternatives such as battery electric or fuel cell vehicles. New technologies will have implications for energy security, with increased demands likely to be placed on the grid by ultra-low emission vehicles (such as electric cars), as well as presenting new opportunities for vehicles to help balance variations in demand for electricity over time and reducing our exposure to volatile oil prices.

[10] In summer 2012 the Government will launch a research programme on sustainable pathways to 2050 which will consider the cumulative impacts of and interactions between different low carbon technologies. See Annex B for further details on the wider environmental impacts of reducing emissions and meeting carbon budgets.

[11] OBR (2010) *Assessment of the Effect of Oil Price Fluctuations on the Public Finances*. Available at: http://budgetresponsibility.independent.gov.uk/wordpress/docs/assessment_oilprice_publicfinances.pdf

1.13 **Low carbon industry:** Industry currently accounts for nearly one quarter of UK emissions, generated by burning fossil fuels for heat and by the chemical reactions involved in some industrial processes. Production of goods – from paper to steel – will need to become more energy efficient and switch over to low carbon fuel sources.

1.14 **Low carbon power generation:** The power sector currently accounts for 27% of UK emissions. As heating, transport and industry become increasingly electrified, the amount of electricity we need to generate is very likely to increase from today, and it will need to be almost entirely carbon-free. By 2050, the three sources of UK electricity are likely to be renewables (in particular onshore and offshore wind farms); coal, biomass or gas-fired power stations fitted with CCS technology; and nuclear power.[12] The grid will need to be larger, stronger and smarter to reflect the quantity, geography and intermittency of power generation. We will also need to ensure the security of the fossil fuel resources required to make the low carbon transition.

1.15 **Low greenhouse gas agriculture and forestry:** Emissions from agriculture, land use and forestry – mostly in the form of nitrous oxide and methane – made up around 9% of total emissions in 2009, but will account for an increasingly large share of overall UK greenhouse gas emissions as other sectors decarbonise over the next three decades. In order to meet our 2050 target, the agricultural sector will need to contribute to reducing emissions by adopting more efficient practices. We will also ensure the development of a sustainable and expanding forestry sector.

2050 futures

1.16 While our vision for 2050 is clear, there are huge uncertainties when looking 40 years ahead as to exactly how that vision will be achieved. Our approach has been to try to explore a range of plausible scenarios for what the UK might look like in 2050 and to seek to draw lessons from the similarities and differences between those scenarios. In line with our principle of seeking the most cost effective technology mix, our starting point for this has been to take the outputs of the 'core' run of the cost-optimising model, MARKAL, which was produced as part of the Department of Energy and Climate Change's analysis to support the setting of the fourth carbon budget.[13]

1.17 On the supply side, the core MARKAL run produces a balanced generation mix, with 33 gigawatts (GW) of nuclear, 45 GW of renewables and 28 GW of fossil fuel with CCS power capacity by 2050. On the demand side, the model run drives a sharp reduction in per capita energy demand; in this run, everybody in the UK would use half as much energy in 2050 as they do today, due to the adoption of more energy efficient technologies, with heat pumps, district heating, battery electric and fuel cell vehicles.

1.18 This is only a starting point. Attempting to pick a single pathway to 2050 by relying on a single model is neither possible nor a helpful guide in the face of great uncertainty. But it does give insight into the most cost effective way to achieve the low carbon transition, illustrating the technologies likely to contribute to reducing emissions, and the most cost effective timing for their deployment. It shows that achieving a cost-optimal transition overall often necessitates deploying technologies in the medium term that may not yet be statically cost effective against the carbon price.[14]

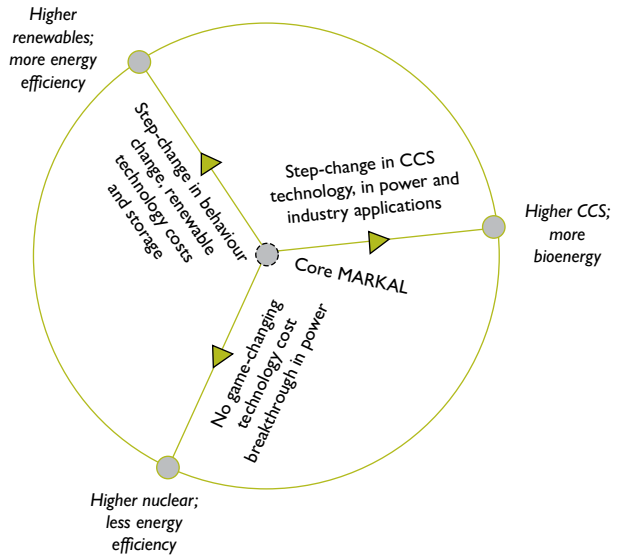
[12] The UK Government works in partnership with the Devolved Administrations in Northern Ireland, Scotland and Wales to deliver the targets set by the Climate Change Act 2008. While the administrations have a shared goal of reducing the impacts of climate change, policies on how to achieve this vary across the administrations – the Scottish Government, for example, is opposed to the development of new nuclear power stations in Scotland. It believes that renewables, fossil fuels with CCS and energy efficiency represent the best long-term solution to Scotland's energy security. This document focuses largely on UK Government policy on climate change, with Devolved Administration views set out in 'Working with the EU and Devolved Administrations' on page 99.

[13] HMG (2011) *Fourth Carbon Budget Level: Impact Assessment (final)*. MARKAL is discussed further at Annex A.

[14] The cost effectiveness of measures is affected by the scale and timing of their deployment. Static cost effectiveness does not account for changes to a measure's cost effectiveness due to variations in the scale and timing of its deployment.

1.19 Alongside this core MARKAL run the Government has developed three further 'futures' that attempt to stress test the results of the core run by recognising that there will be changes that we cannot predict in the development, cost and public acceptability of different technologies in every sector of the economy.

Figure 1: 2050 futures



1.20 Future **'Higher renewables, more energy efficiency'** assumes a major reduction in the cost of renewable generation alongside innovations that facilitate a large expansion in electricity storage capacity. This helps to manage the challenges of those renewables that are intermittent. It is consistent with a world where high fossil fuel prices or global political commitment to tackling climate change drives major investment and innovation in renewables.

1.21 As a consequence, the power generation mix includes deployment of wind, solar, marine and other renewable technologies, as well as back-up gas generation. This future also assumes a major reduction in per capita energy demand driven by people embracing low carbon behaviour changes and smart new technologies such as heating controls, and recognising the financial benefits of taking up energy efficiency opportunities. We electrify the majority of our demand for heat, industry and transport using ground- and air-source heat pumps in buildings and electrified industrial processes, and we travel in ultra-low emissions vehicles.

1.22 Future **'Higher CCS, more bioenergy'** assumes the successful deployment of CCS technology at commercial scale and its use in power generation and industry, supported by significant natural gas imports, driven by changes such as a reduction in fossil fuel prices as a result of large-scale exploitation of shale gas reserves. It also assumes low and plentiful sustainable bioenergy resources (see box 2).

1.23 In this future, significant amounts of relatively low cost, sustainable biomass result in CCS also being used with biomass (BE-CCS) to generate negative emissions.[15] Negative emissions production is a game-changer in that it could offset the continued burning of fossil fuels elsewhere in the energy system. In this scenario, BE-CCS creates around 50 million tonnes carbon dioxide equivalent ($MtCO_2e$) of negative emissions – equivalent to almost 10% of today's total – which creates 'headroom' for some fossil fuel use. As a result, this pathway has less electrification of heat and transport, with more heat demand met through network-level heating systems such as district heating or combined heat and power. In transport, more demand is met through sustainable biofuels use in cars and buses, while strong effort is made to improve the efficiency of UK land management. No unabated gas generation is needed to balance the system in this future.

1.24 Future **'Higher nuclear, less energy efficiency'** is a future that is more cautious about innovation in newer technologies. CCS does not become commercially viable. Innovation in offshore wind and solar does not produce major cost reductions. Lack of innovation in solid wall insulation results in low public acceptability of energy efficiency measures.

[15] In the 2050 modelling, biomass fuel sources are typically assumed to be 'zero carbon' because the CO_2 released with their combustion is equal to the amount sequestered through the process of growing the biomass. Capture of this CO_2 through use of CCS technology (BE-CCS) removes it from the system altogether by pumping it underground – thereby creating 'negative emissions'.

Box 2: Sustainable bioenergy

Sustainable bioenergy is a versatile source of low carbon energy which will play a key role in meeting carbon budgets and the 2050 target. It has applications in each sector – including for the generation of electricity and heat, and as a replacement for more emissions-intensive transport fuels. In 2010 the UK used 73.6 terawatt hours (TWh) of bioenergy.

The *UK Renewable Energy Roadmap* stated that bioenergy could deliver around half of the total generation needed to meet our 2020 renewable targets. To achieve this level of deployment we will need to make the most of domestic supplies such as residues and wastes, increased use of under-managed woodlands and energy crop production on marginal land while also using globally traded feedstocks.

A key condition for the use of bioenergy is its ability to generate genuine emissions reductions. Clear sustainability standards – which account for greenhouse gas emissions throughout the lifecycle and also consider wider environmental impacts – are critical. Current estimates suggest that global and UK biomass demand is likely to increase towards 2050. However, sustainability concerns may constrain the availability of particular feedstocks.

The Government's forthcoming Bioenergy Strategy will set out the role that sustainable bioenergy can play in cutting greenhouse gas emissions and meeting our energy needs. It will provide the strategic direction on the future role of sustainable bioenergy against which future policies in this area can be assessed and developed.

1.25 As a result, nuclear is by far the largest source of electricity in 2050. Natural gas plays a role in matching peaks in demand. Compared with the core MARKAL run, there is less insulation of existing homes and less use of smart technologies and appliances in homes to reduce energy use. Individuals travel more than they do today and continue to make the most of their journeys using cars. We succeed in electrifying most of our demand for heat and transport, with remaining demand met through a mix of other technologies, such as district heating.

Planning for the future

1.26 These three futures, alongside the core MARKAL run, can help us to understand the choices we face as we make the transition to a low carbon economy by 2050. By looking at the commonalities and differences between them, we can try to understand which technologies and efforts now may be 'safe bets' in the face of future uncertainty, and to identify the points in time between now and 2050 when choices between technologies will need to be made if we are to keep different possible futures open. The Government's approach in this document, and in planning for the first four carbon budgets, is to ensure that we are supporting the safe bets; that we are acting to keep open different possibilities where we do not yet know what the cost effective and appropriate path may be; and that we identify and plan for decision points where possible paths diverge.

1.27 The three futures suggest parameters around the key uncertainties in the transition: the degree of energy efficiency that may be achieved across the economy; the lowest cost technology mix for decarbonising remaining energy demand (especially heating and transport demand); and the lowest cost technology mix for decarbonising electricity supply.

1.28 All three futures are published in the 2050 Calculator web tool at http://2050-calculator-tool.decc.gov.uk and further detail on their specific choices and implications can be found at Annex A. These futures indicate a range of deployment for key technologies in 2050, acknowledging that a number of factors – notably cost – will ultimately determine the level of deployment within this range.

1.29 The 2050 futures set out a helpful framework for developing the Government's strategy to achieve carbon budgets on the way to 2050. In each sector, we need to ensure that our strategy for meeting the first four carbon budgets puts us on a path to deliver this range of ambition in 2050. Part 2 of this document sets out how we will do this in each sector. Part 3 provides a range of scenarios for ways in which we could meet the fourth carbon budget, all of which would put us on track to deliver these 2050 futures.

Table 1: Summary of 2050 futures

(All figures in 2050)	Measure	Core MARKAL	Renewables; more energy efficiency	CCS; more bioenergy	Nuclear; less energy efficiency
Energy saving per capita, 2007–50		50%	54%	43%	31%
Electricity demand increase, 2007–50		38%	39%	29%	60%
Buildings	Solid wall insulation installed	n/a[16]	7.7 million	5.6 million	5.6 million
	Cavity wall insulation installed	n/a[16]	8.8 million	6.9 million	6.9 million
	House-level heating	92%	100%	50%	90%
	Network-level heating	8%	0%	50%	10%
Transport	Ultra-low emission cars and vans (% of fleet)	75%	100%	65%	80%
Industry	Greenhouse gas capture via CCS	69%	48%	48%	0%
Electricity generation	Nuclear	33 GW	16 GW	20 GW	75 GW
	CCS	28 GW	13 GW	40 GW	2 GW
	Renewables[17]	45 GW	106 GW	36 GW	22 GW
Agriculture and land use	Bioenergy use	~350 TWh	~180 TWh	~470 TWh	~460 TWh

[16] MARKAL does not provide figures for numbers of specific insulation measures deployed. The 2050 futures figures are taken directly from the 2050 Calculator, and should be taken as illustrative rather than precise targets for deployment.

[17] Note that the 2050 futures do not assume that existing renewables generation is repowered at the end of its lifetime. The 2050 Calculator assumes that wind turbines have a lifetime of 20 years.

Part 2: Our strategy to achieve carbon budgets

Achieving carbon budgets

2.1 As set out in Part 1, the Government's approach to avoiding the risk of dangerous climate change has at its heart the Climate Change Act 2008. The Act requires that five-yearly 'carbon budgets' be set three budget periods ahead, so that it is always clear what the UK's emissions pathway will be for the next 15 years.

Achieving carbon budgets one to three

2.2 The first three carbon budgets, for the years 2008–12, 2013–17 and 2018–22, were set in May 2009. Table 2 overleaf shows the level of the first three carbon budgets.

Our current policy framework

2.3 The 2050 futures give us a clear vision of the longer-term changes we will need to see in each sector of the economy. The Government already has a comprehensive package of policies in place to deliver the emissions reductions necessary to meet the first three carbon budgets and to provide incentives for the development and take-up of the portfolio of technologies necessary to put us on track to 2050. Domestic policies such as the Green Deal, the Renewable Heat Incentive and roll-out of Smart Meters, along with EU-wide policies such as the EU Emissions Trading System (EU ETS) and regulations on new car and van CO_2 emissions standards, are forecast to drive down emissions in the UK over this decade and provide a platform for further, deeper, cuts in emissions during the 2020s and beyond. More information on these policies can be found later in this report.

Emissions projections for carbon budgets one to three

2.4 The Government's emissions projections[18] provide forecasts for UK emissions over the short and medium term. These take into account the estimated energy and emissions savings from our current policy framework, and reflect estimates of the key economic factors that drive energy use and emissions, such as economic growth and fossil fuel prices (see box 3 on page 23). These projections are an essential tool for projecting progress and assessing risks to meeting carbon budgets. The table overleaf shows the latest emissions projections (central scenario) for the first three carbon budgets.

[18] DECC (2011) *Updated Energy and Emissions Projections 2011*. See: www.decc.gov.uk/en/content/cms/about/ec_social_res/analytic_projs/en_emis_projs/en_emis_projs.aspx

Table 2: October 2011 emissions projections (million tonnes of carbon dioxide equivalent ($MtCO_2e$))

	First carbon budget (2008–12)	Second carbon budget (2013–17)	Third carbon budget (2018–22)
Legislated interim budgets[19]	3,018	2,782	2,544
Percentage reduction from 1990 baseline[20]	23%	29%	35%
Net UK carbon account	2,922	2,650	2,457
Projected performance against first three carbon budgets (negative implies emissions under budget)	−96	−132	−87
Uncertainty range in projected over-achievement (high to low emissions projection)	−73 to −124	−73 to −172	−19 to −142

2.5 As can be seen, with current planned policies, the latest projections suggest that the UK is on track to meet its first three carbon budgets and that we expect to reduce emissions to below their levels by 96, 132 and 87 million tonnes carbon dioxide equivalent ($MtCO_2e$) respectively, based on central forecasts.

2.6 This forecast over-achievement suggests that the UK is in a strong position to deliver on more ambitious carbon budgets out to 2020. We continue to lobby strongly in Europe for a move to a more ambitious 2020 target and, if successful, we will amend our second and third carbon budgets accordingly, following effort share negotiations with other Member States, to ensure that they are consistent with new EU obligations.

Achieving the fourth carbon budget

2.7 On 30 June 2011, the level of the fourth carbon budget for the years 2023–27 was set in law, committing the UK to reduce emissions to 50% below 1990 levels. The Low Carbon Transition Plan, published in July 2009, set out the strategy for meeting the first three carbon budgets.[21] This Carbon Plan updates and supersedes the 2009 report and presents the Government's strategy for meeting all four carbon budgets, with a particular focus on the fourth carbon budget.

2.8 The level of the fourth carbon budget (1,950 $MtCO_2e$) assumes a split between emissions that will fall in the traded sector (690 $MtCO_2e$) and emissions that will fall in the non-traded sector (1,260 $MtCO_2e$). In the traded sector, emissions are capped by the EU ETS – see box 4 on page 24 for more information.

2.9 Whether or not we manage to reduce emissions by the amount required to meet carbon budgets will depend on the level of the UK's share of the EU ETS cap. We know that the current EU ETS cap is not sufficiently tight to deliver the

[19] The 'interim' carbon budgets are set on the basis of the current EU target to reduce emissions by 20% from 1990 levels by 2020.

[20] These percentages have changed since 2009 when quoted in the Low Carbon Transition Plan (HM Government (2009) *The UK Low Carbon Transition Plan: National strategy for climate and energy*, www.decc.gov.uk/publications/basket.aspx?FilePath=White+Papers%2fUK+Low+Carbon+Transition+Plan+WP09%2f1_20090724153238_e_%40%40_lowcarbontransitionplan.pdf&filetype=4) owing to an update in the greenhouse gas inventory which revised total 1990 baseline UK greenhouse gas emissions from 777.4 $MtCO_2e$ to 783.1 $MtCO_2e$. This number is the denominator in this calculation, hence while the budget levels (in $MtCO_2e$) have not changed, the 1990 baseline and percentage reductions have.

[21] HM Government (2009) *The UK Low Carbon Transition Plan: National strategy for climate and energy*.

Box 3: The Government's emissions projections

Emissions projections are inherently uncertain and the outturn could be higher or lower than the projections. This is due to uncertainty over future temperatures, fossil fuel prices, carbon prices, economic growth, demographic trends and the impact of our policies. There is also modelling uncertainty surrounding the ability to forecast economic relationships, for example the relationship between economic growth and emissions, uncertainty which is likely to increase over time as the structure of the UK economy and economic relationships evolve. As an example, while on central projections we expect the over-achievement in the third carbon budget to be 87 $MtCO_2e$ over the five-year period, the over-achievement might be as much as 142 $MtCO_2e$ (under low emissions projections) or as little as 19 $MtCO_2e$ (under high emissions projections). In the case of the traded sector, the uncertainty increases significantly beyond 2020 due to the fact that we do not have renewables targets beyond 2020: removing a key input such as this naturally increases the range of uncertainty. Not yet knowing the level of the future EU ETS cap similarly adds to uncertainty beyond 2020. The Government's approach is to focus on the central projections when setting carbon budgets, which require a single value to compare with emissions in 1990, and to carefully monitor the outturn.

necessary emissions reductions to meet the fourth carbon budget. The UK is pushing for the EU to show more ambition by moving to a tighter 2020 emissions target, which in turn will drive a more stringent EU ETS cap. We will review our progress in 2014. If at that point our domestic commitments place us on a different emissions trajectory than the ETS trajectory agreed by the EU, we will, as appropriate, revise up our budget to align it with the actual EU trajectory. Before seeking parliamentary approval to amend the level of the fourth carbon budget, the Government will take into account the advice of the Committee on Climate Change (CCC), and any representations made by the other national authorities.

Emissions projections for the fourth carbon budget

2.10 On central projections based on our current policy framework, UK territorial emissions are forecast to be around 2,207 $MtCO_2e$ over the fourth carbon budget (or 441.4 $MtCO_2e$ a year). This assumes that emissions savings from the legacy of current policies will continue, even where those policies do not currently extend beyond 2020. This is particularly the case for efficiency standards, such as the new car CO_2 target, where even without the 2020 car CO_2 target being extended and tightened, it is assumed that – as more new cars are sold beyond 2020, replacing older, less efficient vehicles in the fleet – emissions from transport will continue to fall.

2.11 The projections therefore show that our current suite of policies on its own is not likely to be sufficient to deliver the fourth carbon budget. On central projections, there is an expected shortfall in emissions of around 181 $MtCO_2e$ in the non-traded sector over the five-year period (or 36.2 $MtCO_2e$ a year).[22]

How to achieve the fourth carbon budget

2.12 The CCC was set up under the Climate Change Act to advise the Government on carbon budgets. Its fourth carbon budget report, published in December 2010,[23] gave a clear illustration of the kind of actions that the UK Government and Devolved Administrations would need to take to deliver the necessary emissions reductions. All sectors of the economy will need to play their part by the time of the fourth carbon budget but the CCC's advice focuses on the need for greater energy efficiency, particularly from energy use in buildings; for greater electrification of both heat and transport; and for decarbonisation of the power sector.

[22] Section B2 of Annex B contains further discussion of emissions projections for the fourth carbon budget period.

[23] See: www.theccc.org.uk/reports/fourth-carbon-budget

Box 4: The EU Emissions Trading System

The EU Emissions Trading System (EU ETS) is an EU-wide carbon cap and trade system which started in 2005, covering electricity generation and the main energy-intensive industries, including refineries and offshore, iron and steel, cement and lime, paper, glass and ceramics. It sets a declining limit on emissions and allows participants to trade the right to emit with each other, enabling emissions cuts to be made where they are cheapest.

Power and industries covered by the EU ETS together make up around 40% of UK emissions, and are collectively known as the traded sector. The level of emissions in the traded sector is governed by the UK's share of the declining level of the EU ETS cap. While the current ETS cap trajectory enables us to achieve the first three carbon budgets, the fourth carbon budget was set assuming that the ETS cap will be tightened further in the future. Continuing the current trajectory of the cap into the 2020s would not be sufficient to deliver the deep emissions reductions needed in the UK power and heavy industry sectors during the fourth carbon budget.

The scarcity of allowances in the ETS creates a carbon price. While the current carbon price set by the EU ETS is important to incentivising low carbon generation, it is not enough on its own – it has not been stable, certain or high enough to encourage sufficient investment in the UK. The Government therefore plans to introduce a Carbon Price Floor to support the carbon price, described further in paragraph 2.156.

2.13 The non-traded sector covers all sectors that fall outside of the EU ETS, including the buildings, transport and agricultural sectors. In the non-traded sector, there are three areas that have the potential to contribute significantly to emissions reductions over the fourth carbon budget period, in line with our vision for 2050. They are:

- ensuring that our homes are better insulated to improve their **energy efficiency**;
- replacing inefficient **heating systems** with more efficient, sustainable ones; and
- ensuring a step-change in our move towards **ultra-low carbon vehicles**, such as electric vehicles.

2.14 The traded sector covers all sectors that fall within the EU ETS, including power generation and most of the industry sector. The main area to contribute towards meeting the fourth carbon budget will be the installation of **low carbon electricity generation**.

2.15 The sections that follow illustrate the Government's plans in each of these areas.

Box 5: The Government's response to the Committee on Climate Change's Renewable Energy Review

In May 2010, the Department of Energy and Climate Change asked the Committee on Climate Change (CCC) to undertake a review of the potential for renewable energy deployment for 2020 and beyond, including whether there is scope to increase the current target, taking into account technical potential, costs and practical delivery.

The CCC approached the work in two phases. Phase 1 provided interim conclusions in September 2010, which agreed that the UK 2020 target was appropriate, and should not be increased. Phase 2, published in May 2011, provided recommendations on the post-2020 ambition for renewables in the UK, and the possible pathways to maximise their contribution to the 2050 carbon reduction target.

The Government thanks the Committee for its work and advice. We welcome its recognition that 15% renewables by 2020 is both an appropriate and achievable scale of ambition.

We are committed to achievement of the 2020 renewables target and agree with the CCC that our focus should now be on delivering that ambition, while working with industry to drive down costs. The *UK Renewable Energy Roadmap*, published in July 2011, sets out a programme of actions that Governments across the UK are taking to set us on the path to achieving the target.[24]

We acknowledge that renewables have the potential to provide 30–45% of energy by 2030 and possibly higher levels in the longer term and that, before making any future commitments, we need to resolve current uncertainties and reduce costs. We have considered and responded to the CCC's advice on the post-2020 potential for renewables in the electricity, buildings, industry and transport sections of this report.

[24] See: www.decc.gov.uk/en/content/cms/meeting_energy/renewable_ener/re_roadmap/re_roadmap.aspx

Box 6: Emissions data in the Carbon Plan

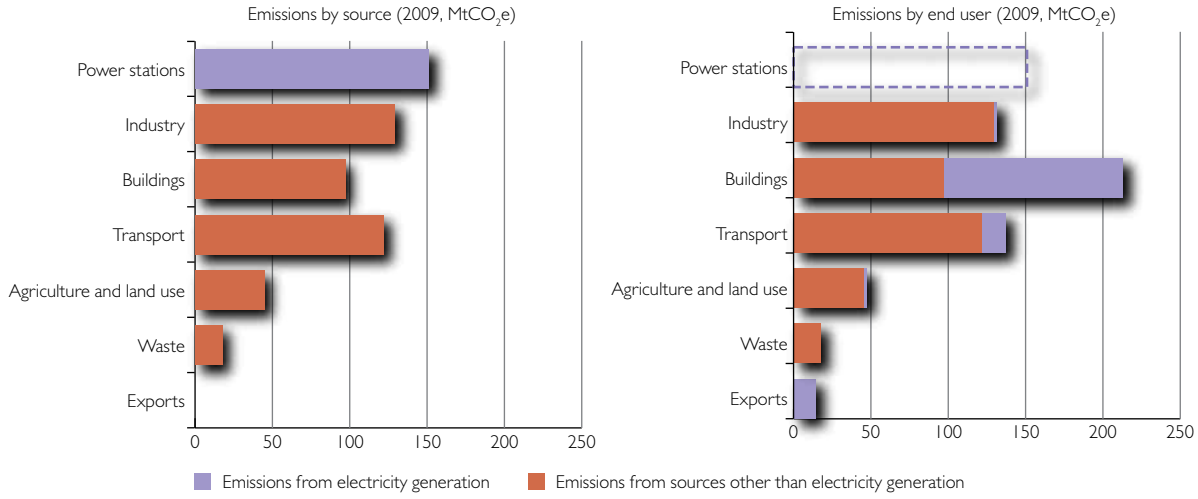
This report explains the progress the UK has already made in reducing greenhouse gas emissions since 1990. The sections which follow describe the Government's strategy to reduce emissions over the fourth carbon budget in each area of the economy. We have disaggregated historic and projected emissions along different lines to the National Communication (NC) sector classification[25] and the Standard Industrial Classification (SIC),[26] in order to clarify which areas make the most substantial contribution to emissions.

For the purpose of presenting historic emissions, we have allocated emissions from electricity generation to the **end user** of that electricity. This has been done in all sections except electricity generation where the emissions reported are **by source**. This breakdown is particularly important for some areas, such as buildings, where emissions from electricity generation make up the majority of the total. In most areas, the package of policies discussed targets both emissions relating to electricity use in that area, as well as emissions from other sources.

For all other figures (save historic emissions), emissions have been allocated by source, i.e. the emissions directly produced by that sector.[27]

The chart below shows a comparison of source and end user emissions.

Chart 5: Emissions by source and end user for each section in this report



Source: DECC National Statistics
Note: The 'exports' category relates to emissions within the UK from producing fuels (e.g. from a refinery or coal mine) which are subsequently exported for use outside the UK.

[25] These are consistent with the UK Greenhouse Gas Inventory. Available at: www.decc.gov.uk/en/content/cms/statistics/climate_change/gg_emissions/uk_emissions/2009_final/2009_final.aspx

[26] The SIC is consistent with the Digest of UK Energy Statistics (DUKES). It is also consistent with the breakdown of the Updated Energy and Emissions Projections (UEP).

[27] The historic emissions data quoted have been created on the basis of the NC sectors; the emissions projections data have been created on the basis of the UEP sectors.

BUILDINGS

Where we are now

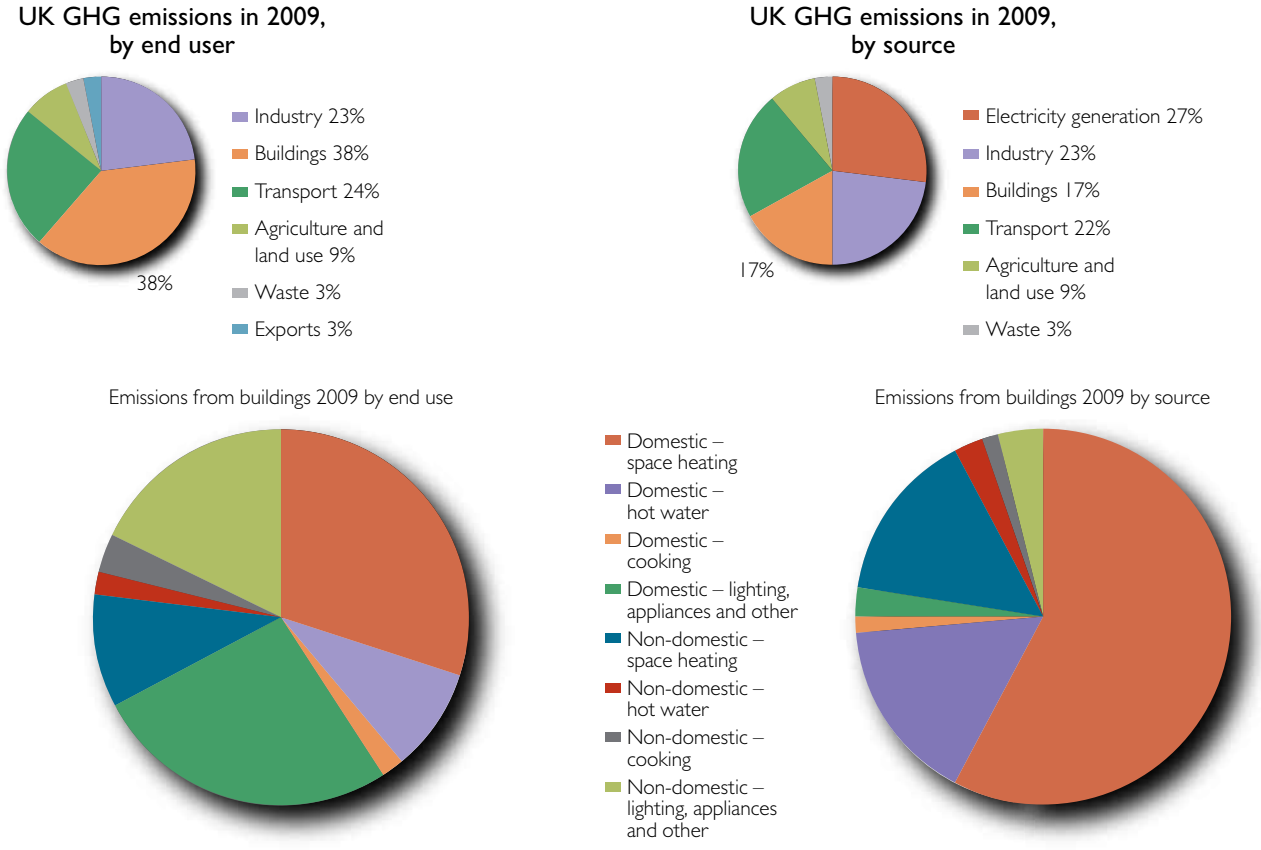
2.16 In 2009, our domestic buildings were responsible for 25% of the UK's emissions and just over 40% of its final energy use. Over three quarters of the energy we use in our homes is for space and hot water heating, most of which comes from gas-fired boilers. Lighting and appliances account for a smaller percentage of domestic energy demand, and emissions here are expected to reduce as the electricity grid is decarbonised.

2.17 The energy we use for heating and powering our non-domestic buildings is responsible for around 12% of the UK's emissions, three quarters of which comes from private businesses, with the remainder from public buildings. In addition, energy use for cooling is more significant in the commercial sector than for residential buildings.

2.18 Since 1990, emissions from buildings have fallen by around 9.2 $MtCO_2e$, or 9%.[28]

2.19 Over this period, government policies, including Warm Front, the Energy Efficiency Commitment and the Carbon Emissions Reduction Target have dramatically accelerated

Chart 6: Proportion of UK emissions from the buildings sector in 2009 (by end use and by source)[29]



Source: UK greenhouse gas statistics

[28] This section covers all heat and power in relation to domestic, commercial, private and public buildings (but not industrial process heat or power). The sectoral breakdowns in this report are for illustrative purposes only. Annex B presents emissions and savings data using the standard Updated Energy and Emissions Projections/National Communication basis.

[29] The emissions estimates in this section refer to greenhouse gas emissions from combustion of fuels (primarily gas, oil and coal) and have been presented both by end use and by source. This breakdown is particularly important where emissions from electricity generation make up a significant amount of the total.

the deployment of cavity wall and loft insulation. In 2010 alone, over 400,000 existing homes received cavity wall insulation and over a million lofts were insulated, leading to warmer homes and savings on energy bills (see chart 7). And, as a result of the 10.8 million cavity walls insulated so far, the UK will save over £1 billion this year on its national heating bill.

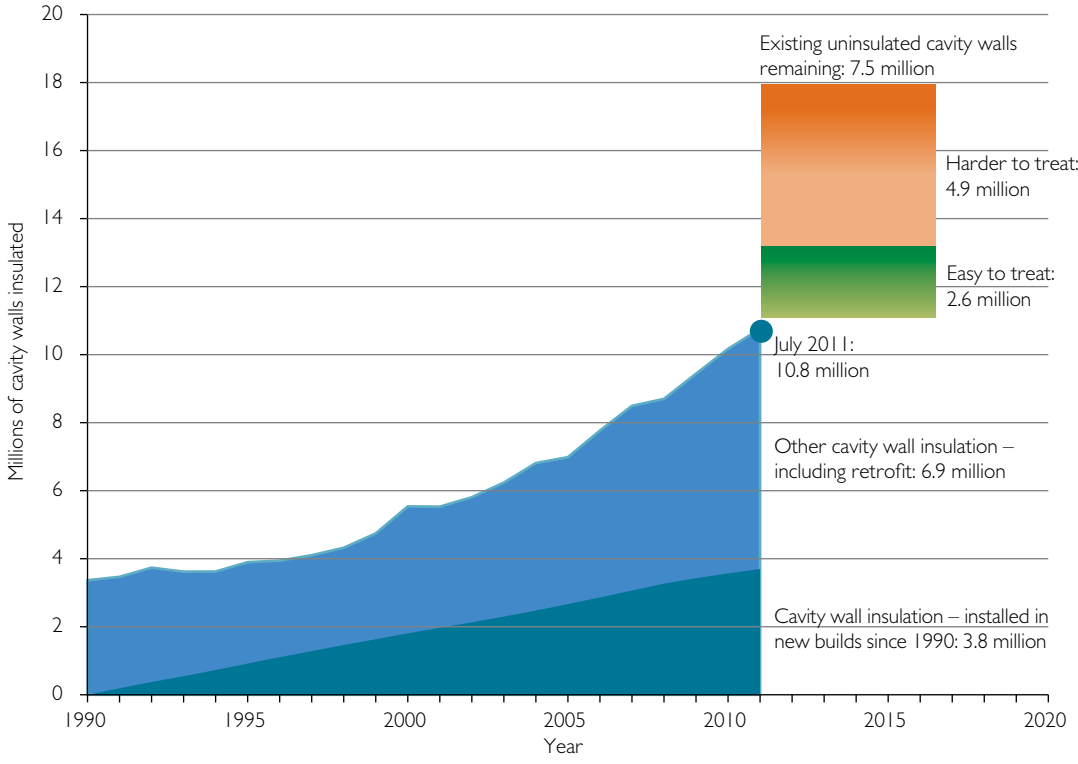
2.20 In addition, new buildings standards mean that a house built today demands only a fraction of the energy for space heating required by a house built before 1990. Improvements in this area have also been supported by new condensing boiler standards. Since legislation was introduced in 2005 mandating the installation of condensing boilers[30] in all but special applications, installation rates have increased to over 1.5 million a year (see chart 8), which in turn has saved 4.1 $MtCO_2e$ alone. This has led to savings for many householders (approximately £95 off their energy bills this year) and at least £800 million for the UK as a whole.[31]

Where we will be in 2050

2.21 By 2050 the emissions footprint of our buildings will need to be almost zero. We can achieve this through a mix of two main changes:

- **Reducing demand for energy in buildings** By increasing the thermal efficiency of buildings through better insulation; by encouraging consumers to use smarter heating controls and Smart Meters; and by improving the energy efficiency of lighting and appliances, and encouraging more efficient use of hot

Chart 7: Cavity walls insulated since 1990 and remaining uninsulated cavities



Source: Department of Energy and Climate Change

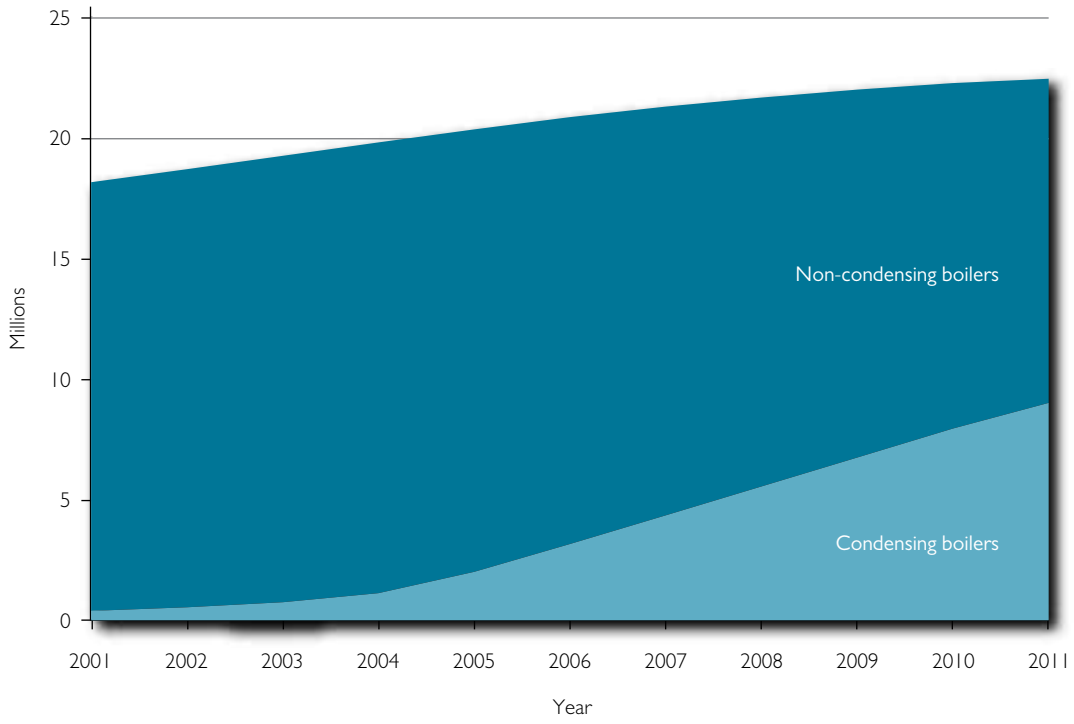
[30] Condensing boilers can reach efficiencies of around 90%.

[31] Savings calculated based on the average efficiency improvements of condensing boilers.

water. Better demand management can save money, bringing down energy bills, and release resources to support other activity and promote growth.

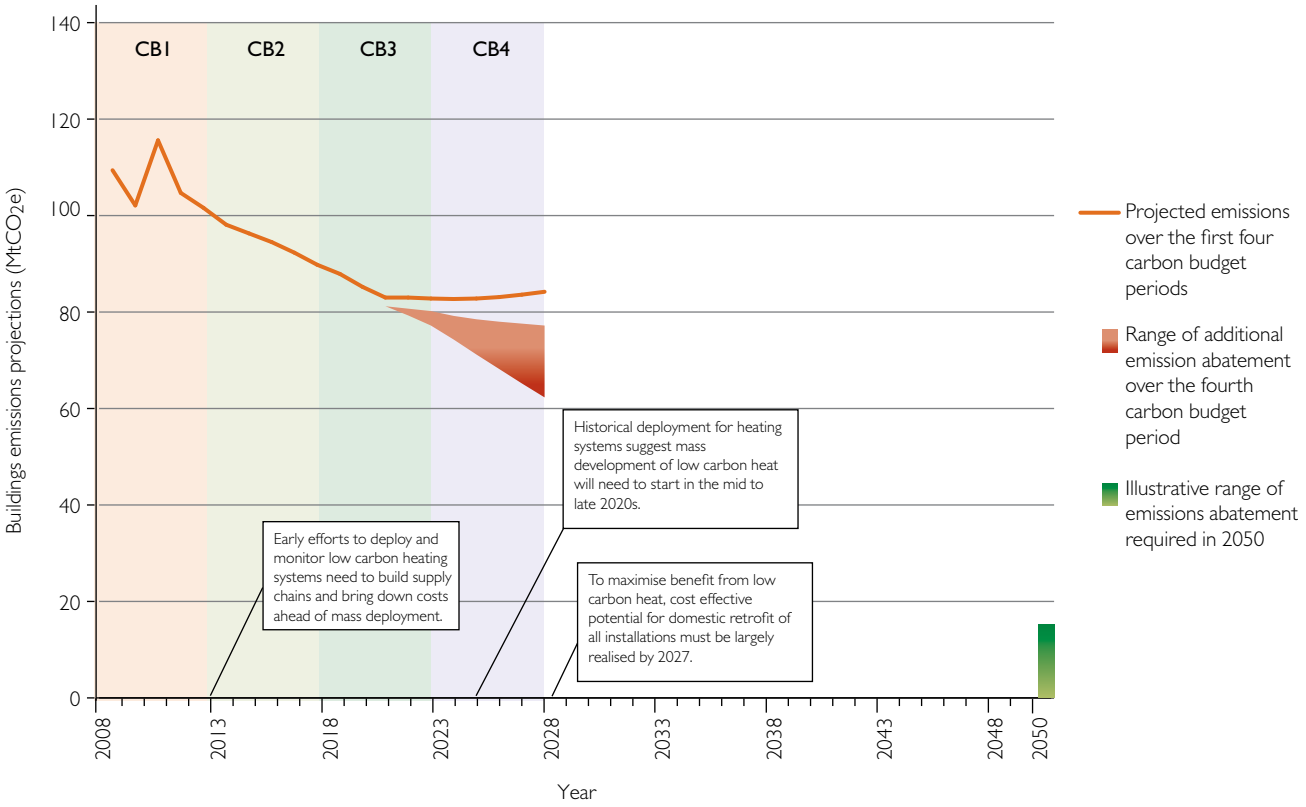
- **Decarbonising heating and cooling supply**
  By supporting the transition from conventional gas and oil boilers to low carbon heating alternatives such as heat pumps and more efficient systems such as heating networks or combined heat and power. A move away from fossil fuels for heating, hot water and appliances can reduce our dependence on imports and associated price volatility, thereby improving the security of our energy supplies.

Chart 8: Deployment of condensing and non-condensing boilers since 2001



Source: Department of Energy and Climate Change

Chart 9: Emissions projections in the buildings sector for the first three carbon budgets and illustrative ranges of emissions abatement potential in the fourth carbon budget period and in 2050[32]



Source: Department of Energy and Climate Change

[32] The emissions projections derive from UEP data. The illustrative ranges for emissions abatement potential for 2050 and the fourth carbon budget derive from the 2050 futures and fourth carbon budget scenarios – these are discussed in Parts 1 and 3 of this report respectively.

How we will make the transition

2.22 Chart 9 on the previous page illustrates the trajectory we expect emissions from buildings to follow over the first four carbon budgets on the way to 2050.

2.23 While we are on track for the first three carbon budgets, the UK will need between 26 and 75 $MtCO_2e$ of additional abatement from buildings during the fourth carbon budget period, over and above what the Government expects to be delivered through current policy. Learning from history, it has taken around 40 years for cavity wall insulation to reach today's level of market penetration. Achieving the scale of change ahead therefore requires us to start now.

2.24 **This decade** we need to **complete the cost effective 'easy wins'** in the buildings sector. This means maximising our energy efficiency efforts over the next decade. This will reduce costs and the amount of low carbon heating needed in future years.

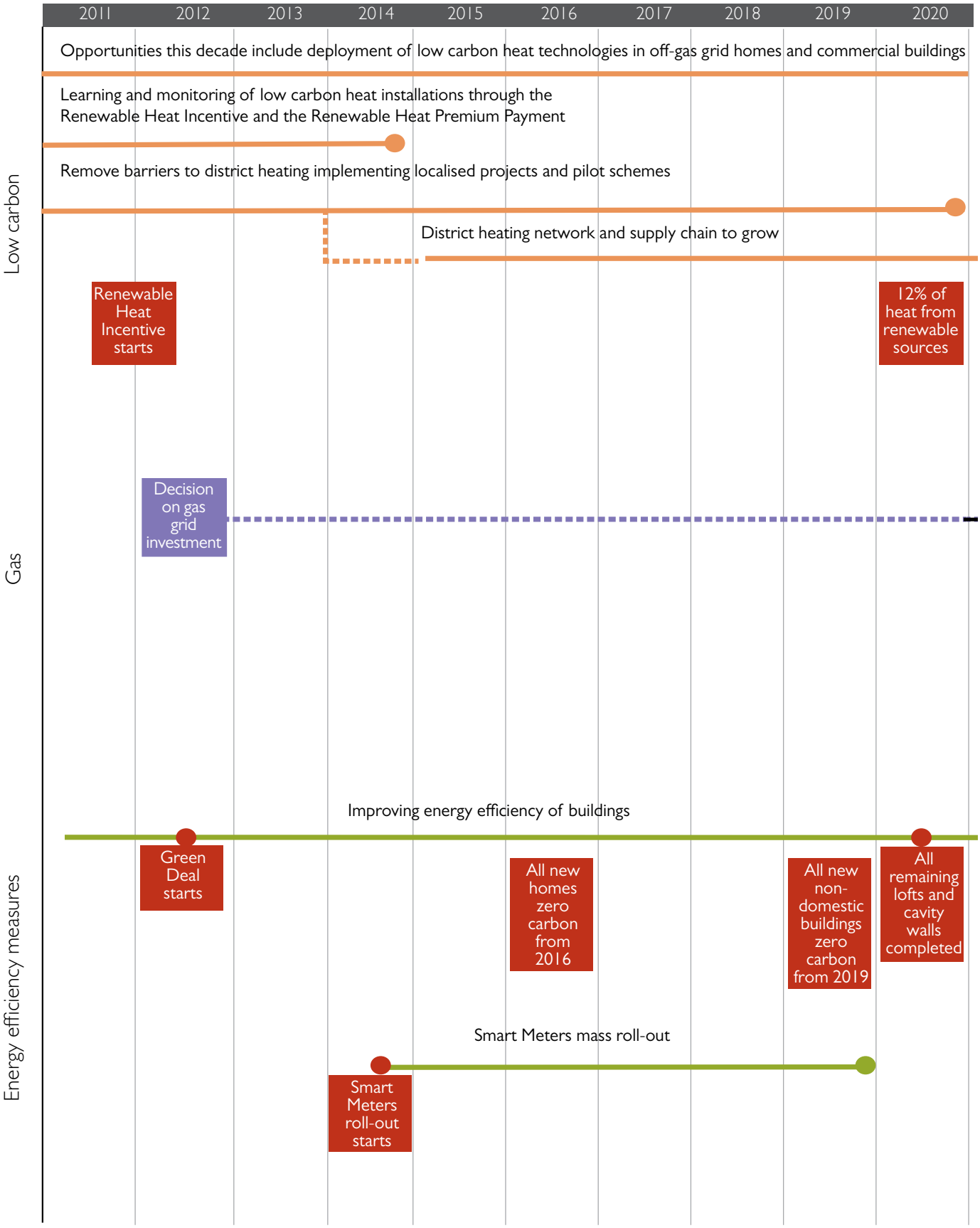
2.25 The Government's current policy package will depend on the final design of the Green Deal and Energy Company Obligation in the light of public consultation. It is likely to result in all practicable cavity walls and lofts having been insulated by 2020, together with up to 1.5 million solid walls also being insulated.

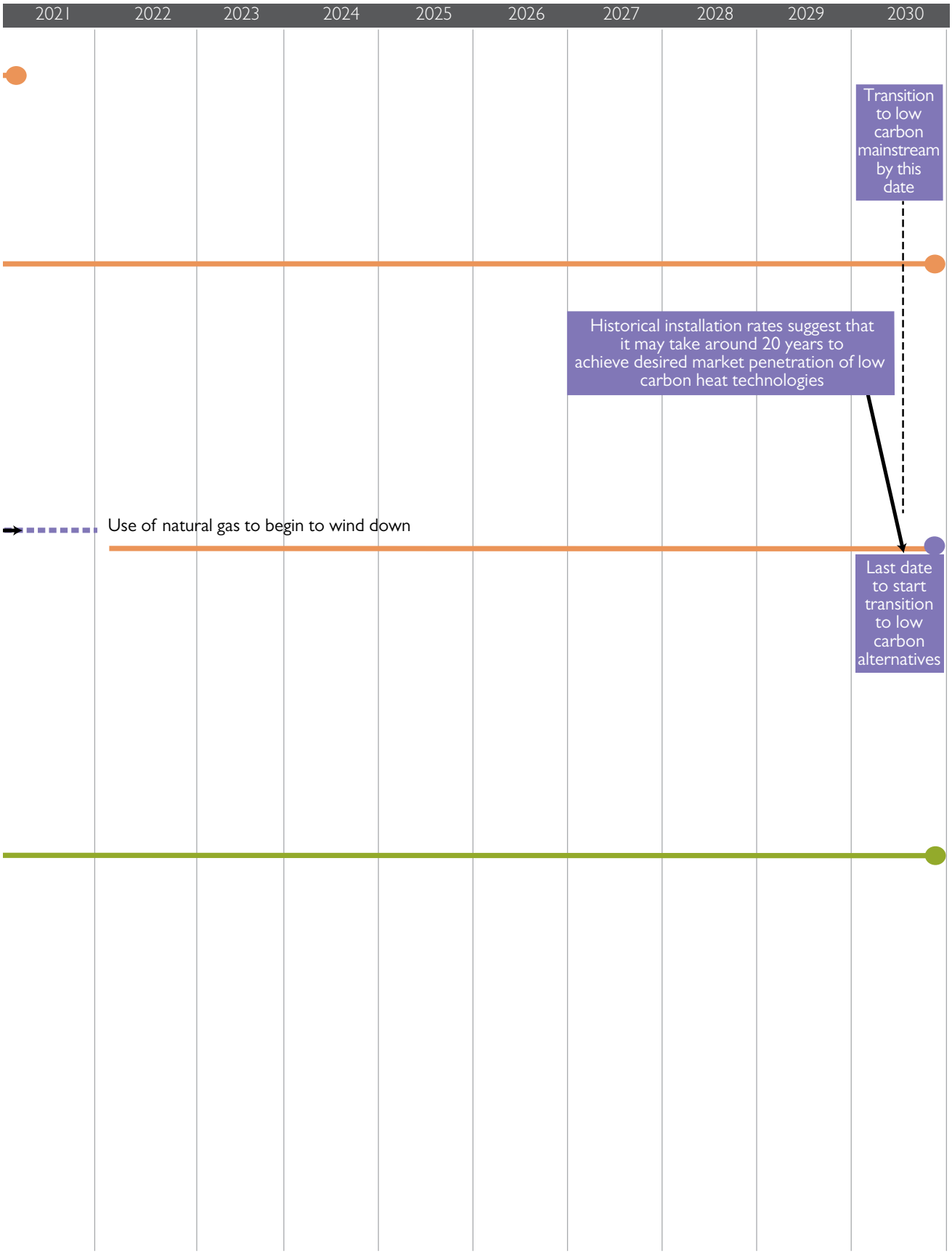
2.26 We also need to **prepare for the future**. In the buildings sector, this means acting now to build the supply chain for low carbon heating, cooling, and lighting and appliances to stimulate the innovation and competition that will bring the cost of these technologies down to a level that will make them competitive with fossil fuel-based (or less efficient) alternatives.

2.27 We will begin building the market for low carbon heating technologies, such as air- and ground-source heat pumps, so that these can displace expensive, carbon intensive alternatives. At the same time, we will encourage further deployment of heating networks, particularly in urban areas where building-level solutions may face more barriers. And in parallel we will continue to improve the efficiency of our existing gas boilers.

2.28 **The 2020s** will be a key transitional decade in delivering mainstream low carbon heat from heating networks and in buildings, and will see the expansion of low carbon heat at scale into residential areas. Progress in the 2020s will be important in ensuring a smooth and cost effective transition to low carbon heat – 2030 would be the latest opportunity at which to begin roll-out at scale taking into account historical deployment trends (see chart 10 overleaf).

Chart 10: Decision points and key actions for buildings to 2030




2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
Transition to low carbon mainstream by this date
Historical installation rates suggest that it may take around 20 years to achieve desired market penetration of low carbon heat technologies
Use of natural gas to begin to wind down
Last date to start transition to low carbon alternatives

Reducing demand for energy in buildings

2.29 Reducing our demand for energy is the cheapest way of cutting emissions, and will also benefit consumers and our economy:

- In the **near term**, it will reduce demand for gas and electricity in buildings, helping to bring down emissions.
- In the **medium term**, it will save money on bills, releasing spending power to benefit the economy and it will enable smaller, and therefore cheaper, low carbon heating and cooling systems to be installed.
- In the **long term**, it will help to reduce the challenge of balancing the electricity grid.

2.30 The Government is aiming to lead by example in reducing its energy demand. On 14 May 2010, the Prime Minister committed the Government to **reducing its carbon emissions by 10% in 12 months**. The Government has achieved this target, reducing its emissions by 13.8%.[33] Real-time reporting of energy use has also been implemented across central government headquarters buildings to ensure greater public transparency of government energy efficiency.[34]

2.31 We can achieve a reduction in energy demand either by improving the energy efficiency of buildings, lighting and appliances, or by changing the way we behave so that we use energy more intelligently and reduce the amount we need.

2.32 As a result of the boiler standards introduced in 2005, savings made from the introduction of condensing boilers up to 2020 are expected to amount to around £2 billion a year for the UK as a whole. Over this period total savings from condensing boilers will amount to £15 billion.[35] In addition, by 2020 we will also capture the remaining potential in cavity walls and lofts:

- insulating all cavity walls, where practicable, by 2020 (building on around 11 million since 1990), saving an additional £200 million a year; and
- insulating all lofts, where practicable, by 2020 (building on 9 million lofts since 1990).

Improving the heat efficiency of buildings

2.33 Looking beyond 2020, we may need:

- **between 1 million and 3.7 million additional solid wall insulations** by 2030 (see chart 11 overleaf); and
- **between 1.9 million and 7.2 million other energy efficiency related installations**, such as improved glazing, by 2030.

2.34 Many energy efficiency measures are inherently cost effective and help people and businesses save money on their bills, but barriers such as upfront costs, disruption and lack of information about how to take up these opportunities can present real problems.[36]

2.35 The **Green Deal** is the Government's flagship energy efficiency policy, designed to overcome barriers to improving the UK's building stock. The framework, launching in 2012, will mean that households and businesses will have the opportunity to improve their energy efficiency at no upfront or additional cost, paying back through future savings on their energy bills.

2.36 The Green Deal will promote a 'whole house' approach, offering a comprehensive package of measures and ensuring that the needs of the property are assessed as a whole. This will mean that the improvements happen in the right order and that hassle and disruption are minimised.

2.37 In addition, microgeneration technologies may be eligible for the Green Deal to the extent that they can typically be expected to generate

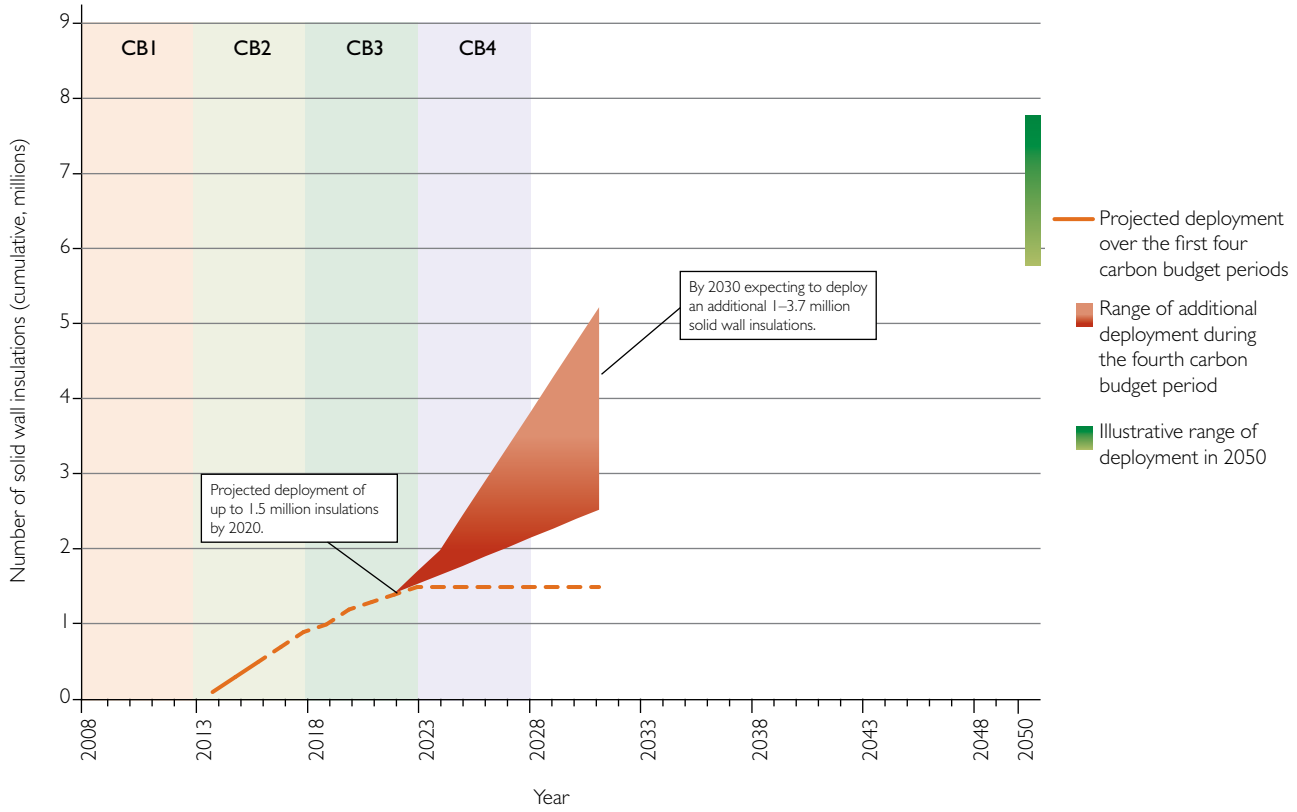
[33] This was an ambitious and challenging commitment on energy efficiency, spanning 3,000 central government office buildings and 300,000 civil servants.

[34] Available on government departments' websites.

[35] Calculated on the basis of 20 million condensing boilers being in place in 2020.

[36] The Energy Efficiency Deployment Office (EEDO), which will be set up in the Department of Energy and Climate Change by the end of the year, will aim to drive a step-change in energy efficiency by supporting existing programmes across government and by identifying and designing a strategy to realise further energy efficiency potential across all sectors of the economy.

Chart 11: Projected deployment of solid wall insulation over the first three carbon budgets and illustrative range of deployment over the fourth carbon budget period and in 2050



Source: Department of Energy and Climate Change

energy efficiency savings. The Government intends to use the Green Deal to provide information on low carbon heat alongside energy efficiency measures. The Government will in the future look to develop policy instruments for low carbon heat in a way which is compatible with our policies for reducing energy demand, so that consumers will be able to assess all options available.

2.38 Private rented buildings are one of the most difficult sectors to improve. While tenants benefit from more energy efficient buildings, it is the landlords who decide whether to pay to make the changes. The Green Deal will help tackle this split incentive.

2.39 The Government will work with the sector to encourage uptake of energy efficiency measures through the Green Deal. From 2016, domestic private landlords will not be able unreasonably to refuse their tenants' requests for consent to energy efficiency improvements. In addition, the Energy Act 2011 contains provisions for a minimum standard for private rented housing and commercial rented property from 2018, and the Government intends for this to be set at **Energy Performance Certificate** band E. Use of these regulation-making powers is conditional on there being no net or upfront costs to landlords, and the regulations themselves would be subject to caveats setting out exemptions. If these powers are used, the Government envisages that landlords would be required to reach the minimum standard or carry out the maximum package of measures fundable under the Green Deal and Energy Company Obligation (even if this does not take them to band E).

2.40 Alongside the Green Deal, the new **Energy Company Obligation (ECO)**, which will provide an additional £1.3 billion a year, will play an important role in supporting the installation of solid wall insulation, and also in providing upfront support for basic heating and insulation measures for low-income and vulnerable households. The costs of ECO are assumed to be spread across all household energy bills in Britain.

2.41 The UK's building stock is one of the oldest in Europe and the Government recognises that, to enable the transition to a decarbonised building sector, standards will need to be raised in every type of housing.

2.42 The Government is committed to successive improvements in **new-build standards** through changes to Part L of the Building Regulations in England and their equivalents within the Devolved Administrations. In October 2010, the new regulations in England and Wales introduced a 25% improvement on 2006 carbon emissions standards for new buildings, while regulation in Scotland delivered a 30% reduction on their 2007 standards. In England, the current review of the Building Regulations is looking at opportunities for further improvements planned for 2013 where these can be achieved while meeting our deregulatory aim. The Government intends to consult on these changes shortly. The review of Part L will also look at ways of generating take-up of greater levels of energy efficiency measures in existing buildings in order to help support demand for the Green Deal.

2.43 In December 2010, the Government committed that all new non-domestic buildings in England would be **zero carbon** from 2019. And in the *Plan for Growth*,[37] published alongside Budget 2011, the Government committed that all new homes from 2016 would be zero carbon. In driving investment in local low carbon energy generation and energy efficiency, zero carbon policy can work closely with local spatial planning in contributing to future growth.

2.44 We also need to tackle the performance of the existing building stock, and ensure that the poorest and most vulnerable households are able to heat their homes affordably, in line with the aim of the Government's efforts to tackle fuel poverty and achieve the statutory target.[38]

2.45 Subject to public consultation, the ECO will therefore include an **Affordable Warmth** target, aiming to provide heating and insulation measures to low-income households and households in private tenures housing someone who is older, disabled or a child. In some circumstances, this will mean delivering low carbon heating, but the focus of this particular element of the ECO policy is likely to be on more efficient gas systems for households.

Improving the electrical efficiency of lighting and appliances

2.46 As well as improving the fabric of our buildings themselves, it will also be important to minimise the energy we use for our lighting and appliances. **Energy-using products** in our homes and offices, such as white goods, lighting and televisions, contribute around 14% of the UK's CO_2 emissions. By removing the least efficient products from the market and promoting the sales of the most efficient, emissions and energy bills are reduced significantly.

2.47 By the end of 2012, minimum EU performance standards and labelling conventions will have been agreed for most domestic and commercial appliances. Looking further ahead, these standards will also cover energy-related products, which may not directly use energy but which contribute to energy consumption, such as double glazing and insulation. The first of these is likely to be regulated from 2014.

2.48 By 2020, the measures agreed so far are projected to save the UK 7 $MtCO_2e$ per annum, and the next tranche of measures are expected to save a further 6 $MtCO_2e$ per annum, subject to the stringency and timing of these measures being finalised in Europe.

Changing behaviour to reduce demand

2.49 The choices consumers and businesses make about how to use energy can have a huge impact on energy demand and on the costs they face. To help homes make the best use of their energy and prevent waste, the Government is mandating **Smart Meters** to be installed in every home by 2019. Rolling out Smart Meters will enable people to understand their energy use and maximise

[37] See: http://cdn.hm-treasury.gov.uk/2011budget_growth.pdf

[38] Target to eradicate fuel poverty as far as reasonably practicable by 2016 (Warm Homes and Energy Conservation Act 2000).

opportunities for energy saving. The Government is also mandating the provision of in-home displays for domestic customers and ensuring that consumers have the information and advice to make changes that will cut carbon and energy bills (through its consumer engagement strategy).

2.50 **Energy Performance Certificates (EPCs)** are required on the sale, rent or construction of a building. Prepared by accredited and suitably qualified energy assessors, EPCs give consumers A to G ratings for a property's energy efficiency and also provide advice on measures that can be carried out to improve its efficiency. The Energy Saving Trust estimates that the average household could save up to £300 a year by making energy saving improvements. **Display Energy Certificates** are required for buildings occupied by a public authority which are larger than 1,000 m^2 and are frequently visited by the public.

2.51 A revised version of the domestic EPC will be launched in April 2012. It has been redesigned and made more consumer friendly with clear signposting to the Green Deal and information on which measures qualify for Green Deal finance. In future, the EPC will also be used as a mechanism to disclose the existence of a Green Deal on a particular property.

2.52 The Government will also be producing guidance to support local authorities and social landlords to cut carbon emissions and maximise the opportunities for energy efficiency retrofit. This will help to drive forward large-scale retrofit of social housing, helping to stimulate the Green Deal and Energy Company Obligation markets.

2.53 In order to address the energy efficiency potential that exists in large, non-energy-intensive businesses, the Government has put in place the **CRC Energy Efficiency Scheme**. This scheme, currently in its introductory phase, combines a range of mechanisms to address the barriers to energy efficiency deployment. Over 2,000 participants submitted reports in July 2011 for the first compliance year. The Government is aware that a number of stakeholders have raised concerns about the complexity of the scheme. Therefore, in early 2012, the Government will issue a formal consultation on our proposals for a simplified scheme.

2.54 The Government also believes that there may be potential for smarter use of **heating controls** to help save energy, by giving consumers and businesses greater control and flexibility over the way in which they heat and cool their homes. At a relatively simple level, thermostatic radiator valves (currently estimated to be deployed in around 55% of homes with a boiler)[39] allow radiators to be turned down or off in rooms that are not in use. More sophisticated options, such as remote controls and sensors that respond to building occupancy, offer more possibilities. As these technologies develop, this may enable consumers to reduce the average internal temperature of their buildings – delivering savings of around 10% of energy use on space heating for every 1°C reduction – without experiencing a big change in their levels of thermal comfort.

Decarbonising heating and cooling supply

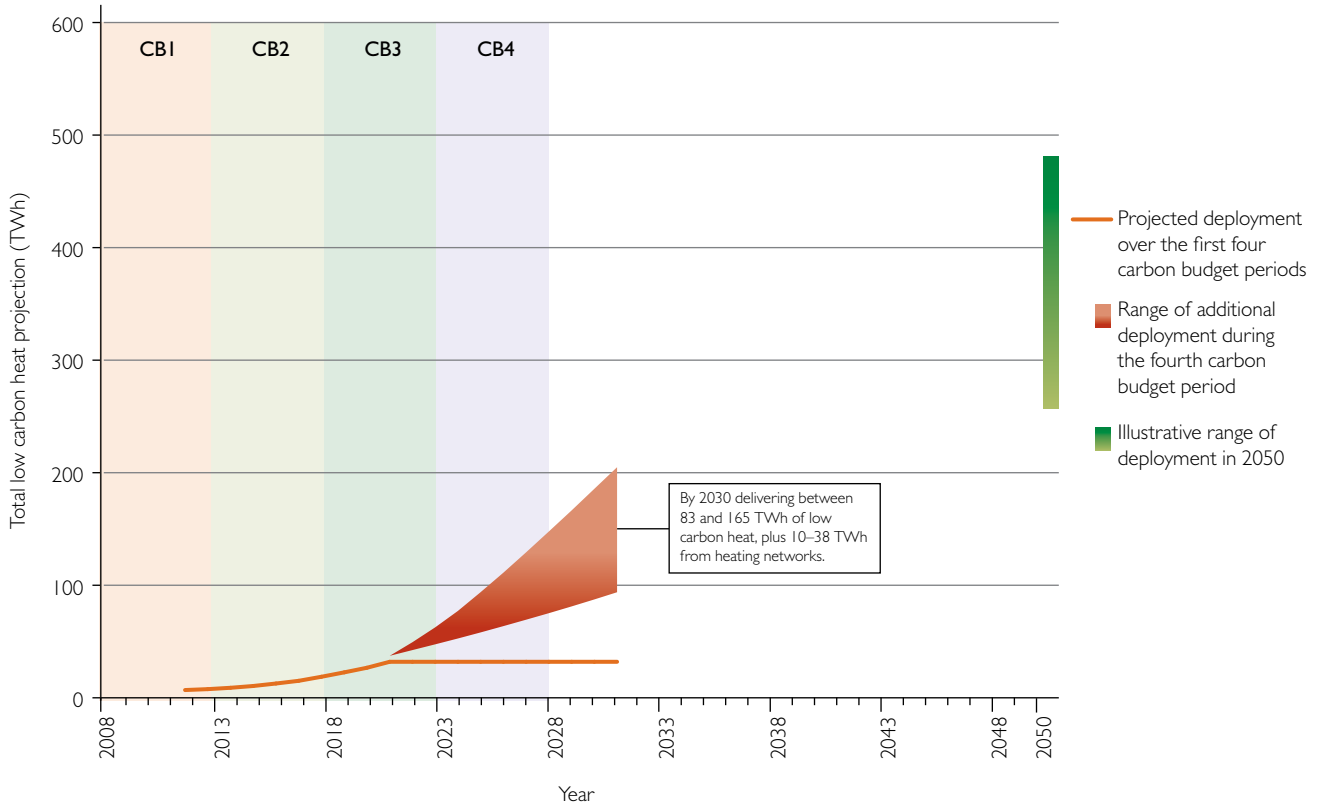
2.55 Achieving a cut in building emissions to virtually zero by 2050 will only be achievable if we decarbonise our supply of heat and cooling as well as reducing demand. It is likely that we will still get most of our heat from natural gas well into the 2020s.

2.56 As things stand, we are increasingly dependent on other countries for our oil and gas supplies, and continuing to use these fuels may mean that we are more exposed to global pressures which lead to price spikes and increases. Keeping the price of energy competitive is crucial. For many years, our domestic consumers have benefited from the UK's competitive energy market – from 2008 to the present day, UK gas prices have been among the lowest in Europe.

2.57 As we look further ahead, the proportion of heat provided directly by natural gas will fall as we see increased use of low carbon technologies, but

[39] BEAMA analysis of EST HEC data and EHCS in the Heating and Hot Water Taskforce (2010) *Heating and Hot Water Pathways to 2020.*

Chart 12: Projected deployment of total low carbon heat in buildings over the first three carbon budgets and illustrative ranges of deployment in the fourth carbon budget period and in 2050[40]



Source: Department of Energy and Climate Change

this will be a gradual process. Deployment of heat pumps and other low carbon heat technologies, and the construction of district heating systems in urban areas with high heat demand, will replace natural gas as the primary source of heat in this country, a process that has already started and will take many decades to complete. Continuing efforts to deploy highly efficient condensing boilers in homes and businesses remains a priority in the transition.

2.58 Looking to the future, between 21% and 45% of heat supply to our buildings will need to be low carbon by 2030. We will therefore need **between 1.6 million and 8.6 million building-level low carbon heat installations by 2030**, delivering 83–165 terawatt hours (TWh) of low carbon heat, alongside 10–38 TWh of low carbon heat delivered through heating networks (see chart 12).[41]

[40] The main differences in assumptions between government modelling and that done by the Committee on Climate Change (CCC) are around the cost and effectiveness of heat pumps where the Government assumes that performance and cost do not improve as quickly as the CCC does, and biomass, where the Government assumes greater availability for low carbon heat than the CCC. However, the differences in assumptions lead to only a small difference in the expected deployment of low carbon heat to 2030.

[41] In the lower range, our modelling shows mainly commercial installations take up low carbon heat, with a large heat load per installation. In the higher range most of the additional installations come from domestic-level heat pumps and biomass boilers, with smaller heat loads per installation.

2.59 The portfolio of technologies through which we can achieve the decarbonisation of heating and cooling supply is diverse.

Box 7: Technology portfolio for low carbon heat

Building-level technologies

Biomass boilers – These work like conventional boilers, but instead of using natural gas or heating oil they burn biomass, such as wood pellets, to produce the heat used to provide heating and hot water.

Electrical resistance heating – This converts electrical energy directly into heat. It can also be used as secondary back-up heating or with a storage system which takes advantage of cheaper electricity, sold during low demand periods such as overnight.

Heat pumps – These use electricity to leverage ambient heat from the air or ground (or in some cases from water), using a compressor just like a fridge. This allows heat pumps to work at efficiencies far higher than even the best gas boilers, typically producing three units of heat for every unit of electricity. Heat pumps can either directly heat the air inside a building or heat up water for central heating and hot water systems. Some heat pumps can also be operated in reverse cycle mode to provide cooling. Heat pumps perform better in houses with low temperature heat emitters.[42]

Micro-combined heat and power (CHP) – CHP is described below and, in the form of micro-CHP, can be used as an alternative to boilers to provide heat and electricity at building level.

Solar thermal hot water – For buildings with sufficient south-facing roof space, solar panels can be fitted and connected to a water tank to provide hot water. This will not usually be sufficient to meet all of a building's hot water needs year round, but it can be an effective, low carbon way to supplement other sources of water heating.

Network-level technologies

Combined heat and power (CHP) – Technologies that generate both heat and electricity are collectively known as CHP. These can use a range of fuels (not necessarily low carbon) including biomass, wastes and bioliquids. At present, CHP is most commonly used by industry to provide heat and electricity for large sites. It can also be used to provide a source of heat for heating networks.

Gas grid biomethane injection – Sustainable biomass and wastes can be converted to gas and upgraded to biomethane, a gas that can directly replace or blend with natural gas in the grid and is compatible with existing boilers. This could be done at a large scale, or in smaller areas of the grid ringfenced for this purpose.

Heating networks – Heat can be generated by commercial-scale low carbon heat installations such as heat pumps or biomass boilers, or using low-grade heat generated in thermal power stations. Heat exchangers then transfer the heat into buildings via a network of steam/hot water pipes to provide space heating and hot water.

[42] Most houses' heat emitters in the UK have small surface area and consequently must operate at higher temperature to maintain comfort. Therefore, heat pump installation is usually accompanied by replacement of radiators (e.g. with underfloor heating, or with radiators more appropriate for use with heat pumps).

Building-level technologies

2.60 Decarbonisation at the level of individual buildings substitutes current heating systems (such as gas boilers) for low carbon alternatives such as heat pumps or biomass boilers. Of the technology choices described in box 7, heat pumps are likely to be a particularly attractive option. Their ability to operate at efficiencies of up to 300%, to use electricity – which will also be decarbonised in the medium to long term – as a fuel, and the flexibility for some to provide cooling as well as heating, makes them a strong candidate to provide space heating, hot water and cooling for domestic and commercial buildings into the future.

2.61 The portfolio of options above have specific strengths and applications for which they are best suited. There are also technical and practical barriers to these technologies and measures, which will need to be addressed if we are to see large-scale deployment.

2.62 All households and businesses will need to play a part in this transformation. The Government aims to create the right conditions for homes and businesses to generate their own heat using low carbon technologies or make use of low carbon heat from a heat network, but there are a number of key obstacles to overcome, including the following:

- Low carbon heat technologies such as heat pumps and biomass boilers are still expensive relative to conventional boilers, costing in excess of £5,000, and payback periods for this investment are often long. This is by far the biggest barrier to deployment.
- Low carbon heat technologies take longer to install compared with a conventional boiler, which offers a particular barrier given that heating systems are often 'distress purchases' – bought only when the old system breaks down.
- The installation of technologies such as ground-source heat pumps requires a specialist skill set, meaning that finding installers with adequate training and skills is a potential barrier to deployment.
- Heat pumps in particular can place added strain on the electricity grid. This can partially be managed through the use of storage, such as hot water cylinders to store heat, or batteries to store electricity generated off-peak.

2.63 While we do not expect mass market deployment ahead of the 2020s, there are important opportunities now to build a market for low carbon heat in buildings, particularly in commercial buildings and off-gas grid homes. Many public and commercial buildings have already taken up energy efficiency measures, and work to develop low carbon heating in public and commercial buildings will help to build the supply chain for low carbon heat in the UK. Cooling demand is also expected to rise significantly in these buildings, so increasing the efficiency of air conditioning units and installing low carbon alternatives such as reversible heat pumps will also be important. In the residential sector, 4 million households are not currently heated by mains gas, and many have to rely on expensive, higher carbon forms of heating. Heating oil is still used in around 2 million homes, for example. These households will gain more from switching to low carbon heating because their heating bills and carbon emissions are higher than average and they currently suffer the inconvenience of having to have fuel delivered.

2.64 The Government is therefore committed to providing financial support for low carbon heat consistent with the UK's 2020 renewables target.[43] The **Renewable Heat Incentive (RHI)** is the first financial support mechanism of its kind in the world to increase the deployment of renewable heat. Under phase 1 of the scheme, communities, charities, and public and private sector organisations can apply to receive a payment for generating heat using eligible low carbon heat technologies. The support levels will be set out in legislation.

[43] The 2009 Renewable Energy Directive sets a target for the UK to achieve 15% of its energy consumption from renewable sources by 2020.

2.65 Under phase 1 of the RHI, the Government expects to deliver:[44]

- an additional 56.5 TWh of low carbon heat by 2020 (of which, 30.5 TWh will be delivered to buildings – up to 112,000 low carbon heat installations), saving 43 $MtCO_2e$ overall (of which over half is from buildings) over the period 2011–20; and
- 11% of our heat coming from new and diversified renewable sources, as part of an overall ambition to achieve 12% by 2020.

2.66 The quality of installations and the supply chain to support low carbon heat need to be first class to ensure consumer confidence. The Government is requiring all RHI installations (up to and including 45 kWh) be installed by an accredited Microgeneration Certification Scheme installer.

2.67 The Government expects to introduce support for the domestic sector under the second phase of the scheme. In the interim, the Government has launched the **Renewable Heat Premium Payment (RHPP)**. The RHPP provides a single payment to households that install low carbon heat, and could deliver up to 25,000 installations. A crucial part of the RHPP is then monitoring a significant number of installations made under the scheme. This information will inform the Government's longer-term approach to support for low carbon heat.

Network-level technologies

2.68 At network level, substituting natural gas with sustainable biomethane in the grid is, at first glance, the least disruptive option. Decarbonising our heat and hot water supply without having to change our heating systems, and while using a gas grid that is already built, initially appears like an attractive option.

2.69 However, injecting biomethane into the gas grid presents a number of challenges. With biomass likely to be needed for sectors that are hard to electrify, such as freight and some industrial processes, combined with doubts over the scale of sustainable global biomass supply, it would be high risk to assume that large-scale biomethane injection into the grid is a viable option. The gasification process or anaerobic digestion of UK-sourced waste(s) or biomass could only meet a small proportion of UK demand, with gas consumption in buildings currently running at close to 500 TWh a year. Relying on imports would leave the UK exposed to international bioenergy prices that may rise substantially. Heat networks, where heat is generated remotely and supplied to buildings, offer a more promising option.

2.70 Up to half the heat demand in England, and much of it in other parts of the UK, is found in areas that potentially have heat loads dense enough to make heat networks a viable means of delivering heating direct to homes and businesses. Combined in the medium and long term with low carbon heat sources, this offers a valuable alternative to building-level heating as a means of decarbonising the UK's heat supply.

2.71 Heating networks have the advantage of convenience and flexibility, and would allow for the cost effective deployment of transitional heat sources. For example, in the nearer term, it may make most sense for heat networks to be supplied by combined heat and power plants fuelled by natural gas but, in the long run, this may be supplanted by heat from nuclear or carbon capture and storage power plants, energy from waste plants or from dedicated large-scale heat generation through heat pumps or biomass boilers large enough to supply whole cities. This approach allows for a portfolio of heating sources to be deployed which best suit local contexts.

2.72 Heat networks require significant deployment of new infrastructure and therefore face a number of barriers, notably the cost of installing the pipes, as well as questions of regulation, ownership and charging structures. Practicalities of geography can also restrict the

[44] The following figures include savings in industry which account for around 26 TWh of renewable heat in 2020, unless specified. These also reflect the impacts of the change in the large biomass tariff as a result of the EU ruling (however, this is not reflected in the annexes to this document).

deployment of heating networks. The Government will set out in the new year how it will work with local authorities and other stakeholders to address barriers to district heating, along with barriers to other approaches to low carbon heat.

2.73 The Government will therefore work with local authorities and other stakeholders to explore potential to remove barriers in these areas.

2.74 The interactions between the different technologies and approaches described here for decarbonising our heat supply are complex, and will make a big difference to how we heat and cool our homes and businesses in future. The Government recognises the importance of low carbon heat to achieving our ambitions for decarbonising the economy and deploying renewable energy, as well as the importance to consumers of heating our homes and businesses in a secure, affordable way, and will therefore **publish a document on its strategy for decarbonising heat in the new year**.

TRANSPORT

Where we are now

2.75 Domestic transport emitted around 137 $MtCO_2e$ in 2009, accounting for around 24% of UK domestic greenhouse gas emissions (see chart 13 below).[45] Domestic emissions from transport rose steadily between 1990 and 2007, driven primarily by rising road traffic levels. They have since fallen back to roughly what they were in 1990. This fall is partly the result of the recent economic downturn, but statistical data suggests that the main factors have been improvements in new car fuel efficiency and the increased uptake of biofuels, driven by existing government and EU policy.

2.76 **By 2030** we project that current policies could mean that transport emissions reduce to around 116 $MtCO_2e$.[46]

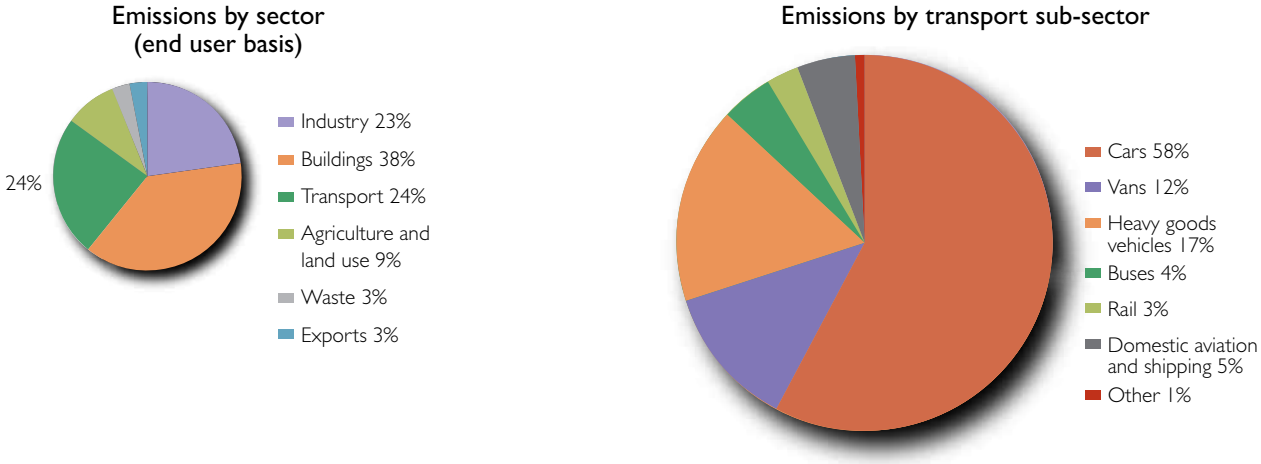
2.77 **By 2050** the transport system will need to emit significantly less carbon than today, while continuing to play its vital role in enabling economic growth, and provide many additional benefits such as lower fuel costs and better energy security.

Where we will be in 2050

2.78 There are many different types of transport and in this report they have been broken down into cars and vans, rail, local sustainable travel, freight, aviation and shipping, as well as considering the role of biofuels.

2.79 The Government's vision is that by 2050 almost every car and van will be an ultra-low emission vehicle (ULEV), with the UK automotive industry remaining at the forefront of global ULEV production, delivering investment, jobs and growth. Due to the time needed for fleet turnover, this requires almost all new cars and vans sold to be near-zero emission at the tailpipe by 2040. These ULEVs could be powered by batteries, hydrogen fuel cells, sustainable biofuels, or a mix of these and other technologies. We cannot say for sure which technologies will emerge as the most effective means of decarbonising car travel, so it is essential that the Government takes a technology neutral approach, allowing us to achieve

Chart 13: Proportion of UK greenhouse gas emissions from the transport sector, 2009



[45] The equivalent figures by source are 121.6 $MtCO_2e$, or 22% of UK emissions.

[46] Transport emissions in the Updated Energy and Emissions Projections include off-road emissions, which are not included in transport emissions as reported on the National Communication basis. This means that 2030 emissions shown here are higher than those reported in emissions statistics. Figures exclude emissions from international aviation and shipping.

emissions reductions in the most cost effective way. Rail travel will be substantially decarbonised through further electrification, more efficient trains and lower carbon fuels. If the Government's proposals for high speed rail go ahead, a new national network linking London to Birmingham, Manchester and Leeds will transform rail capacity and connectivity, promoting long-term and sustainable economic growth. Passengers choosing sustainable travel options such as travel by public transport, cycling and walking will continue to deliver major social and economic benefits, and alternatives to travel, such as working from home, could increasingly do so too.

2.80 The freight sector will have found lower carbon ways of working, such as modal shift to rail and water and more efficient driving techniques, and adopted the necessary ultra-low carbon technologies to continue to supply the UK's factories and consumers while cutting back carbon emissions dramatically.

2.81 Domestic aviation and shipping are already included in UK carbon budgets and so will need to contribute to meeting the 2050 target. International aviation and shipping are not currently included; a decision whether to include them is due by the end of 2012.

2.82 Sustainable biofuels could play a key role in reducing emissions across the different transport sectors, although concerns about sustainable supply may limit their use.

2.83 There are several interdependencies to be considered. Electrifying the car fleet or rail network would reduce tailpipe emissions from individual vehicles to zero, although the positive impact on economy-wide emissions relies on a low carbon grid. As a result there could be substantial benefits in local air quality and reducing traffic noise. Uptake of alternatives to travel could mean more emissions from heating and lighting commercial and residential buildings. There may also be competition for sustainable feedstocks between transport biofuels and bioenergy in other sectors.

How we will make the transition

2.84 **Over the next decade**, the Government will seek to make significant progress towards achieving the 'easy wins' in cutting emissions from transport. Cars and vans make up the largest share of emissions. Incentivising more efficient combustion engines and the use of sustainable biofuels is a central plank of the plan to reduce these emissions. Looking ahead, the emergence of ULEVs and hybrid and electric cars over this period will be crucial in preparing for progress in the 2020s.

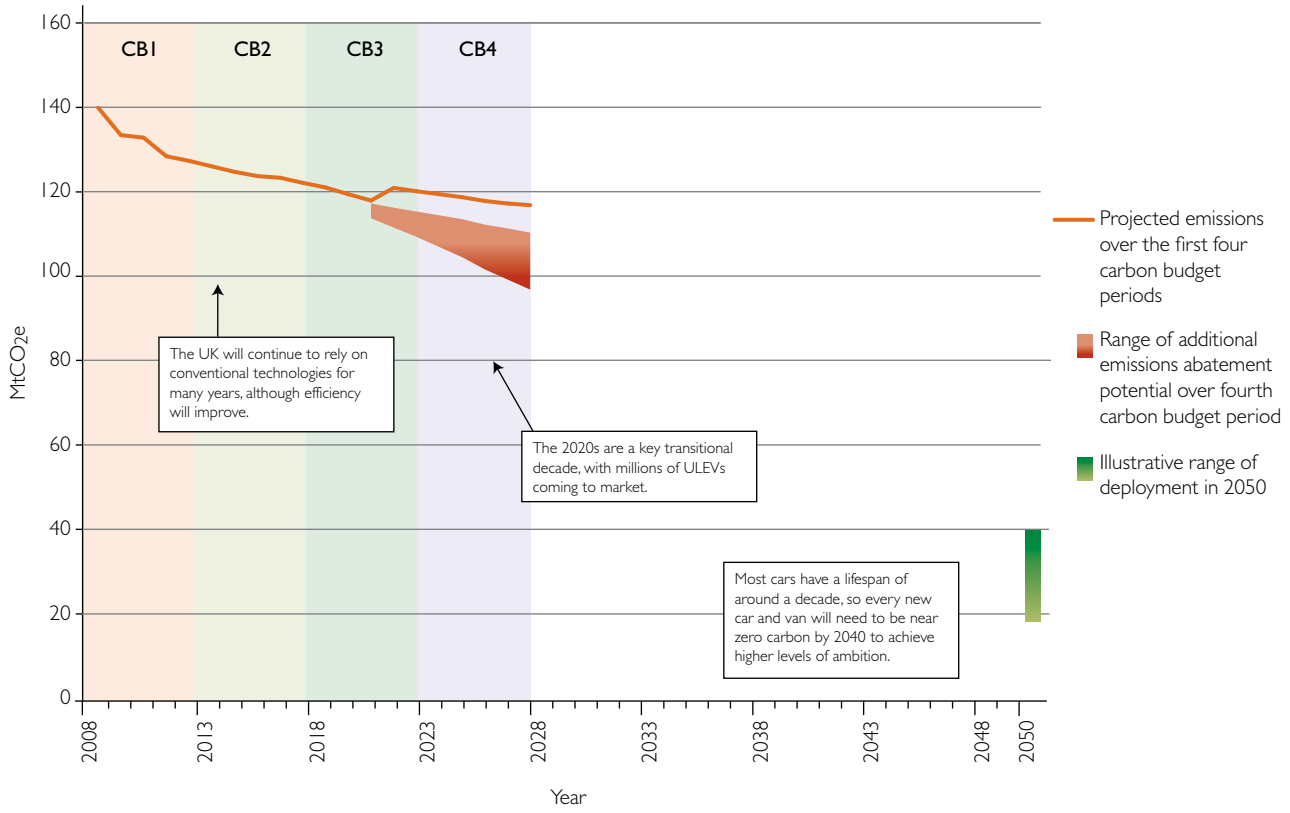
2.85 Other transport sectors will also need to take steps towards decarbonisation in the next decade. The freight industry will begin to reduce its emissions through increased efficiency and government support on infrastructure. Further electrification of the rail network will support low carbon modal shift in the future. Emissions from domestic aviation will be capped as part of the EU ETS. And the public will be encouraged to make lower carbon travel choices, such as taking public transport or cycling more often.

2.86 With deeper cuts required through the 2020s, we will move towards the mass market roll-out of ULEVs, such as those powered by electric batteries, hydrogen fuel cells and plug-in hybrid technology. Further improvements to the efficiency of conventional vehicles and sustainable biofuels are expected to play a vital role. Other sectors will need to continue to play a role.

2.87 Chart 14 illustrates some possible emissions trajectories for decarbonising the transport sector overall over the next decade, over the fourth carbon budget and out to 2050.

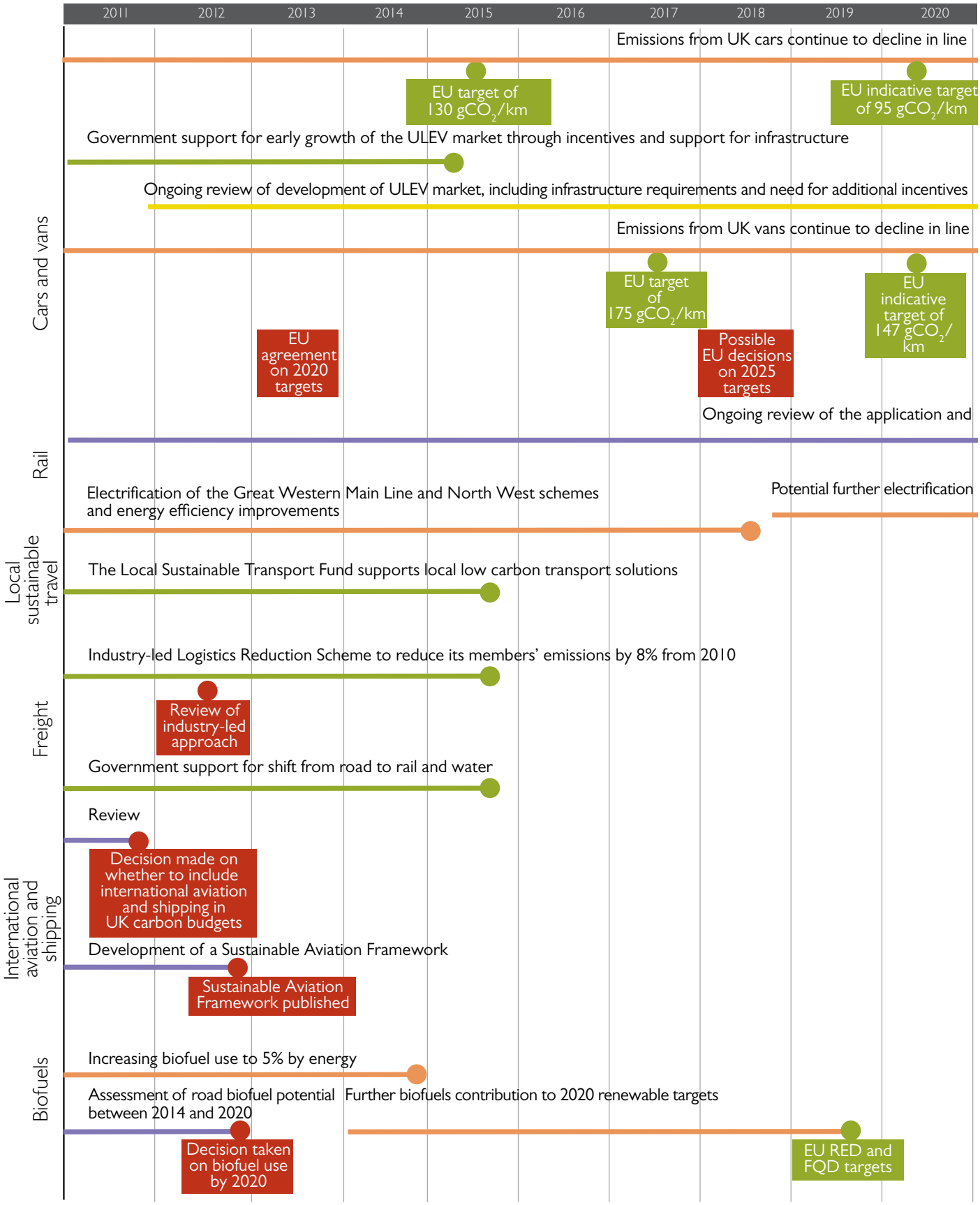
2.88 Details on action needed across the different modes of transport over the next decade and then during the fourth carbon budget are set out below. Chart 15 on pages 50 and 51 gives a summary of some of the key actions and decision points that will set us on the way to decarbonising transport.

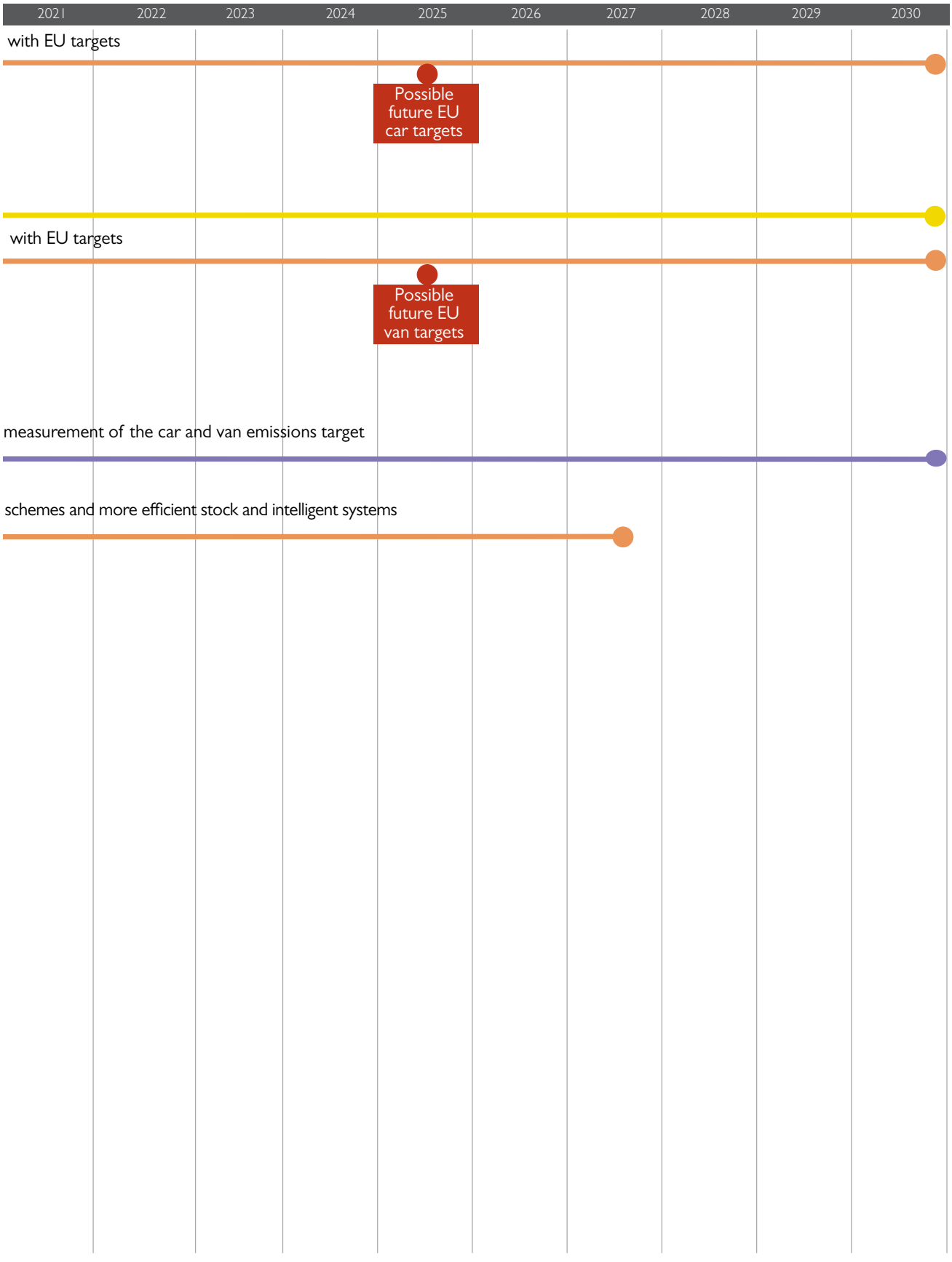
Chart 14: Emissions projections in the transport sector in the first three carbon budgets and illustrative ranges of emissions abatement potential in the fourth carbon budget period and in 2050[47]



[47] The emissions projections derive from Updated Energy and Emissions Projections data. The illustrative ranges for emissions abatement potential for the fourth carbon budget and 2050 derive from the 2050 futures and fourth carbon budget scenarios – these are discussed in Parts 1 and 3 of this report respectively.

Chart 15: Decision points for transport to 2030




2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
with EU targets
Possible future EU car targets
with EU targets
Possible future EU van targets
measurement of the car and van emissions target
schemes and more efficient stock and intelligent systems

Cars and vans

2.89 **Over the next decade**, the focus will be on continuing improvements to the efficiency of conventional petrol and diesel cars, welcoming ULEVs to market, and supporting research and development into new ULEV technologies. Many major motor manufacturers have already taken a lead in bringing forward ULEV models and entering the growing UK market. The UK automotive industry is well placed to stay ahead of international competitors and remain a vibrant source of growth in the coming decades.

2.90 The Government's existing policy mix puts it on track to progressively reduce the carbon impact of cars and vans. Currently, a major driver of emissions reductions for both cars and vans are the EU new vehicle CO_2 targets. These are set at 130 gCO_2/km in 2015 and 95 gCO_2/km in 2020 for cars, and 175 gCO_2/km in 2017 and 147 gCO_2/km in 2020 for vans. EU emissions standards will continue to be vital in delivering the Government's carbon reduction goals for cars and vans.

2.91 A review of the 2020 car and van targets is due to complete by 1 January 2013, and in the next few years we expect the European Commission to make proposals for post-2020 new car and van emissions standards. As part of the Government's mission to rebalance the UK economy and foster sustainable economic growth, it is important to create the conditions for long-term investment in the UK automotive industry. We will therefore work towards ambitious but realistic targets for vehicle standards beyond 2020 which, when considered alongside domestic policies, are consistent with both meeting the fourth carbon budget and reaching near-zero average new car emissions by 2040.

2.92 To support early growth of the ULEV market, the Government is taking an integrated and pragmatic approach:

- The 2010 Spending Review made provision for **around £300 million** over the life of this Parliament for consumer incentives to reduce the upfront cost of eligible ULEV vehicles to consumers and businesses. The Plug-In Car Grant provides 25% (up to £5,000) of the cost of an eligible vehicle and will be reviewed regularly to ensure that it remains the most effective way of incentivising uptake. Consumers and businesses also benefit from a favourable tax regime, with plug-in vehicles receiving exemptions from Vehicle Excise Duty and Company Car Tax, as well as Enhanced Capital Allowances.

- The £30 million **Plugged-In Places** programme is the key mechanism for commencing the roll-out of recharging infrastructure in the UK and providing learning to inform future development of a national network.

- The Government published an electric vehicle infrastructure strategy, which set out a clear vision and the steps the Government is taking to remove barriers. There is potential for the **Green Investment Bank** to provide targeted financial solutions for appropriate plug-in vehicle infrastructure projects in the future.

- To ensure necessary technological development the Government is supporting low and ultra-low emission vehicle research, development and demonstration (RD&D), focusing on priorities identified in conjunction with the UK Automotive Council. We will continue to monitor the level of RD&D support to ensure that barriers to the development of ULEV technologies through the 2020s are identified and tackled.

2.93 The Government will continue its role in working with industry to identify and remove potential barriers to ULEV uptake as the market develops, for example in the provision of hydrogen infrastructure should the market develop this way.

2.94 **Over the fourth carbon budget**, the efficiency of the car and van fleet will need to continue to improve, with accelerated uptake of ULEVs required in order to meet the 2050 target.

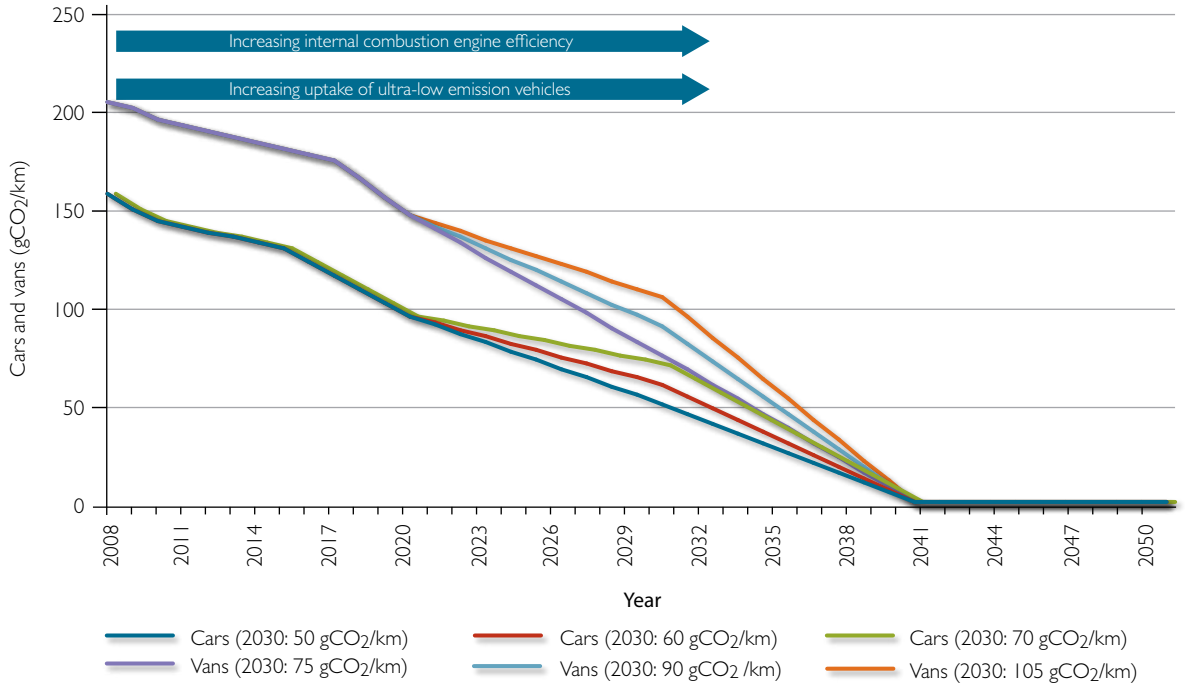
2.95 The Government's analysis for the fourth carbon budget has considered what level of average new car and van emissions might be necessary in the 2020s, independent of technology type. For new cars we consider a range of emissions between 50 gCO_2/km and 70 gCO_2/km

in 2030 to be plausible, and for vans a range between 75 gCO_2/km and 105 gCO_2/km. These scenarios are seen as credible but challenging by industry, and they are all consistent with the goal of ensuring that average emissions of new cars and vans are near-zero at the tailpipe by 2040 (see chart 16).

2.96 By pursuing a framework for improvements in average fuel efficiency as opposed to specific technology targets, the Government intends to create the incentives for industry to develop the emissions reduction technologies that work best for consumers.

2.97 Barriers to ULEV uptake include costs of ownership including insurance; consumer acceptability, for example over the range of battery electric vehicles, or payload requirements for vans; availability, and cost of natural resources such as lithium and rare earth metals; and the appropriate infrastructure for different ULEV technologies, providing adequate re-charging access and speed. Our strategy is designed to tackle these barriers as detailed at paragraph 2.92. Nevertheless uncertainties around when these barriers will come down could mean mass ULEV uptake is delayed into the 2030s.

Chart 16: Projected average new car and van emissions over the first three carbon budgets and illustrative ranges of average new car and van emissions in the fourth carbon budget period and to 2050



Box 8: Some technology options for road transport

Battery electric vehicle: A vehicle driven by an electric motor and powered by rechargeable batteries, as opposed to a hydrogen fuel cell or a petrol/diesel combustion engine.

Flywheel hybrid vehicle: A vehicle with a mechanical flywheel energy storage device that captures kinetic energy when braking, returning the energy to the wheels on acceleration.

Gas-fuelled heavy goods vehicle: A heavy goods vehicle (HGV) powered by natural gas or biogas rather than diesel.

Hybrid electric vehicle: A vehicle powered by a combustion engine with varying levels of electrical energy storage captured when braking and stored in a battery or supercapacitor.

Hydrogen fuel cell electric vehicle: A vehicle driven by an electric motor powered by a hydrogen fuel cell which creates electricity on board.

Plug-in hybrid electric vehicle: A plug-in version of a full hybrid, usually with a larger battery and a greater electric driving range. In addition to capturing energy when braking, the on-board battery can be charged from an external source when the vehicle is not in use.

Series hybrid: A plug-in hybrid where the wheels are driven exclusively by an electric motor with an additional internal combustion engine connected in series. The engine runs at optimum efficiency to power an on-board generator to charge the battery. 'Range extenders', which use a small combustion engine to charge the battery to enable longer-distance journeys, are a type of series hybrid.

Ultra-low emission vehicle (ULEV): Any vehicle that emits extremely low levels of carbon emissions compared with current conventional vehicles.

Rail

2.98 **Over the next decade**, the Government will make and start to implement decisions about rail which will continue **over the fourth carbon budget**. Government has committed to the electrification of the Great Western Main Line as far west as Cardiff, and routes in the North West, and, as announced in the recent Autumn Statement, will also take forward the electrification of the North Trans-Pennine route from Manchester to York via Leeds. Other schemes are also under consideration for electrification, including of the Midland Mainline and the Welsh Valleys. While additional abatement is likely to be modest, it can nevertheless be a cost effective way to cut carbon, particularly where the technical difficulties of electrifying are small, and the lines are well used delivering considerable wider economic benefits.

2.99 The Government is also working closely with the rail industry to improve energy efficiency and reduce emissions across the rail network. Next year the rail industry will publish its second Rail Technical Strategy assessing how, over the longer term, technology can help to deliver a more cost effective, higher capacity, higher performance and lower carbon railway.

2.100 A decision on the Government's strategy for a national high speed rail network, and on the proposed route of the initial London–West Midlands link, is due in December 2011. This initial phase would be broadly carbon neutral, with the potential for valuable carbon reductions as the network is expanded further north. Such a national network could see as many as 6 million air trips and 9 million road trips switching to high speed rail each year, reducing carbon and cutting congestion on roads and at airports.

Local sustainable travel

2.101 **Over the next decade**, sustainable travel measures, such as encouraging the use of local public transport, cycling or walking, will enable people to make lower carbon travel choices. In doing so they will reduce emissions, boost the local economy through reduced congestion, and improve air quality and health. Alternatives to travel could also grow in prominence: technological advances (such as video conferencing) have the potential to shift the location and pattern of travel for both work and leisure, with potential carbon benefits from reduced travel demand, as well as economic, social, and environmental gains.

2.102 The Government has introduced the Local Sustainable Transport Fund (worth £560 million over the lifetime of the current Parliament) to enable local authorities to deliver transport solutions that build strong local economies and cut carbon emissions. In the recent Autumn Statement the Government announced a further £50 million to be used by local transport authorities for small transport improvement schemes costing less than £5 million, as well as up to a further £25 million for the Green Bus Fund for the purchase of low carbon emission buses.

2.103 **Over the fourth carbon budget**, more people choosing to take public transport, walk or cycle could mean up to a 5% reduction in urban car trips. However, uncertainties around the impact of individual initiatives, and barriers such as convenience, safety and appropriateness to journey, may prevent the highest levels of abatement from being realised.

Freight

2.104 **Over the next decade** there are likely to be a range of measures that will help to reduce the carbon impact of freight. These include eco-driving techniques, better management of logistics supply chains, improved vehicle design using lower carbon fuels, and making best use of other modes such as rail.

2.105 Industry and the Government are already taking a range of actions to drive down emissions from freight:

- There is considerable industry appetite to take the lead in making cost effective carbon reduction happen. The Government has endorsed the Freight Transport Association-led Logistics Carbon Reduction Scheme, which records and reports emissions reductions from road freight and has set a target for its members of an 8% reduction in emissions between 2010 and 2015. The success of this industry-led approach will be reviewed in 2012.

- The Government provides the Mode Shift Revenue Support and Waterborne Freight Grant schemes in England and Wales, to support modal shift which is not always commercially viable for the operator. The Government is also facilitating provision of infrastructure, such as improved capacity at our ports by consenting for major container terminal developments. In addition, Network Rail is funded to deliver over £200 million in Strategic Freight Network enhancements through to 2014, with an additional £55 million funding being made available in the Logistics Growth Review to improve rail connectivity to Felixstowe port.

2.106 The Government has also launched a trial of longer semi-trailers which will help to identify the potential carbon benefits that could be achieved from their wider introduction and the consequent reduction in the number of lorries on the roads.[48] The recently published Logistics Growth Review also includes a package of measures to overcome some of these barriers and uncertainties and to help put the UK on track to deliver a deep cut in road freight emissions by 2050. These measures will support green growth by encouraging the adoption of low emissions HGV technologies and the development of the UK manufacturing base in these technologies. The Government is making available £8 million to pump-prime investment in low emissions HGVs and their supporting infrastructure.

[48] See: www.dft.gov.uk/publications/longer-semi-trailers

2.107 **Over the fourth carbon budget**, significant further efficiency improvements could be possible, although there are considerable uncertainties. In the longer term the sector will require alternative technologies and fuels to deliver more substantial carbon reductions. The Government believes that initial market take-up of some of these low emission technologies, such as gas-fuelled lorries and flywheel hybrids, is challenging but achievable during the fourth carbon budget. This would require barriers, such as uncertainties over costs and infrastructure requirements, and concerns over vehicle range, weight and size issues with some low emissions options, to be overcome.

Aviation and shipping

2.108 **Over the next decade**, emissions from domestic aviation are included in the EU Emissions Trading System (EU ETS). Domestic aviation and shipping are included in UK carbon budgets, although they contribute a very small proportion of total emissions.

2.109 International aviation and shipping emissions are not currently included in the UK's 2050 target and carbon budget system, although international aviation is included in the EU ETS. The Government must decide whether to include them by the end of 2012, or explain to Parliament why it has not done so. This decision will need to be considered alongside development of the UK's sustainable aviation policy framework through 2012/13, which will also consider whether to adopt the previous administration's 2050 aviation CO_2 target.

Biofuels

2.110 **Over the next decade**, use of biofuels in the UK is covered by the EU Renewable Energy Directive (RED),[49] which requires that 15% of total energy consumption and 10% of energy for transport come from renewable sources by 2020, and the EU Fuel Quality Directive, which requires a 6% reduction in the greenhouse gas intensity of fuel by 2020.[50] The Government has committed to the target of 5% biofuels use by volume by 2014 but has not yet decided on an appropriate level of biofuel ambition post-2014, pending further consideration of sustainability issues (including those about indirect land use change) and cost effective delivery of the 15% target. The Government proposes to consult in 2012 on the approach for biofuels to 2020.

2.111 The main driver of increasing biofuel uptake is the Renewable Transport Fuels Obligation. This requires suppliers of liquid fossil fuel intended for road transport to increase the proportion of biofuel in their fuel annually until April 2013, when it will reach 5% of total road transport fuel supplied by volume. The Government consulted on changes to this legislation earlier this year and published a response in November 2011.[51]

2.112 It is important to ensure that the negative indirect impacts of biofuels are minimised, and that in the longer term there remains scope to deploy biofuels in sectors where there are few other options to decarbonise. The Government's forthcoming Bioenergy Strategy will address these issues.

2.113 **Over the fourth carbon budget**, given this uncertainty, for the purposes of analysis for the fourth carbon budget we have assumed biofuel uptake in 2020 of 8% by energy, in line with recommendations of the Committee on Climate Change. Over the fourth carbon budget period, we have modelled scenarios in which this level increases to 10%, decreases to 6%, or stays constant at 8% out to 2030. These scenarios do not prejudge the policy decisions to be made.

[49] Under the RED some biofuels, such as those made from waste, can be double counted towards the 10% target, although not towards the 15% target.

[50] Relative to the lifecycle greenhouse gas emissions from fossil fuels.

[51] See: www.dft.gov.uk/consultations/dft-2011-05

Next steps

2.114 The key challenge in transport is decarbonising travel in a way that is both cost effective and acceptable to consumers. In the fourth carbon budget, increasing efficiency in cars, vans and freight practices, ultra-low emission vehicle technologies, sustainable biofuels, sustainable travel choices and electrified rail will all have a role to play, and the Government's technology neutral approach will allow industry to develop the low carbon technologies most appropriate for users. The existing policy mix puts the Government on a pathway to realise this vision for low carbon transport, but it will continue to be reviewed regularly, and in future will require further ambitious measures such as EU car and van emissions targets for beyond 2020.

INDUSTRY

Where we are now

2.115 UK industry was responsible for 131.6 $MtCO_2e$ of emissions in 2009, accounting for 23% of the UK's total emissions.[52] Over 80% of these emissions originate from generating the heat that is needed for industrial processes such as manufacturing steel and ceramics, and the remainder from chemical reactions involved in processes such as cement production.

2.116 Between 1990 and 2009, end user emissions from industry have reduced by 111 $MtCO_2e$. While the UK industrial sector has grown by an average of 1% a year over the last 40 years, the sector's emissions have fallen by 46% since 1990. Embracing cost effective, energy efficiency measures, as well as sectoral readjustments towards higher-value products, has helped to drive this lower carbon growth. The energy intensity of UK industry has fallen on average by 2.7% a year since 1970. Since 1990 this average has declined to 1.3% a year.[53]

2.117 Around a quarter of UK energy demand is consumed by industry. Natural gas, electricity and oil/petroleum are the main energy sources for the sector. UK industry employs over 4 million people, accounting for around 15% of the UK workforce and a third of the national GDP.[54] The sector is varied and complex, covering very different modes of production, material demands, ownership and end products. It is one of the main drivers of a flexible and strong UK economy.

Where we will be in 2050

2.118 If industrial emissions were to remain steady over the coming decades, they would grow from 23% now to over half of the emissions allowed by the 2050 target. In order to achieve the UK's commitment to cutting emissions by 80% by 2050, this level of industry emissions would require an excessive reduction from other sectors. Thus, the industry sector has to contribute its fair share.

2.119 Decarbonising the UK economy could require a reduction in overall industry emissions of up to 70% by 2050. Achieving this while maintaining competitive growth in the sector could entail the following:[55]

- The historical growth trend of 1970 to 2009 continues, leading to industrial output increasing by over 30% to 2050.
- Energy demand by industry decreases by up to a quarter from today's levels.
- Industry achieves a decrease of up to 40% in energy intensity through a mix of fuel switching and taking up remaining efficiency opportunities.
- Over half of industrial energy demand is supplied by either bioenergy or electricity.
- Carbon capture and storage rolls out during the 2020s, and by 2050 could capture around a third of industry's emissions.[56]

2.120 This low carbon transition will inevitably be challenging, but at the same time it has the potential to bring real benefits for UK industry:

- Taking up the remaining opportunities for energy, material and process efficiency will reduce manufacturing costs and boost the competitiveness of UK industry.

[52] The equivalent figure by source is 129.1 $MtCO_2e$ (23% of UK emissions).

[53] See DECC (2010) *Energy Consumption in the UK: Industrial data tables.* Available at: www.decc.gov.uk/en/content/cms/statistics/publications/ecuk/ecuk.aspx, table 4.5.

[54] Office for National Statistics (2009) *Annual Business Survey*, Production and Consumption Sectors (B–E).

[55] See Annex A of this document and, for more detail, 2050 Futures from the 2050 Pathways Calculator spreadsheet.

[56] AEA Technology (2010) *Analysing the Opportunities for Abatement in Major Emitting Industrial Sectors: Report for The Committee on Climate* Change.

- Low carbon manufacturing, using inputs such as sustainable biomass and future supplies of decarbonised electricity may increasingly be demanded by both UK and export markets.
- Moving to low carbon technologies in other sectors of the economy will create new markets for the goods produced by UK industry: the steel for wind turbines, the aluminium for electric vehicles and the cement for new homes. We also depend on industry to manufacture components for power stations, ships, planes and home appliances – products which need to become ever more energy efficient and low carbon over the coming decades.[57]

How we will make the transition

2.121 A number of technologies will be needed to make the transition to low carbon industry. These technologies are at varying stages of development and commercialisation, and range from well established, mature technologies to those which are still at laboratory stage, meaning there remains significant uncertainty about how and where they will be deployed.

2.122 **This decade**, we expect industry to focus on cost effective measures such as **energy, process and material efficiency**. Industry needs to continue to seize opportunities to boost energy, process and material efficiency, and new opportunities will arise as new technologies and materials are developed. As technologies mature, energy efficiency is likely to continue to improve over the coming decades, albeit at a decreasing rate.

2.123 Action this decade will also help industry **prepare for the future**, to support the innovation needed for more technically challenging or costly measures involving advanced fuel switching or carbon capture and storage.

2.124 **The 2020s** and beyond will see the continued take-up of remaining efficiency measures, but also greater deployment of more advanced decarbonisation measures in two main areas:

- **Fuel switching** – The majority of industrial emissions arise from generating heat from fossil fuels for manufacturing processes, meaning that changing to lower carbon fuels such as sustainable biomass and biogas represents one of the most important means by which the sector can decarbonise over time. The type of fuel switching possible will differ between sub-sectors.[58] For lower temperature processes a range of options may be possible, for example using biomass boilers to generate the steam required, or 'process integration' for exploiting heat already used in higher temperature processes. Higher temperature processes often present a greater challenge, and may need innovative solutions such as sustainable biomass to replace coke, or a shift towards the electrification of processes. Fuel switching will develop gradually, depending on the needs of each sub-sector of UK industry and, in particular, the temperature of the heat required.
- **Carbon capture and storage (CCS)** – For some industrial processes, greenhouse gas emissions are an intrinsic part of the chemistry and can only be mitigated through innovative options such as CCS. In the long term, the deployment of a combination of sustainable biomass and further CCS should be able to address remaining combustion and the carbon dioxide component of process emissions.

[57] See, for example, CBI (2011) *Protecting the UK's Foundations: A blueprint for energy-intensive industries*. Available at: www.cbi.org.uk/media-centre/policy-briefs/2011/08/protecting-the-uks-foundations-a-blueprint-for-energy-intensive-industries/

[58] The industrial sector can be disaggregated into the energy-intensive industry (EII) sector, which tends to require significant amounts of high grade heat at 1,000°C and above (e.g. iron and steel or aluminium), and the non-EII sector, for which demand is generally for lower grade heat, typically around 100–300°C (e.g. food and drink, pharmaceuticals).

2.125 Process emissions will also need to be tackled. Fluorinated gas (F-gas) emissions from air conditioning and refrigeration currently make up around 2% of UK emissions. They are expected to decrease as a result of the impact of the current regulatory framework and voluntary moves by businesses to replace F-gases with other refrigerants with lower global warming potential.

Energy, process and material efficiency

2.126 The Government's latest projections suggest that industrial energy consumption will fall by 12% by 2030 compared with 2008 levels (see chart 17 overleaf). The main drivers of this drop in energy consumption will be as follows:

- **Conventional energy efficiency** – While much has been achieved, there remain opportunities for greater energy efficiency in some areas, for instance through process optimisation and control or use of continuous processes rather than having to start and stop equipment. Many measures can be retrofitted, with rapid payback periods and little upfront capital investment.

- **Process and thermal efficiency** – There are additional opportunities to reduce emissions through changing processes as well as making them more efficient, for instance through changes to improve process integration, or recovering and re-using heat.

- **Material efficiency** – A number of measures can reduce the economy's demand for the primary manufacture of energy-intensive goods and therefore reduce associated emissions. These include greater recycling, greater reuse with re-melting and greater commoditisation of products.

2.127 The Government will continue to incentivise these efficiency improvements during this decade and beyond via a set of European and national policy frameworks:

- **European Union Emissions Trading System (EU ETS)** – The cap-and-trade system covers over 70% of direct and indirect industrial sector emissions. The main incentive mechanism for emissions savings within this system is the gradual tightening of the cap as well as a resulting carbon price. The Government intends the EU ETS to remain a critical driver for the UK's industrial low carbon transition for this decade and beyond.

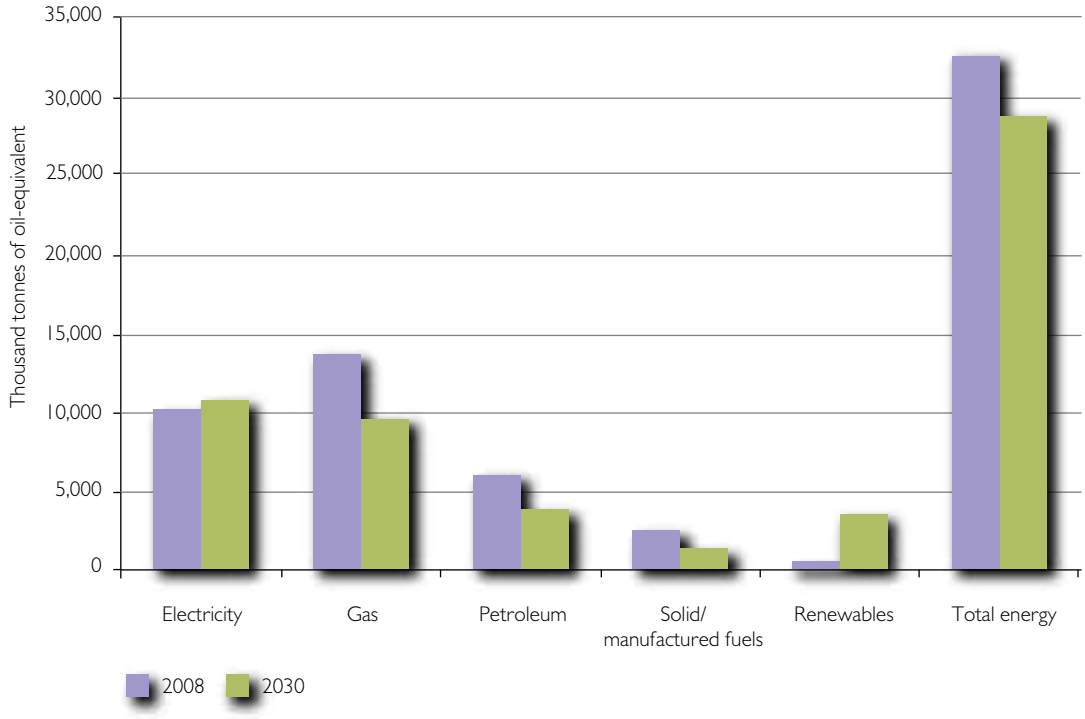
- **Climate Change Levy (CCL) and Climate Change Agreements (CCAs)** – Cost effective energy efficiency measures are also being supported by government policy instruments through the CCL. This is a tax charged on high carbon energy supplied to businesses and the public sector. The Government introduced the CCAs to reduce the impact of the CCL on the competiveness of energy-intensive industry, while still incentivising industry to take action to reduce emissions. These voluntary agreements provide a discount on the CCL for eligible industries in return for meeting challenging energy efficiency or emissions reduction targets.[59]

[59] Current CCAs entitle participants to claim CCL discount until the end of March 2013. The Government announced in the 2011 Budget that the scheme will be extended to 2023, and is currently developing proposals that will simplify the scheme. These proposals will provide targeted financial benefits to business in the range of £2.4–£3.4 million from 2012 to 2020.

Fuel switching

2.128 Alongside energy efficiency-driven reductions in demand, government projections show a shift in energy consumption patterns. Industry currently receives the majority of energy from gas use. Towards 2030 government predicts a switch to more low carbon energy sources, such as bioenergy and electricity.[60]

Chart 17: Energy use in 2008 and 2030 by fuel type and total for UK industry



Source: Department of Energy and Climate Change (Updated Energy and Emissions Projections)[61]

[60] Analysis using the Energy End-Use Simulation Model (ENUSIM) suggests that there is remaining potential for further energy efficiency improvements. Further detail on future abatement potential has been derived from work undertaken by AEA Technology. We have undertaken analysis to expand the potential abatement beyond those considered in the AEA work (AEA Technology (2010) *Analysing the Opportunities for Abatement in Major Emitting Industrial Sectors: Report for The Committee on Climate Change*). In addition, we have undertaken modelling to calculate abatement due to the uptake of renewable heat and the initial deployment of CCS.

[61] See: DECC (2011) *Energy and Emissions Projections Annex C*. Available at: www.decc.gov.uk/en/content/cms/about/ec_social_res/analytic_projs/en_emis_projs/en_emis_projs.aspx. Note: offshore refinery processes are excluded from this chart.

2.129 Fuel switching in the industry sector is expected to take place via several routes:

- **Cogeneration/combined heat and power (CHP)** – The combined production of heat and electricity can reduce primary energy demand by up to 15% regardless of the fuel input, making gas CHP an efficient way of using fossil fuels in industrial processes. Biomass and biogas can be used for the combined production of heat and electricity to provide further emissions reductions.

- **Sustainable biomass and biogas** – Sustainable biomass and biogas offer a direct alternative to fossil fuels as a means of generating hot water and steam for low temperature processes up to around 300°C. To maximise energy efficiency in the use of sustainable biomass, it can be combined with cogeneration of electricity and heat. Some high temperature applications, such as cement kilns, may be suitable for biomass or waste combustion. Some applications, such as ceramics or glass furnaces, require high calorific value and clean burning fuels, and may therefore require the use of biogas.

- **Electrification of processes** – As the grid decarbonises, electricity will become an important source of low carbon energy for industrial processes. Electricity is currently used to drive motors and machinery, compressors and refrigeration. It is also used to supply heat demand, particularly where volatile or flammable products are used or low temperature controllable heat is required. Some sectors already make extensive use of electricity especially where this is the only commercially available process, as it is for aluminium. Other processes may require further innovation and capital investment before being able to use low carbon electricity.

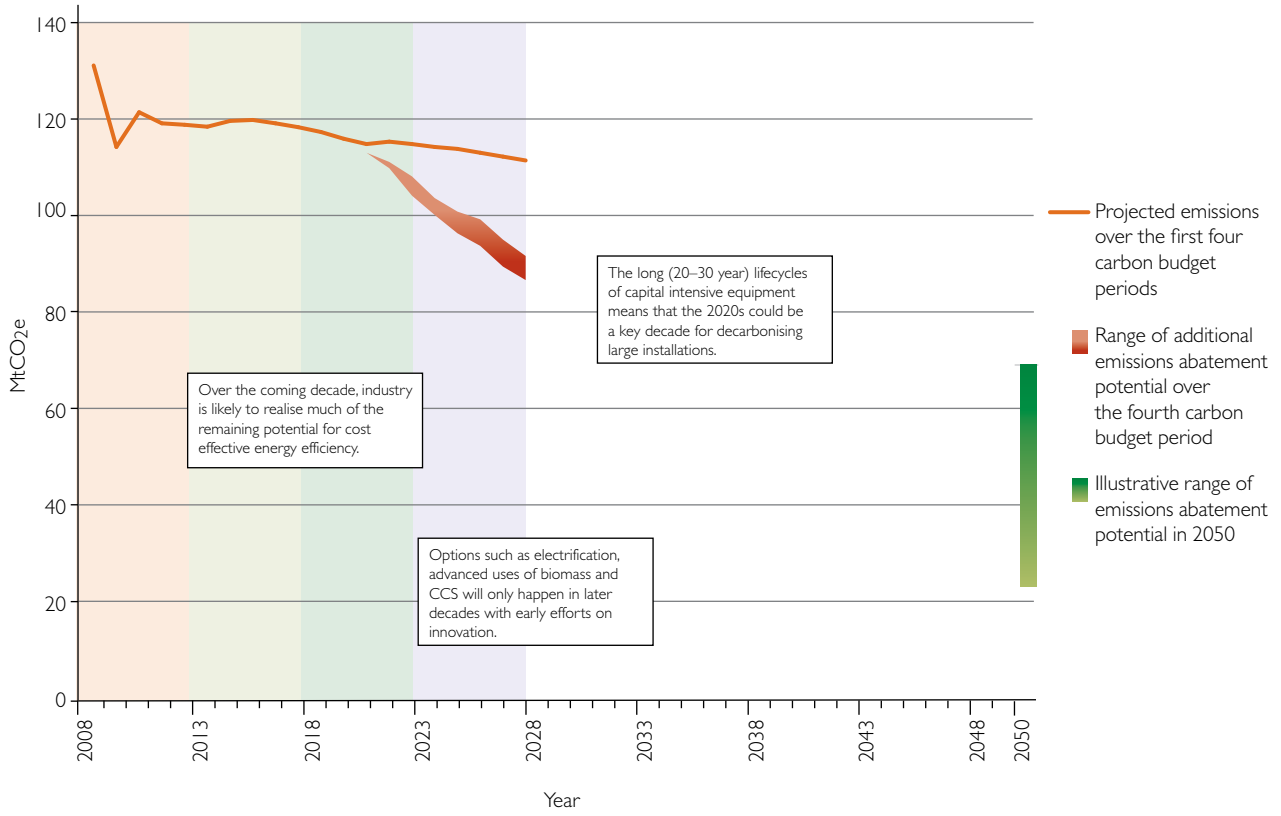
2.130 In practice, it is likely that in the short term industry will exploit large-scale CHP opportunities, and will take up the cost effective potential for fuel switching to sustainable biomass (including energy from waste). In the 2020s and beyond, we may see deployment of options with longer payback periods and those which require greater innovation such as use of biomass in high temperature processes and, as we move towards a decarbonised electrical grid, electrification of industrial processes.

2.131 Some critical technologies for fuel switching (such as advanced forms of sustainable bioenergy and electrolysis) are not yet at commercial stage. Public and private support to address innovation gaps, both in the UK and internationally, will be critical if we are to make these technologies a viable part of a low carbon future.

2.132 The **Renewable Heat Incentive (RHI)** will support substantial deployment of bioenergy for the generation of low carbon heat within the commercial and industrial sectors. The Government estimates that up to 48% of the additional low carbon heat anticipated to provide the 12% low carbon heat necessary to meet the overall renewable energy target in 2020 will come from the industrial sector, including the generation of energy from waste.

2.133 The Government will continue to incentivise a combination of natural gas-fired and renewable

Chart 18: Emissions projections in industry for the first three carbon budgets and illustrative ranges of emissions abatement potential in the fourth carbon budget period and in 2050[62]



Source: Department of Energy and Climate Change

CHP. CHP, especially for large-scale industrial plants, constitutes a significant opportunity to enhance energy efficiency and lower emissions from the industrial sector.

2.134 Chart 18 above illustrates the emissions trajectory for decarbonising the UK industry sector up to 2050, focusing in particular on the range of abatement potential over the fourth carbon budget period.

2.135 The fourth carbon budget range on the above chart indicates the level of emissions abatement industry could achieve by taking up cost effective (that is, measures whose cost is lower than the projected carbon price) energy efficiency and fuel switching measures over the coming one and a half decades. These include measures incentivised through the European Union Emissions Trading System and Climate Change Agreements, for example process optimisation, and the Renewable Heat Incentive (RHI), using

[62] The emissions projections derive from Updated Energy and Emissions Projections data for the industry and refineries sectors for CO_2 emissions and the National Communication industrial processes and energy supply sectors for non-CO_2 emissions. The illustrative ranges for emissions abatement potential for 2050 and the fourth carbon budget derive from the 2050 futures and fourth carbon budget scenarios – these are discussed in Parts 1 and 3 of this report respectively. Please also see: AEA Technology (2010) *Analysing the Opportunities for Abatement in Major Emitting Industrial Sectors: Report for The Committee on Climate Change*.

bioenergy to produce hot water and steam for industrial processes. The variation between the fourth carbon budget range is due to different levels of low carbon heat take-up incentivised under the RHI. A central set of assumptions on what energy efficiency and CCS measures industry may choose to take up is included in the range. We recognise that there is uncertainty around the precise choices that will be made in such a diverse sector of the economy.[63]

Industrial carbon capture and storage

2.136 CCS has a role to play in capturing emissions from combustion of industrial heat, for example from the continued use of coke-fired blast furnaces for steel production, or for processes where emissions result directly from the chemistry of the process itself, such as the manufacture of cement or lime. Initial deployment of CCS technology is expected during the fourth carbon budget period, particularly for sectors with lower capture costs, e.g. ammonia production.

2.137 Today, **CCS technology research projects** are supported by UK and international sources of funding – with the aim of turning it into a viable option for the coming decades.[64]

2.138 Deployment of CCS needs to be planned within sufficiently long time spans. In the industrial sector, assets are typically of high capital value, with lifetimes of up to 40 years. It is often only possible to make significant changes or innovations to integrated processes when these assets are replaced or renewed, which may limit the rate at which technology can be adopted.

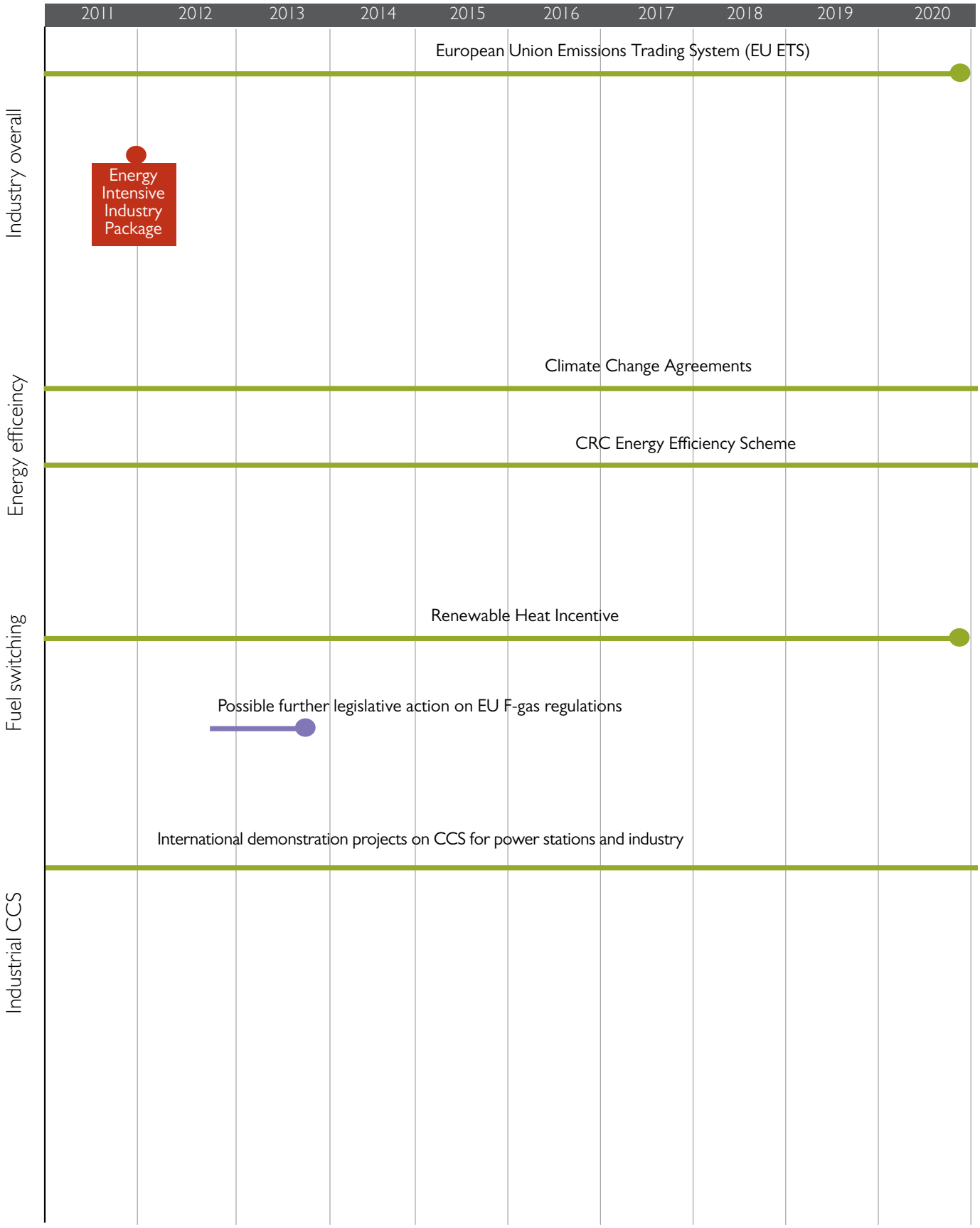
2.139 Critical technologies – such as industrial CCS, high temperature use of biomass, or further electrification of thermal processes – may not be available at commercial scale for 10–15 years. While the exact phasing of the low carbon transition is uncertain and depends on investment choices by industry as well as international action and competition, we can identify some possible stages and decision points along the way (see chart 19 on pages 66 and 67).

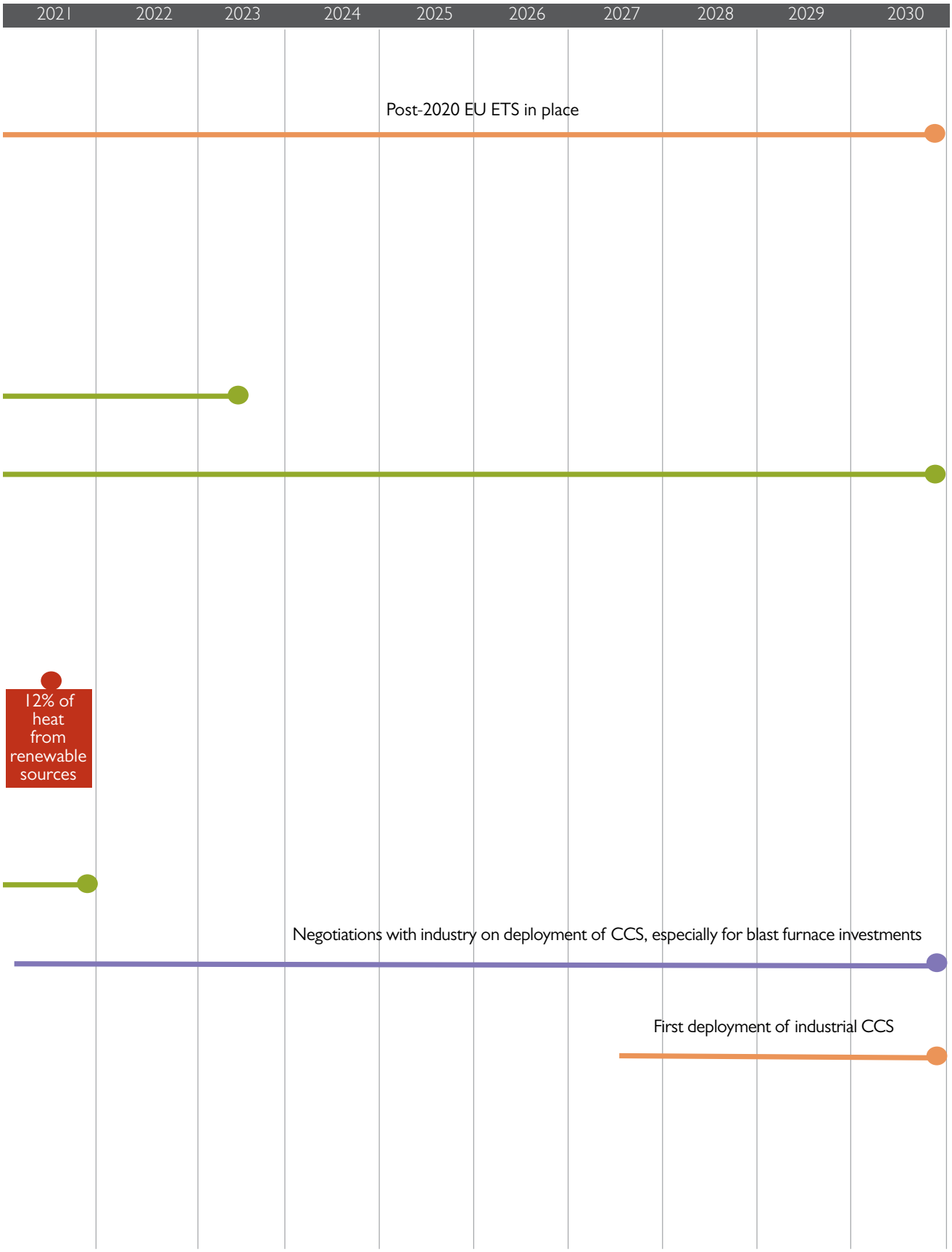
2.140 The Government will work with industry to address key risks of this low carbon transition, such as reducing the impact of the anticipated increasing cost of energy, to ensure that UK industry remains competitive internationally. This will be particularly important in those sectors which are especially exposed to rising energy costs as well as to international competition, where there is a role for government in helping these industries to manage the transition. As part of this work, the Government recently announced a package of measures to support sectors which are particularly exposed to these risks.

[63] There have been significant revisions undertaken to the 2011 Updated Energy and Emissions Projections (www.decc.gov.uk/en/content/cms/about/ec_social_res/analytic_projs/en_emis_projs/en_emis_projs.aspx). This may impact upon previously undertaken analysis of abatement potential from, for example, AEA Technology. Therefore, we have taken up a lower level of 'realistic' energy efficiency abatement in our projections. For further information see: AEA Technology (2010) *Analysing the Opportunities for Abatement in Major Emitting Industrial Sectors: Report for The Committee on Climate Change.*

[64] See, for example, the EU-funded project for industrial CCS where CO_2 capture is being applied at a steel plant in Florange, France.

Chart 19: Decision points for industry to 2030




2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
Post-2020 EU ETS in place
12% of heat from renewable sources
Negotiations with industry on deployment of CCS, especially for blast furnace investments
First deployment of industrial CCS

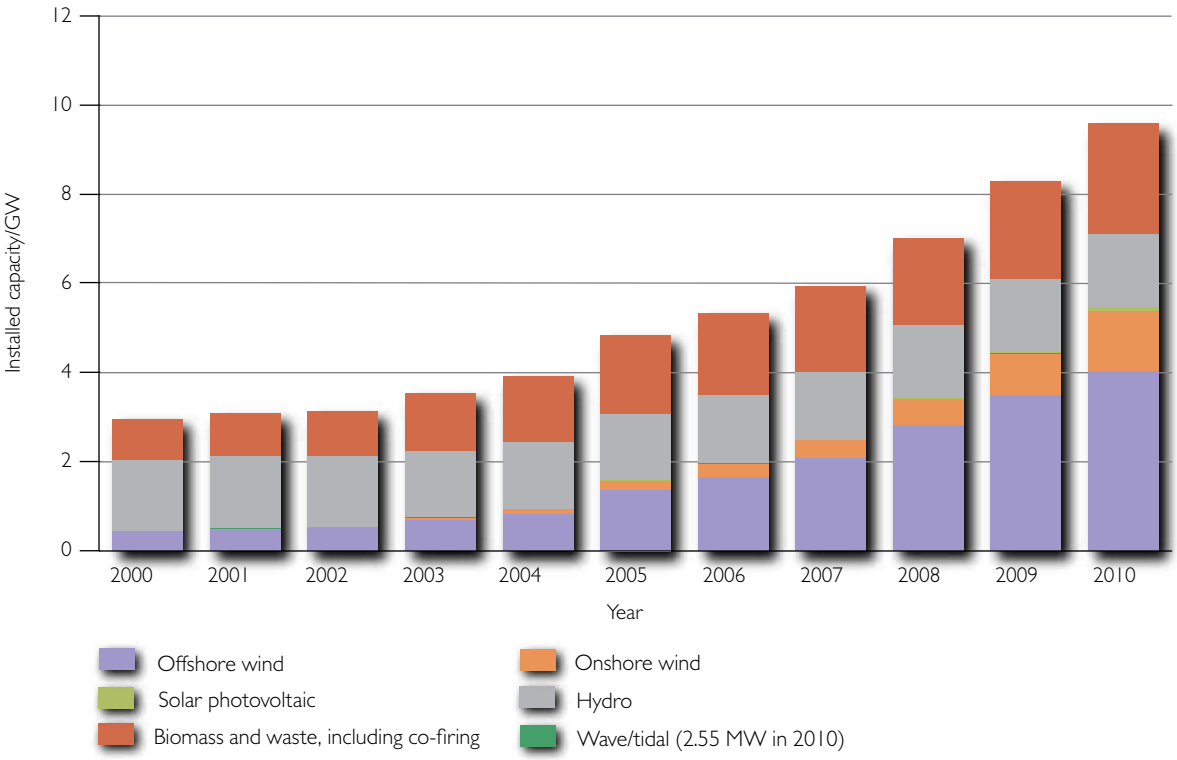
SECURE, LOW CARBON ELECTRICITY

Where we are now

2.141 The power sector is the single largest source of UK emissions today, accounting for 27% of emissions – 156 $MtCO_2e$ – in 2010. By 2050, emissions from the power sector need to be close to zero. Historically, the UK has benefited from robust security of supply, due to domestic natural resources and to competitive markets underpinned by independent regulation. We currently have around 90 GW[65] of generating capacity, giving us around 16%[66] surplus capacity (known as a capacity margin) over electricity demand at peak times.

2.142 Emissions from power stations have fallen by 23% since 1990. While demand has increased by 18% since 1990, the carbon intensity of power generation has fallen from 690 gCO_2/kWh in 1990 to 448 gCO_2/kWh in 2009. This is primarily due to the switch from coal-fired generation to less carbon intensive gas-fired generation during the 1990s, with use of coal roughly halving, as well as increased power station efficiency.[67] Generation from renewable sources has steadily increased since 2006, reaching over 7% of electricity generation in 2010.[68]

Chart 20: Cumulative renewable electricity installed capacity, by technology, from 2000 to 2010



[65] DECC (2011) *Digest of UK Energy Statistics 2011* Table 5.7 Plant Capacity.

[66] National Grid (2011) *Winter Outlook 2011/12*.

[67] DECC/Defra (2011) *2011 Guidelines to Defra/DECC's GHG Conversion Factors for Company Reporting* Annex 3 Table 3a.

[68] DECC (2011) *Energy Trends, June 2011*.

2.143 Latest projections show that as a result of government policies, emissions from the power sector are expected to fall by around two thirds during the next two decades, to 49 $MtCO_2e$ a year in 2030. Over the five years of the fourth carbon budget period, power stations are projected to emit 357 $MtCO_2e$.[69]

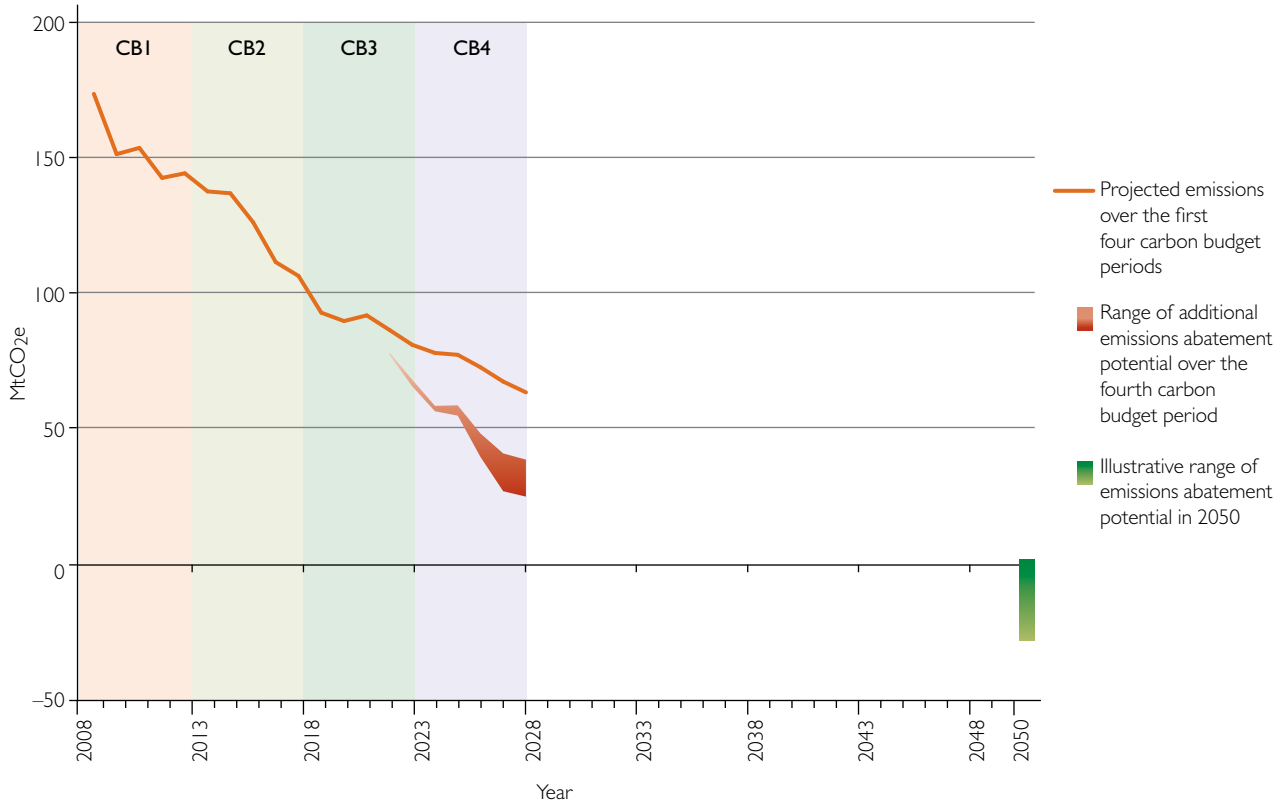
Where we will be in 2050

2.144 By 2050, we are likely to need much more electricity. The 2050 futures set out in Part 1 suggest that electricity supply may need to increase by around 30–60%. We may need as much as double today's electricity capacity to deal with peak demand. While more energy efficiency will reduce demand per head of population by 30–50%, this will be outweighed by rising demand from electrification of heating, transport and parts of industry, and economic and population growth.

2.145 By 2050, electricity supply will need to be almost completely decarbonised. Power will be generated largely from renewables, and nuclear and fossil fuel stations fitted with CCS technology. Experience from other countries demonstrates that this is possible: almost 90% of the electricity supply of both Sweden and France is zero carbon, using mainly nuclear and hydro power.

2.146 The nature of the electricity system will also need to change. Wind and solar power are intermittent. Nuclear power is hard to turn on or off quickly. Meanwhile, demand for electricity, if heating and cars are plugged into the grid, will also be more variable. As a result, our electricity system will need to become smarter at balancing demand and supply. This will mean a combination of back-up generation capacity, bulk storage of electricity and greater interconnection, but also smarter ways of managing energy demand. On

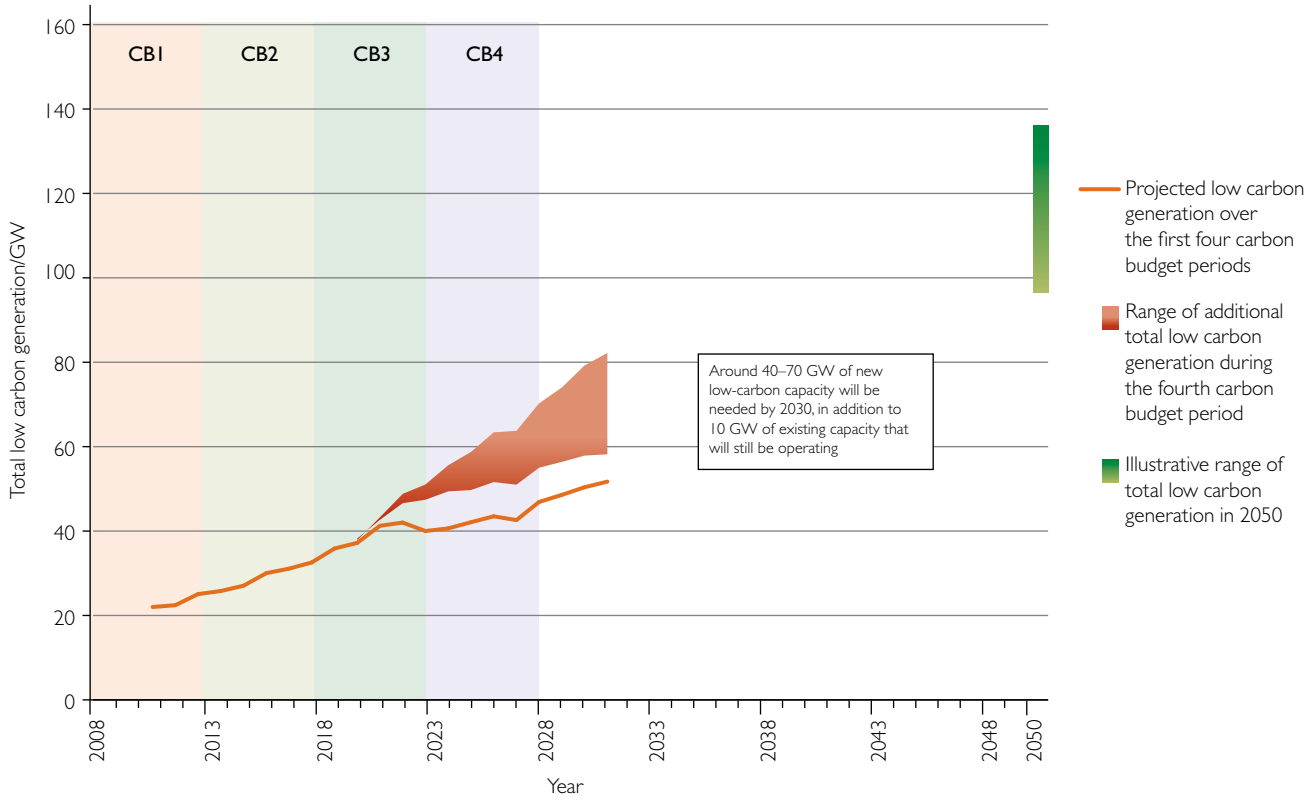
Chart 21: Emissions projections for electricity for the first three carbon budgets and illustrative ranges of emissions abatement potential in the fourth carbon budget period and in 2050[70]



[69] DECC (2011) *Updated Energy and Emissions Projections 2011*. Available at: www.decc.gov.k/en/content/cms/about/ec_social_res/analytic_projs/en_emis_projs/en_emiss_projs.aspx. These do not take into account the measures due to be introduced as a result of the Electricity Market Reform.

[70] The emissions projections derive from Updated Energy and Emissions Projections data. The illustrative ranges for emissions abatement potential for 2050 and the fourth carbon budget derive from the 2050 futures and fourth carbon budget scenarios – these are discussed in Parts 1 and 3 of this report respectively.

Chart 22: Projected deployment of low carbon generation over the first three carbon budgets and illustrative ranges of deployment potential in the fourth carbon budget period and in 2050



Source: Department of Energy and Climate Change, Redpoint modelling, 2050 Calculator

the way to 2050, some flexible fossil fuel plant is likely to be needed to ensure security of supply. In 2050, the role of fossil fuels is likely to be limited to power stations fitted with CCS, although it is possible that some unabated gas could still be used as back-up capacity without compromising our emissions targets.

How we will make the transition

2.147 **Over the next decade**, the UK will need to invest in new generation capacity to replace the coal and nuclear power stations that are set to close by the early 2020s in order to maintain our energy security, while meeting our legal commitments to reduce carbon emissions and increase renewable electricity generation.

2.148 To do this, the coming years will see a continuation of previous trends: more switching from coal to gas-powered generation, and renewable electricity rising to 30% of electricity generation by 2020. In common with other countries, the UK will move to a more diverse range of energy sources to increase energy security and reduce exposure to volatile fossil fuel prices, as well as to cut emissions.

2.149 In addition to cutting emissions this decade, the UK also needs to prepare for the rapid decarbonisation required in the 2020s and 2030s by demonstrating and deploying the major low carbon technologies that we will need on the way to 2050. CCS, renewables and nuclear power need to be deployed during this decade, and costs minimised, if they are to be deployed at scale in the next. Industry will lead, but the Government is playing a facilitating role for each technology.

2.150 **During the 2020s**, deep cuts in emissions from the power sector are necessary to keep us on a cost effective path to 2050. There is a clear opportunity for large-scale new low carbon capacity in the next two decades, created by the combination of existing plant closures and an increase in demand. Government modelling suggests that around 60–80 GW of new electricity capacity will need to be built by 2030, and of this around 40–70 GW will need to come from low carbon technologies, such as nuclear, renewables and fossil fuel stations with CCS.[71]

2.151 The Government does not have targets for particular generation technologies for 2030. As the 2050 futures in Part 1 illustrate, different combinations of the three key low carbon technologies are all plausible. The Government's aim is therefore to run a low carbon technology race between CCS, renewables and nuclear power. Diversity will bring competition between technologies that will drive innovation and cost reduction, and will hedge against the risk of one technology failing to reduce costs or become publicly acceptable. The low carbon power that can deliver at least cost will gain the largest market share.

2.152 The transition to low carbon power will not happen overnight. Over the next two decades, gas-fired power plants will provide the flexibility that we will need to meet peak demand and manage intermittent generation from some renewables, as well as baseload generation capacity, while new nuclear and renewable capacity is built.

2.153 **Beyond 2030**, as transport, heating, and industry electrification occurs, low carbon capacity will need to rise significantly. The futures described in Part 1 show that we are likely to need 100 GW or more of new low carbon generation capacity in 2050; the exact amount will depend on the technology mix and electricity demand. We currently have only 20 GW of low carbon capacity,[72] meaning that we need to build an average of around 2.5 GW of new low carbon capacity a year for the next 40 years. Although challenging, these build rates are achievable: the UK has built coal-fired power stations at an equivalent rate in the past, and nuclear power stations have been built at a rate of up to 4.5 GW a year.[73] As set out in the Electricity Market Reform White Paper,[74] the mix of low carbon technologies that is built on the way to 2050 is for the market to decide: the technologies with the lowest costs will win the biggest market share.

[71] Based on modelling by Redpoint Energy commissioned for the Carbon Plan. Please see Annex B for further details.

[72] DECC (2011) *Digest of UK Energy Statistics 2011* Table 5.7. Plant capacity – 9.6 GW renewable capacity and 10.9 GW nuclear.

[73] Nuclear Energy Association (2008) *Nuclear Energy Outlook 2008* p.318 – France, 1979–88, an average of 4.5 GW a year.

[74] DECC (2011) *Planning Our Electric Future: A White Paper for secure, affordable and low carbon electricity*. Available at: www.decc.gov.uk/en/content/cms/legislation/white_papers/emr_wp_2011/emr_wp_2011.aspx

Box 9: Decarbonisation of the power sector to 2030

There are many different ways to achieve the decarbonisation of the power sector. It is impossible to predict which will be the most cost effective route and what the power generation sector will look like in 2030. Nevertheless, we can use economic models to produce projections using the best evidence currently available. The scenarios modelled for this report suggest that around **40–70 GW of new low carbon electricity generating capacity will be needed by 2030**, depending on demand and the mix of generation that is built.

The analysis considered a range of decarbonisation scenarios which are consistent with meeting carbon budgets and the 2050 goal. The Government is not setting an explicit decarbonisation goal for 2030 now given the uncertainties involved in setting a target this far in the future – but the actions being taken now are intended to ensure that we are keeping a range of options in play.

These outcomes should not be interpreted as government technology targets. The Government is happy for fossil fuels with CCS, nuclear or renewables to make up as much as possible of the 40–70 GW we think we may need. The Government would like to see the three low carbon technologies competing on cost in the 2020s to win their share of the market.

- **Nuclear** is currently projected to be the cheapest low carbon technology in the future. Depending on assumed possible build rates, new nuclear contributed anywhere from 10–15 GW by 2030 in the scenarios modelled. Actual build rates could make this range higher or lower: industry has announced ambitions to build 16 GW by 2025, and if one reactor could be completed each year from 2019 onwards, it would be possible to reach around 20 GW by 2030.

- Fossil fuel generation with **CCS** could make a significant contribution by 2030, depending on whether it can compete on cost with other low carbon technologies. CCS contributed as much as 10 GW by 2030 in the scenarios modelled. This should not be seen as an upper limit to its potential – more could be deployed if costs reduce quickly as a result of government and industry actions. Industry has set out in their strategy for CCS ambition for at least 20 GW of fossil plant with CCS in operation by 2030.

- The role of **renewable electricity** during the 2020s will depend on the extent of deployment to 2020 and the pace at which costs reduce as a result of the ongoing joint government/industry work. The analysis showed that renewable electricity could provide 35–50 GW by 2030, with the upper end assuming either high electricity demand or significant cost reductions. The Committee on Climate Change's Renewable Energy Review suggests that we could have over 55 GW of renewable electricity capacity by 2030, subject to resolution of current uncertainties such as cost reductions and barriers to deployment, and industry has expressed similar levels of ambition.

2.154 The rest of this section looks in more detail at six key areas that will enable the low carbon transition: reform of the electricity market; and specific action to facilitate nuclear, CCS, renewables, unabated gas and investment in the electricity system. More detail on energy efficiency is set out in the sections on buildings (page 29) and industry (page 59).

Overcoming barriers to low carbon generation

2.155 There are common problems faced by all low carbon generators:

- The carbon price has not been high or certain enough to encourage sufficient investment in low carbon generation.
- The current electricity price is driven mainly by gas power stations. Gas plant has much lower fixed costs relative to its running costs than low carbon plant, which tends to be expensive to build but cheap to run. It is therefore difficult to make the case for capital investment in low carbon in a market where electricity prices move in line with the price of gas.
- There are high barriers to market entry, including poor market liquidity and regulatory burdens.

2.156 The reforms that the Government has proposed in the Electricity Market Reform White Paper are designed to address these problems, creating a level playing field for low carbon technologies:

- A Carbon Price Floor to be introduced from April 2013 to reduce investor uncertainty, place a fair price on carbon and provide a stronger incentive to invest in low carbon generation now.
- The introduction of new long-term contracts from 2014 (Feed-in Tariffs with Contracts for Difference), to provide stable financial incentives to invest in all forms of low carbon electricity generation. These will replace the existing Renewables Obligation (although they will run in parallel with it to 2017);
- An Emissions Performance Standard set at 450 gCO_2/kWh starting in 2013, to reinforce the requirement that no new coal-fired power stations are built without CCS, while allowing the necessary short-term investment in gas to take place.

2.157 The Government is concerned that by the end of this decade there will be a risk of insufficient electricity capacity to meet peak demand, and therefore it recently consulted on options for a capacity mechanism to ensure future security of electricity supply. The options are either a targeted mechanism in the form of a strategic reserve (whereby an amount of generating capacity is procured and held outside of the normal market and only despatched when required) or a market-wide mechanism (whereby all reliable capacity – either generation or non-generation technologies such as demand-side response – is rewarded). Further detail on this and the institutional arrangements needed to deliver Electricity Market Reform will be published at the turn of the year, as part of a Technical Update.

2.158 Timely planning decisions are also critical to the deployment of low carbon infrastructure. The Government is reforming the major infrastructure planning regime as follows:

- To ensure accountability, the Planning Inspectorate will consider applications for energy infrastructure over 50 megawatts (MW) and advise the Secretary of State for Energy and Climate Change, who will make the final decision.

- To provide a clear decision-making framework for applications for nationally significant energy infrastructure, the Secretary of State designated six National Policy Statements for energy in July 2011.

2.159 Electricity Market Reform and planning reform will address the main barriers that face all low carbon generation. But the Government is also addressing barriers specific to each technology, as outlined below.

Nuclear

2.160 Nuclear power is a proven technology able to provide continuous low carbon generation, and to reduce the UK's dependence on fossil fuel imports. New nuclear power stations will help to ensure a diverse mix of technology and fuel sources, which will increase the resilience of the UK's energy system.

2.161 Nuclear is currently cost-competitive with other electricity generation technologies, and recent independent studies indicate that new nuclear is likely to become the least expensive generation technology in the future.[75] The recent Weightman Report on lessons from Fukushima confirmed that there are no fundamental safety weaknesses in the UK's nuclear industry.[76]

2.162 The Government believes that new nuclear power should be free to contribute as much as possible towards the UK's need for new low carbon capacity. The Nuclear National Policy Statement identifies those sites which the Government believes are potentially suitable for deployment by 2025,[77] although it is for energy companies to develop new nuclear power stations, and to decide at what point they wish to develop a site. An application for a new nuclear power station at Hinkley Point (3,260 MW output) was submitted to the Infrastructure Planning Commission by EDF Energy on 31 October 2011.[78] Energy companies have announced intentions to bring forward 16 GW of new nuclear power stations by 2025 (see chart 24). To enable this to happen, the Government has taken forward a series of targeted facilitative actions, including the following:

- **Reducing regulatory and planning risks** for investors and ensuring that owners and operators have **robust funding plans for waste management and decommissioning**.[79]

- **Ensuring that there is an appropriately skilled workforce to deliver industry's ambitions on new nuclear build** – Cogent, the Sector Skills Council, has produced labour market intelligence that allows the Government to identify, monitor and, working with skills bodies, take action where necessary to address skills gaps. The Nuclear Energy Skills Alliance, a grouping of key skills bodies, has been set up to continue to identify mitigating actions and track progress against them.

[75] Parsons Brinckerhoff (2011) *Electricity Generation Cost Model 2011 Update Revision 1*. Available at: www.decc.gov.uk/assets/decc/11/meeting-energy-demand/nuclear/2153-electricity-generation-cost-model-2011.pdf. This includes the costs of decommissioning.

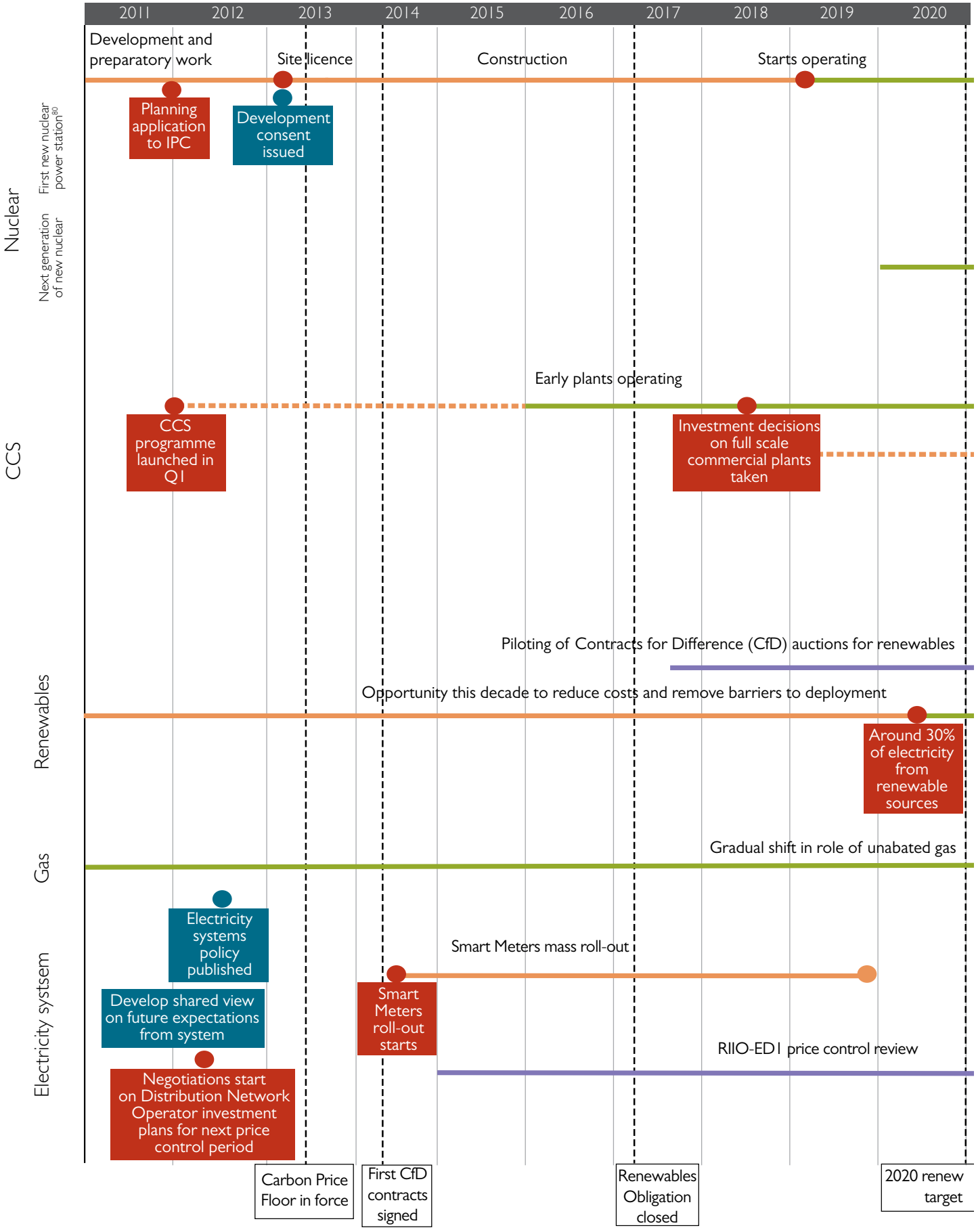
[76] Office for Nuclear Regulation (2011) *Japanese Earthquake and Tsunami: Implications for the UK nuclear industry*. Available at: www.hse.gov.uk/nuclear/fukushima/

[77] HM Government (2011) *National Policy Statement for Nuclear Power Generation (EN-6)*.

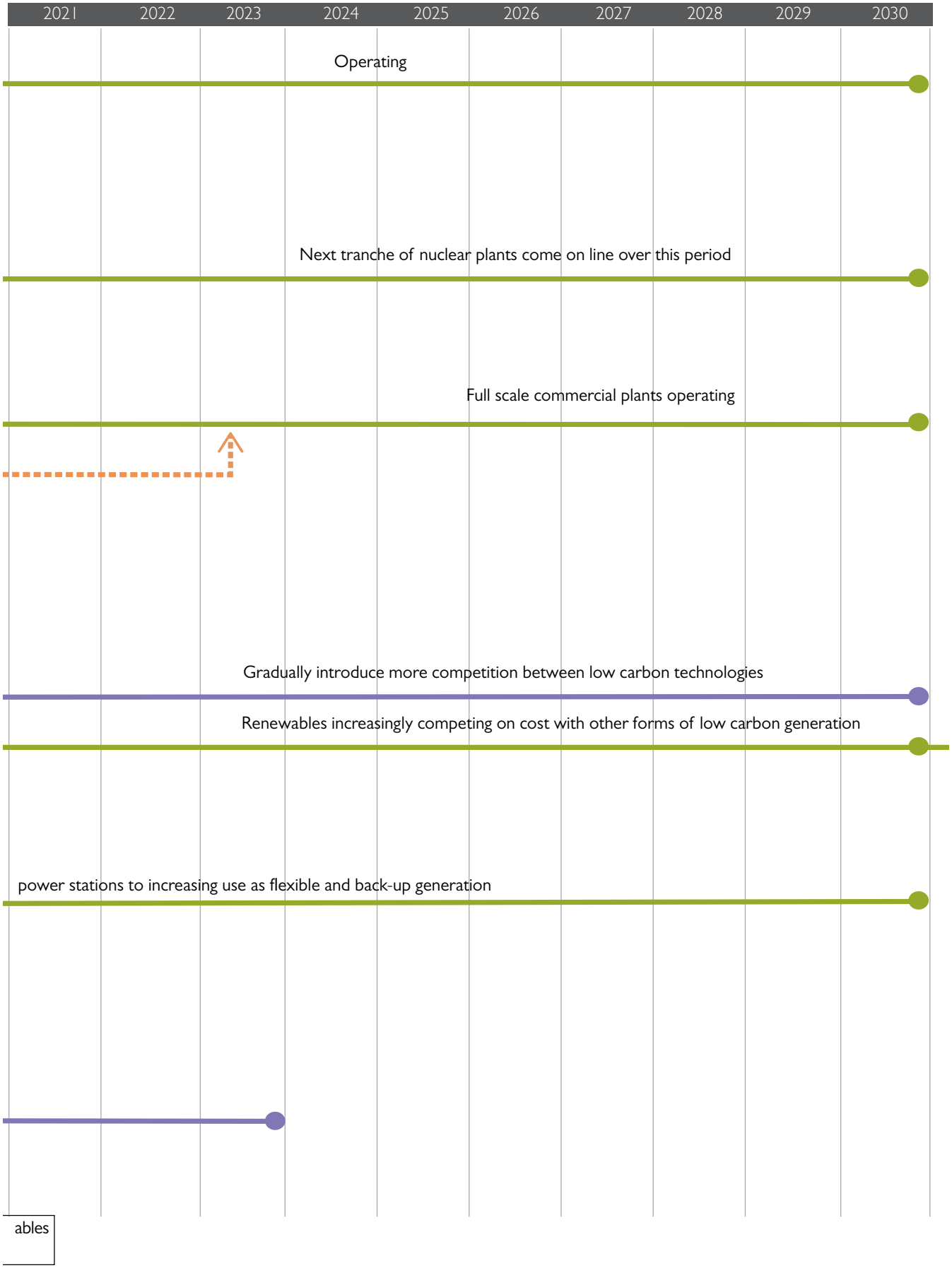
[78] The Infrastructure Planning Commission has 28 days from the day after the date of receipt to review the application and decide whether or not they can accept it.

[79] These are National Policy Statement; Regulatory Justification; Funded Decommissioning Programme; and Generic Design Assessment.

Chart 23: Decarbonisation of the power sector to 2030



[80] All subject to development consent.


2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
Operating
Next tranche of nuclear plants come on line over this period
Full scale commercial plants operating
Gradually introduce more competition between low carbon technologies
Renewables increasingly competing on cost with other forms of low carbon generation
power stations to increasing use as flexible and back-up generation
ables

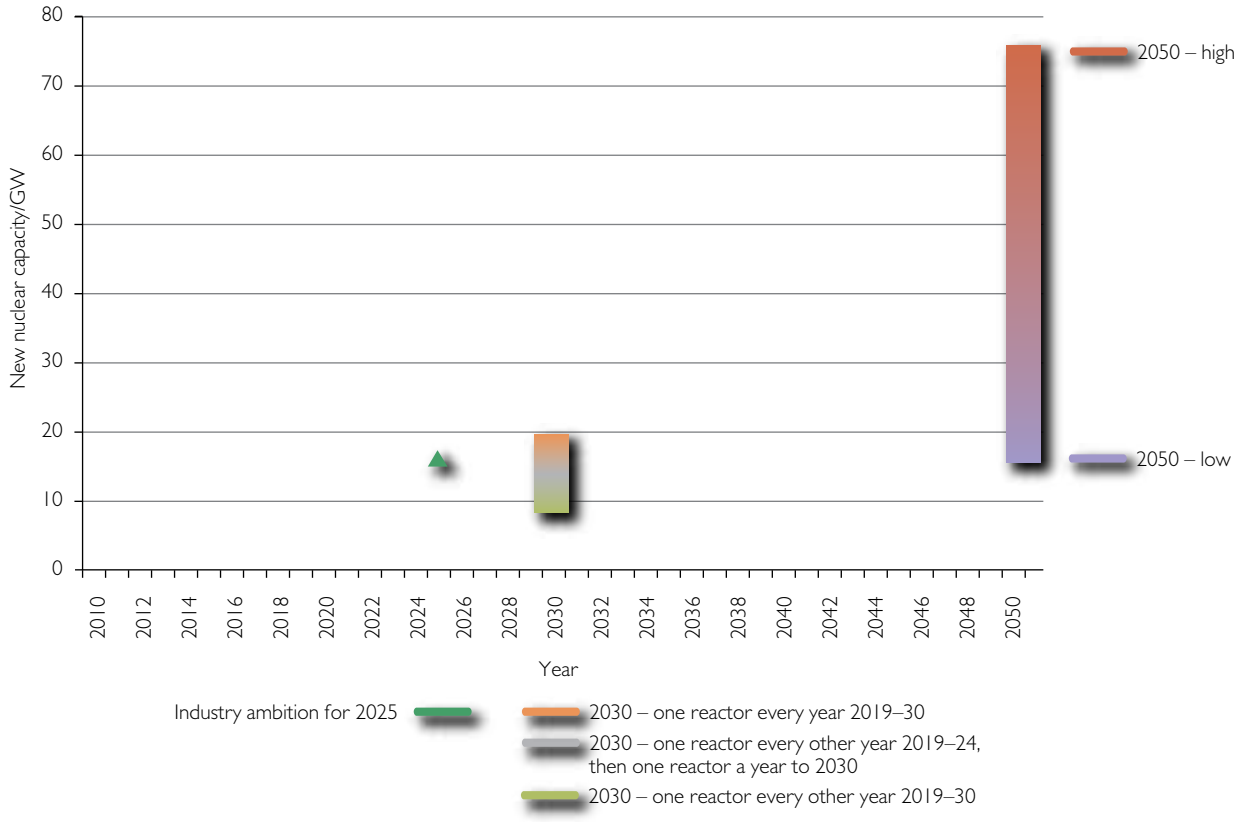
- **Rebuilding the nuclear supply chain** – The Government is working with the industry-led 'sc@nuclear' programme, which aims to engage companies with the nuclear sector and raise the profile of opportunities presented by new build. The Government is collaborating with the Nuclear Advanced Manufacturing Research Centre as it works to attract and improve the capabilities of UK companies through the Fit 4 Nuclear programme. It is also working with the Nuclear Industry Association to facilitate increased co-ordination across those with contracts to let, in order to make best use of supply chain capacity.

Carbon capture and storage

2.163 CCS is a chain of processes for capturing, transporting and storing greenhouse gases underground to reduce emissions from large sources such as fossil fuel power stations. CCS has the potential to become an important low carbon technology over the next 40 years (see chart 25). Successful deployment of CCS will allow fossil fuels to continue to contribute to security of supply by providing flexible electricity generating capacity that will help to balance continuous nuclear power, intermittent wind power and variable demand. Without CCS, the role of unabated fossil fuels in the electricity market by 2050 will be limited to back-up for periods of high demand.

2.164 As yet there are no full-chain commercial-scale CCS power projects in the world, but there are eight operational CCS plants, nearly all linked to natural gas processing. Each of the individual components is already used in other applications, such as injection facilities for the use of CO_2 in enhanced oil recovery operations. Studies show that in the 2020s fossil fuel generation with CCS is expected to be cost-competitive with some other low carbon electricity generation technologies, and will provide a flexible generation source.[81]

Chart 24: Trajectory for new nuclear capacity to 2050



Source: Modelling by Redpoint Energy for the Carbon Plan; Department of Energy and Climate Change

[81] Parsons Brinckeroff (2011) *Electricity Generation Cost Model 2011 Update Revision 1*. Available at: www.decc.gov.uk/assets/decc/11/meeting-energy-demand/nuclear/2153-electricity-generation-cost-model-2011.pdf

2.165 The next step is to bring down costs and risks by supporting development of the technology at scale in a commercial environment. That is why the Government is firmly committed to CCS. There are a number of promising CCS projects proposed in England and Scotland and we expect to commence a selection process as soon as possible, with £1 billion set aside to support the programme. Progress is also being made around the world – the US and Canada have both just broken ground on their first industrial-scale CCS projects on power plants.

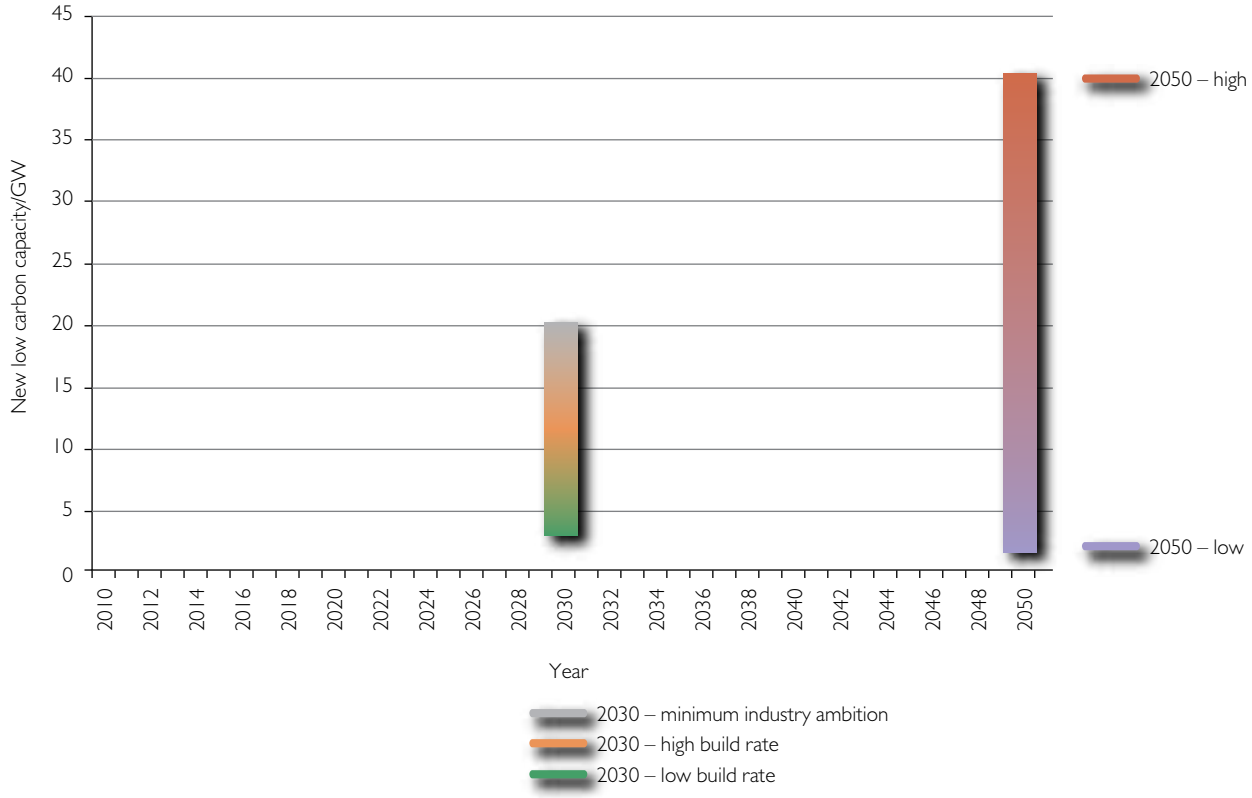
2.166 The Government is also undertaking other actions which will be set out in the CCS Roadmap that will be launched alongside the call for projects. These include development and implementation of the regulatory framework necessary to facilitate CCS projects, and implementation of the policy that there can be no new coal without CCS (enforced by an Emissions Performance Standard).

Renewable electricity

2.167 The Government is committed to dramatically increasing the amount of renewable electricity generation in the UK. Meeting the 2020 renewables target is likely to require renewables to provide over 30% of electricity generation in 2020. Making use of some of the best wind and marine resources in Europe will help to lower emissions and the demand for fossil fuels.

2.168 Looking out to the fourth carbon budget period and beyond, the Government agrees with the conclusions of the Committee on Climate Change's (CCC's) Renewable Energy Review that renewable electricity has the potential to provide over 40% of power generation by 2030 (see chart 26). However, delivering this will require costs to be significantly reduced. To drive cost reductions in offshore wind to £100/MWh by 2020, the Government has established an industry-led Task Force, which will report by spring 2012. It has also committed up to £50 million over the next four

Chart 25: Trajectory for CCS capacity to 2050



Source: Modelling by Redpoint Energy for the Carbon Plan; Department of Energy and Climate Change.

years to support innovation in offshore and marine technologies.

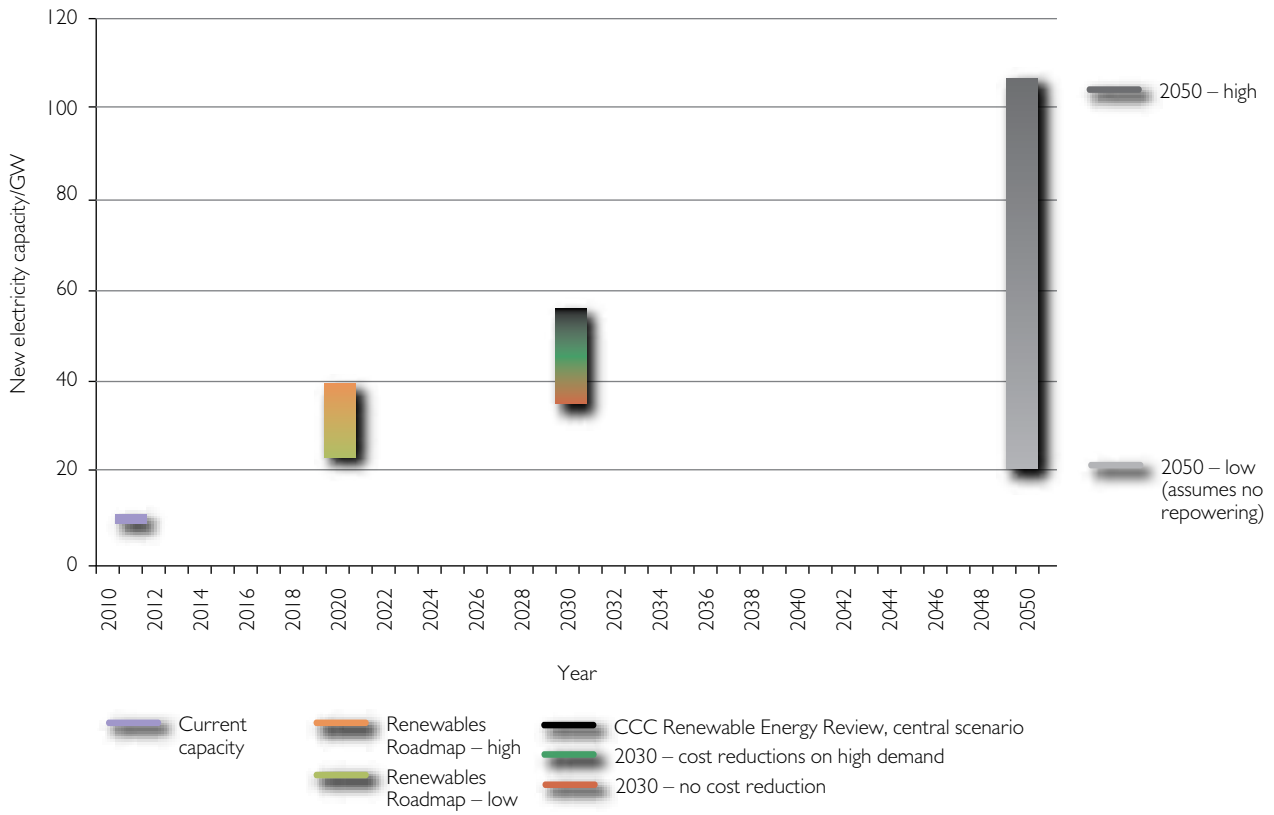
2.169 Levels of renewable energy penetration greater than 40% by 2030 may be technically feasible, but the Government also needs to consider the costs, sustainability and deliverability of such deployment levels, including the challenges for balancing variable electricity supply with demand.

2.170 The Government's immediate focus for renewables is on delivery. In addition to tackling the common barriers to deployment across all low carbon technologies described above, the Government is taking further targeted action on renewables as follows:

- **Reforming the local planning system to make it simpler and swifter** – In addition to reforming the major infrastructure planning regime, the Government recently consulted on a draft National Planning Policy Framework, setting out its objectives for the local planning system, including information on how local plans and development management decisions should support the delivery of renewable and low carbon energy and supporting infrastructure. The Government is also looking at how the planning application process can be improved, including reducing the amount of information expected from applicants and introducing a Planning Guarantee that no application should take longer than one year to reach a final decision, including any appeal.

- **Introducing a new system of marine planning and licensing to deliver sustainable development in the marine environment** – The UK administrations are introducing new marine planning and licensing systems designed to provide regulatory simplicity and certainty for developers.[82]

Chart 26: Trajectory for renewable electricity capacity to 2050



Source: Modelling by Redpoint Energy for the Carbon Plan; Department of Energy and Climate Change.

[82] Marine plans will for a framework for the sustainable development of marine renewables, informing licensing decisions and major infrastructure decisions for larger offshore projects.

- **Access to investment capital** – Offshore wind and energy from waste are likely to be priorities for support from the Green Investment Bank (GIB), which should be able to lend money from 2015, when most funding for the construction of Round 3 offshore wind is required.[83] Prior to the GIB's creation, there will be £775 million of government funding available in 2012/13 to invest in the low carbon economy.

- **Ensuring sustainable bioenergy feedstock supply** – The Government is currently developing a Bioenergy Strategy, which will help to provide strategic direction in ensuring that biomass feedstocks used for bioenergy are sustainable and that they are directed towards the most appropriate uses in electricity, heat and transport.

- **Facilitating development of renewable supply chains** – The Government has committed up to £60 million to encourage the development of port and manufacturing facilities for offshore wind and marine energy parks.

- **Facilitating access to the electricity grid** – The Government has reformed grid access, and is now working to ensure the delivery of new onshore grid investment, and to establish the offshore framework necessary to deploy future levels of renewable electricity.

Unabated gas

2.171 Gas generation capacity will continue to play an important role in providing flexibility and balancing the system. We are likely to need new gas plant within the next decade to replace coal and nuclear closures. There is currently 8.7 GW of gas power station capacity with consent to build and around 4.3 GW under construction. The capacity mechanism should continue to ensure sufficient reliable capacity, including gas, to meet our electricity needs.

2.172 The precise share of gas in the overall energy mix over the fourth carbon budget will be determined by a number of factors. Government modelling suggests that unabated gas could retain a significant role in electricity generation through the 2020s, potentially still producing up to two thirds of today's generation levels in 2030.[84] As the share of renewables in the electricity mix rises, increasing the amount of intermittency on the system, we are likely to need increased back-up gas generation.

2.173 In the longer term, there will be a more fundamental shift in the role of gas in electricity supply. From 2030 onwards, a major role for gas as a baseload source of electricity is only realistic with large numbers of gas CCS plants.[85] However, we may still need unabated gas for back-up even in 2050 – the 2050 futures in Part I suggest the need for significant volumes of back-up gas operating at low load factors in scenarios with high levels of renewable generation.

[83] Third round of offshore wind site allocations by the Crown Estate.

[84] Based on modelling by Redpoint Energy commissioned for the Carbon Plan. Please see Annex B for further details.

[85] HM Government (2011) *2050 Pathways Analysis: Response to the Call for Evidence.*

Reducing electricity demand and balancing the electricity system

2.174 The Government is also currently assessing whether sufficient support and incentives already exist to make efficiency improvements in electricity usage, or whether there is a need for additional measures. The results of this work will be published in summer 2012. At the same time, the Government will publish its policy on balancing the future electricity system. This will cover the whole electricity system and set out the role for government in ensuring that the electricity system supports the low carbon transition in the most secure and affordable way, the most efficient use of assets.

Ensuring that the grid is able to deliver

2.175 The scale of investment required in the electricity network is unprecedented. This is illustrated by plans submitted to Ofgem by the GB electricity Transmission Owners (TOs) for up to £15 billion of new network investment for 2013–21. The Government is working with Ofgem and industry to help meet the network challenges to support a secure, efficient and affordable, low carbon future.

2.176 Onshore, a new grid connection regime introduced in 2010 has meant that projects, particularly renewables, are now getting much speedier connection dates. To date, 73 large projects – with a total capacity of 26 GW – have advanced their connection dates by an average of six years. Work is under way to ensure that the transmission system can be extended and reinforced to connect newer generation that will increasingly be in areas located further away from the main network, in particular through Ofgem's new investment framework, RIIO (Revenue=Incentives+Innovation+Outputs). In 2009 the Electricity Networks Strategy Group (ENSG), a high-level industry group chaired by the Department of Energy and Climate Change and Ofgem, assessed the potential transmission network investment required to 2020. Since then, the TOs have been submitting their priority investments to Ofgem, which has resulted in approval of around £400 million of investment to date. The ENSG is currently refreshing this '2020 vision' and considering analysing possible network requirements post-2020.

2.177 The Government is taking action now to ensure that distribution networks can cope in the future. The Department of Energy and Climate Change and Ofgem co-chaired Smart Grid Forum is developing shared assumptions of future electricity demands and necessary investment levels. At the same time Ofgem has set up the Low Carbon Networks Fund, which is making £500 million available to networks that introduce new innovation and commercial models onto the network.

2.178 Connecting offshore renewable electricity quickly will also require significant investment in offshore transmission assets. The Government has put in place an innovative regulatory regime to deliver offshore energy connections in a cost effective, timely and secure manner. A key element of the regime is the competitive tender process run by Ofgem to appoint Offshore Transmission Owners (OFTOs) to construct (where a generator chooses not to do so itself), and own and operate the offshore transmission assets.

2.179 In recognition of the importance of developing a co-ordinated offshore and onshore transmission network and the potential benefits this could bring, the Government and Ofgem are currently undertaking an Offshore Transmission Co-ordination Project to consider whether additional measures are required within the competitive offshore transmission regime to further maximise the opportunity for co-ordination. Interim conclusions will be published this winter.

AGRICULTURE, FORESTRY AND LAND MANAGEMENT

Where we are now

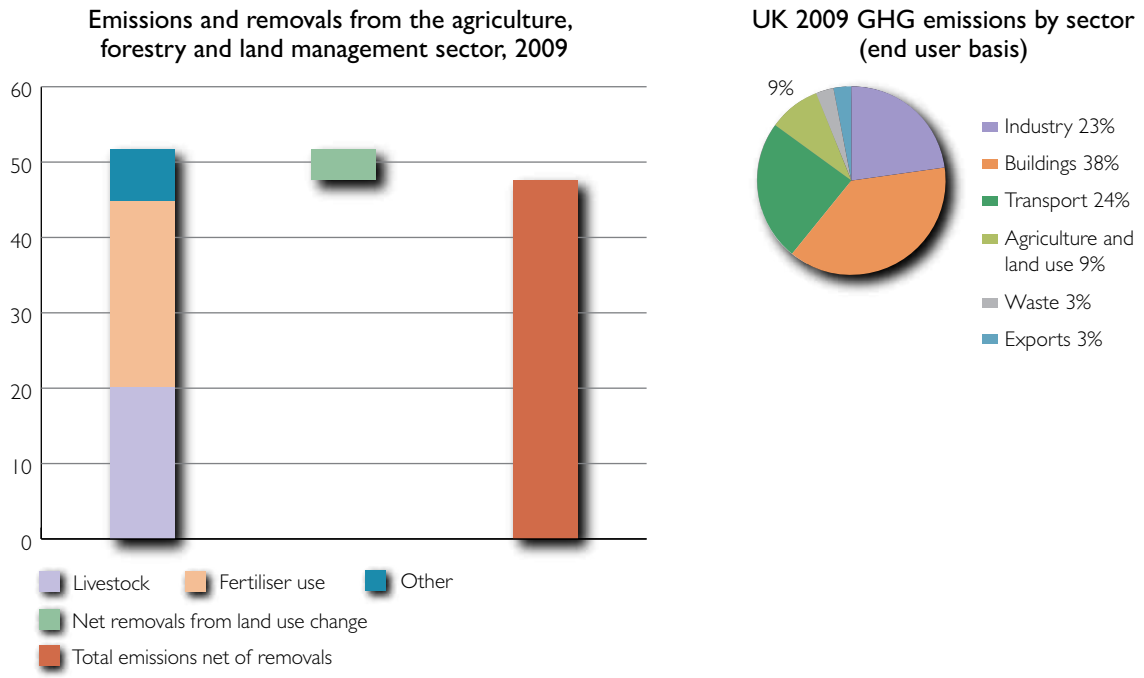
2.180 Agriculture, forestry and land management together accounted for around 9% of UK emissions in 2009.[86] We expect that emissions will be reduced further between now and 2050, but unlike some areas it will not be possible to eliminate those emissions entirely which, to a substantial degree, result from natural processes in soils and the digestive systems of farm animals.

2.181 Good progress has already been made since 1990, with emissions from the agriculture sector down by more than 30%, partly due to lower livestock numbers, but also to the more efficient use of fertilisers in crop production and the decoupling of subsidies from production.

Over the same period, the land use, land use change and forestry sector has changed from a net source of emissions to a net carbon sink. This is primarily because of lower emissions from soils due to less intensive agriculture, and increased removals by forests due to high levels of afforestation from the 1950s to the 1980s.

2.182 Because the agricultural sector covers a diverse range of practices that are part of complex biological systems, emissions from agriculture are heavily affected by variable, uncontrolled elements such as climate, weather and soil conditions, as well as by controlled activities such as livestock diet. One element of uncertainty arises from the fact that there are considerable variations in the level of emissions created, even where farmers are

Chart 27: Proportion of UK greenhouse gas emissions from the agriculture, forestry and land management sector, 2009



[86] On source and end user basis. The figure by end user is slightly higher (48 $MtCO_2e$ compared with 45 $MtCO_2e$ by source). This includes both emissions and the removal of carbon from the atmosphere by sinks such as forests.

adopting the same practices. For example, different soil types and moisture conditions will lead to different levels of emissions from the same degree and method of fertiliser application. As a result, estimates for emissions from agriculture lie within an uncertainty range of around +250%/–90%. This is the reason for the Government's focus on research to expand the evidence base.

Where we will be in 2050

2.183 The Government is committed to reducing emissions from agriculture and land use, and the strategy is to focus on the following practical action:

- In the **agriculture** sector, improvements in crop nutrient management and in breeding and feeding practices will reduce emissions, are likely to increase productivity and save money, and in many cases may also bring environmental co-benefits.
- **Sustainable forest management** can deliver significant emissions savings through carbon sequestration in new woodlands, and through increased use of sustainable wood products which store carbon and act as substitutes for materials with higher emissions associated with their production.
- **Soils**, which naturally store carbon and are important in climate regulation, need to be managed in a way that protects – and, where possible, increases – these stores, particularly as climate change may affect natural processes in a way that could cause some of the store to be lost.[87]

2.184 The pressures of a growing global population and increasing demands for a more resource intensive diet were highlighted in the Foresight Report on the future of food and farming,[88] which identified managing the contribution of the food system to the mitigation of climate change as one of the most important challenges for policy makers. The Government has committed to champion a more integrated approach to **global food security** by governments and international institutions that makes the links with climate change, poverty, biodiversity, energy, water and other policies. The Government has also committed to work in partnership with the whole food chain, including consumers, to ensure that the UK leads the way in sustainable intensification of agriculture. This will ensure that agriculture and the food sector can contribute fully to the low carbon economy by increasing productivity and competitiveness while reducing emissions, protecting and enhancing the natural environment, and using resources more sustainably.

2.185 The sector could also play a role in supporting the diversification of our energy supply by providing sustainable feedstocks for bioenergy.[89]

How we will make the transition

2.186 Whereas in other sectors of the economy a portfolio approach has been proposed – where the most cost effective technologies are supported and a range of possible abatement levels in the fourth carbon budget period are presented – the uncertainties in the agriculture and land management sector mean that our analysis assumes one level of possible emissions abatement potential that might be delivered in the first four carbon budgets. The trajectory graph in chart 28 below provides an illustrative view of this emissions reduction scenario.

2.187 In agriculture the Government is taking a phased approach to reducing emissions. Over the next decade it will focus on encouraging production efficiencies such as improving crop nutrient management, and breeding and feeding practices, which save both money and emissions. The Government recognises that further action will be needed in the future that goes beyond this, but that there is a great deal of uncertainty around

[87] UK soils hold around 10 billion tonnes of carbon, half of which is in peat habitats. This is more than in all the trees in the forests of Europe (excluding Russia), and equivalent to more than 50 times the UK's current annual greenhouse gas emissions. Source: Defra (2009) *Safeguarding Our Soils: A strategy for England.* Available at: http://archive.defra.gov.uk/environment/quality/land/soil/documents/soil-strategy.pdf

[88] Government Office for Science (2011) *The Future of Food and Farming: Challenges and choices for global sustainability*. Available at: www.bis.gov.uk/assets/bispartners/foresight/docs/food-and-farming/11-546-future-of-food-and-farming-report.pdf

[89] Annex A sets out the amount of demand for sustainable bioenergy in the three 2050 futures.

what actions can successfully reduce emissions to the levels that will be required by 2050. We are therefore also putting in place the research and structures that will give us the knowledge and practical tools to reduce emissions in the longer term.

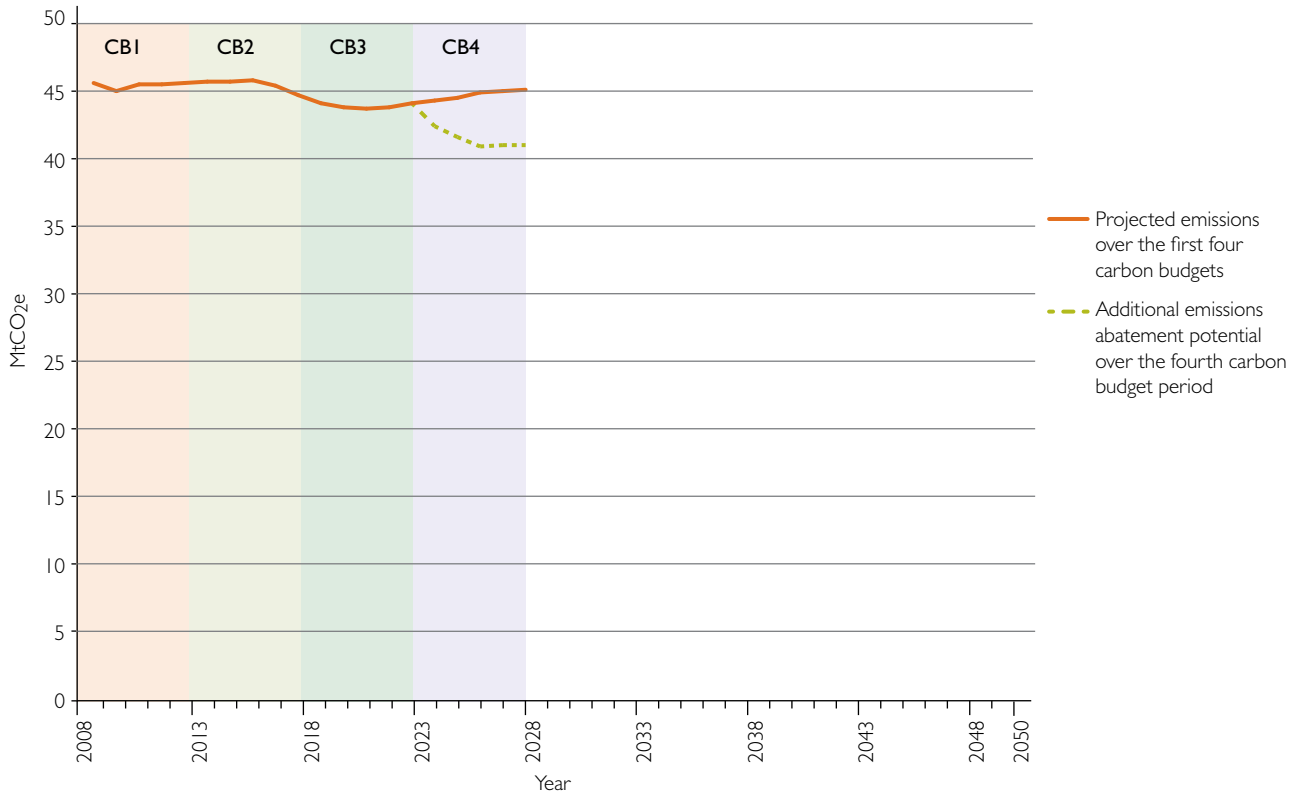
2.188 Chart 29 on page 90 shows some of the key actions and decision points that will set us on the way to further reducing emissions from the sector to 2030.

Agriculture

2.189 **Over the next decade**, a range of actions are being taken in the agriculture sector – both industry- and government-led – which will keep us on track towards the level of emissions abatement identified in the fourth carbon budget period.

2.190 In England, the agricultural industry partnership published the *Agriculture Industry GHG Action Plan: Framework for Action* in 2010, outlining how reductions could be delivered by the end of the third carbon budget period through the uptake of more resource efficient practices.[90] It has committed to reducing emissions by 3 $MtCO_2e$ a year during the third carbon budget period, and in 2011 published a Phase 1 Delivery Plan which explained how the Action Plan will be implemented. Many of the measures identified – such as better use of nutrients, improving livestock productivity and better use of on-farm energy and fuel – could be adopted at minimal or no cost and would help to improve industry competitiveness. The meat and dairy sector bodies have also delivered industry-led environmental product roadmaps, which encourage farmers to employ more sustainable farming practices and management techniques.[91]

Chart 28: Greenhouse gas emissions projections in the agriculture sector in the first three carbon budgets and illustrative emissions abatement potential in the fourth carbon budget period[92]



[90] For further information see: www.nfuonline.com/ghgap

[91] See: www.eblex.org.uk/documents/content/publications/p_cp_testingthewater061210.pdf and www.dairyco.net/library/research-development/environment/dairy-roadmap.aspx

[92] The emissions projections derive from Updated Energy and Emissions Projections data. The illustrative emissions abatement potential for the fourth carbon budget derives from the fourth carbon budget scenarios discussed in Part 3 of this report.

2.191 To support these industry-led efforts to reduce emissions, the Government has undertaken a number of initiatives, including the following:

- Investing £12.6 million, in partnership with the Devolved Administrations, to strengthen understanding of on-farm emissions, and enable better reporting of actions taken on the ground and more targeted advice.
- Investing in a wider programme of research on measures with potential to reduce emissions, for example the impact and cost effectiveness of tackling endemic diseases in cattle, improving nutrient use through better feed management and optimising lifetime protein use for milk production.
- Engaging in partnerships with Research Councils and industry through the Technology Strategy Board, and internationally through the Global Research Alliance, to promote exchange of data, training and research to help improve how agricultural greenhouse gas research is conducted and to enhance scientific capability.
- Funding a pilot project to trial methods for delivering integrated environmental advice for farmers – including on greenhouse gas emissions – with a view to wider delivery by the Government and industry advisors.
- Including climate change mitigation as a topic of advice under the Farm Advisory System contract during 2012 and 2013.
- Committing, in the Natural Environment White Paper, to review use of advice and incentives for farmers and land managers, to create a more integrated, streamlined and efficient approach that is clear and that can yield better environmental results.

2.192 There is a close relationship between the level of agricultural production and emissions from the sector. The Common Agricultural Policy (CAP) and other factors that impact on production levels are likely to be strong drivers of action on emissions. Alongside the EU's budget negotiations for 2014–20, the shape of the CAP for this period is currently being re-negotiated. The European Commission's proposals for the future of the CAP were formally released on 12 October 2011.[93] These will be negotiated by Member States in the Agriculture Council and, for the first time, with the European Parliament through co-decision.[94] Through funding for the UK's agri-environment programme, the CAP already incentivises actions that deliver emissions reductions and the Government is committed to making the CAP more effective in delivering environmental benefits. The negotiations are expected to last throughout 2012 and 2013, and final legislation is due to come into effect on 1 January 2014.

2.193 In 2012 the Government will involve a number of interested organisations in evaluating the likely impact of all these policies in England, as well as in assessing the progress being made by the industry-led Action Plan, in order to identify the policy options for the future.[95] It is probable that the sector will reduce emissions through a combination of on-farm measures that can be successfully implemented (and others that may emerge over time or as a result of further improvements in technology), supported by developments in the broader policy and economic landscape.

2.194 **Over the fourth carbon budget period**, the Government's analysis (based on a review of the Scottish Agricultural College's (SAC's) analysis for the Committee on Climate Change) suggests that, at a carbon price of zero, there is around 7.5 $MtCO_2e$ a year (central estimate, of which 5 $MtCO_2e$ is in England) of total annual abatement potential from the application of on-farm measures.[96]

[93] See: www.defra.gov.uk/food-farm/farm-manage/cap-reform/

[94] This means joint decision making by both the European Parliament and the Council.

[95] See: www.defra.gov.uk/corporate/about/what/business-planning/

[96] In their 2008 advice on the level of the first three carbon budgets, the Committee on Climate Change relied on analysis carried out by SAC, which considered a range of measures that can be adopted by farmers, including measures to improve crop nutrient management, manure treatment and storage, plant breeding, soil drainage and the modification of livestock diets. The central estimate includes the abatement that industry expects to deliver during the third carbon budget period. This is within a range of between 3 $MtCO_2e$ and 19 $MtCO_2e$ by the end of the fourth carbon budget period.

2.195 While in theory this represents an additional 16.9 $MtCO_2e$ of abatement over the fourth carbon budget period compared with baseline projections, the uncertainty in our data means that it is difficult to determine the exact potential for reductions in the fourth carbon budget period and beyond.[97] Work is under way to improve the agriculture greenhouse gas inventory, which will help to refine the analysis of what is feasible.

Forestry and land management

2.196 The Government is committed to strong support for woodland creation and for bringing more woodland into active management. An independent panel will provide advice to the Government in spring 2012 on the future direction of forestry and woodland policy.[98] The measures outlined in this section are therefore subject to the panel's findings and the Government's response.

2.197 **Over the next decade**, the Government will continue to support woodland creation through a number of measures, including the following:

- **Rural Development Programme funding and the Woodland Carbon Task Force** – The Government will continue to support woodland creation through woodland grant schemes. The Woodland Carbon Task Force was set up by the Forestry Commission to enable a step-change in the level of woodland creation to help deliver abatement in the sector. It will help to ensure that the contribution of woodland creation to carbon budgets is recognised, and will develop a spatial framework to identify where woodland creation will have the most benefit.
- **The Woodland Carbon Code**, which helps to promote high quality UK-based forest carbon projects, and – together with recent changes to the guidance for businesses on measuring and reporting greenhouse gas emissions[99] – encourages investment in domestic woodland creation projects by helping organisations to report these reductions as part of their net emissions.[100] The **Woodfuel Implementation Plan**, which outlines the actions that Forestry Commission England will take to support the development of a robust woodfuel supply chain over the next four years.[101] This helps to fulfil commitments made under the EU Renewable Energy Directive, and is part of a wider programme to increase sustainable timber production from privately owned woodlands.
- A revised **UK Forestry Standard**, supported by new Forests and Climate Change Guidelines, promotes carbon management in the UK's woodlands,[102] and also provides guidance on adapting woodlands to the impacts of climate change, promoting resilience and ensuring that future abatement is delivered.[103]

2.198 However, in the land use, land change and forestry (LULUCF) sector there are still significant uncertainties about current emissions, future trends, and the potential for permanent sequestration of greenhouse gas emissions through land management. Further work is therefore being carried out to explore the potential to refine further the LULUCF inventory and also to understand the effect of land management practices on soil carbon within current policies.

[97] It is also important to note that some of the mitigation measures SAC identified are likely to be unacceptable because of the potential adverse impacts on biodiversity or animal welfare, and some may even have perverse effects on greenhouse gas emissions which have yet to be fully assessed. The estimates of abatement potential make no allowance for such issues, so the level of cost effective abatement achieved from these measures is unlikely to be at the upper bound suggested by the analysis.

[98] See: www.defra.gov.uk/forestrypanel/

[99] See: www.defra.gov.uk/environment/economy/business-efficiency/reporting/

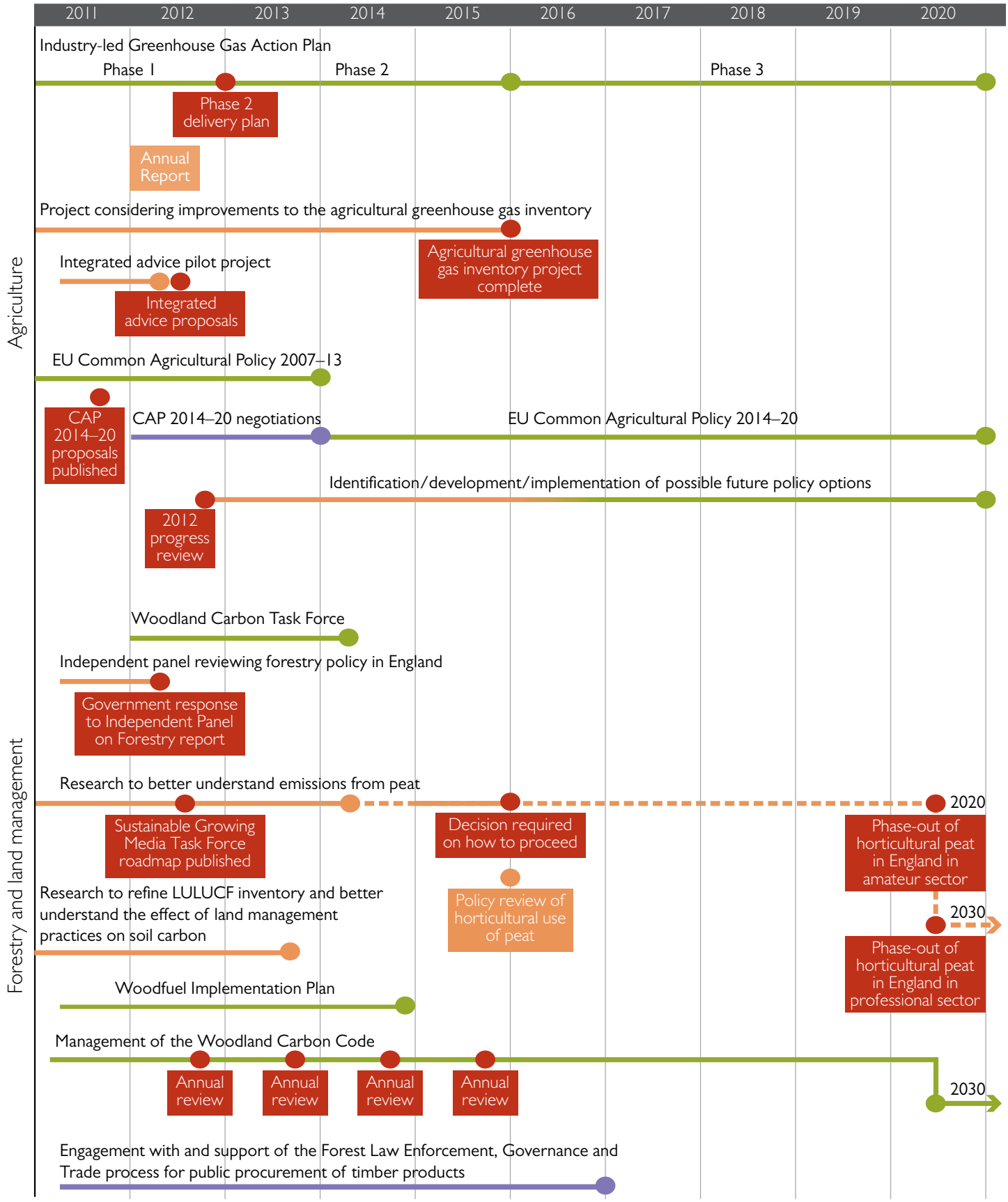
[100] See: www.forestry.gov.uk/carboncode

[101] See: www.forestry.gov.uk/england-woodfuel

[102] See: www.forestry.gov.uk/ukfs

[103] In this context the Defra and Forestry Commission's *Action Plan for Tree Health and Plant Biosecurity* addresses the risk of future tree pest and disease outbreaks to forest carbon storage.

Chart 29: Decision points for agriculture, forestry and land management to 2030



2.199 Internationally, continuing support for the Forest Law Enforcement, Governance and Trade process and chain of custody requirements for public procurement of timber products,[104] together with the development of biomass sustainability criteria for renewable energy production, will promote sustainable approaches to forest management, helping to reduce emissions from deforestation and forest degradation globally.

2.200 The Soil Protection Review[105] addresses threats to soil degradation and contains measures to protect soil organic matter, and so soil carbon. In addition, given the importance of peatlands as carbon stores, the Government is undertaking research to further our knowledge of emissions from peat. This includes a review of restoration methods used in blanket peatlands to assess which could provide the best outcomes for reducing peatland emissions. Peat extraction in the UK causes around 0.4 $MtCO_2e$ of emissions annually, and in the Natural Environment White Paper the Government committed to phase out the use of peat in horticulture in England by 2030.[106]

2.201 **Over the fourth carbon budget**, the Committee on Climate Change has indicated that increased woodland creation could deliver 1–3 $MtCO_2e$ abatement a year by 2030,[107] although assessing the cost effectiveness of abatement is complex because of the dynamics of forest growth and carbon uptake, the nature of the woodland and approaches to its management, and the end use of harvested wood products.

2.202 Looking ahead to 2050, current projections indicate that increasing woodland planting to an average of 24,000 hectares per annum across the UK between now and 2050 would increase forest carbon uptake by 7.7 $MtCO_2e$ per annum in 2050, compared with the level which would be achieved by maintaining 2010 planting rates (6,000 hectares per annum).[108]

Next steps

2.203 The uncertainty in the agricultural greenhouse gas emissions inventory means that a continued focus is required on research and statistics. For example, the Farm Practices Survey provides information on behaviours for a range of on-farm practices across the whole sector.[109] The 2012 progress review will evaluate the results of evidence such as this with interested organisations.

[104] The Government's timber procurement policy is set out at: www.cpet.org.uk/uk-government-timber-procurement-policy

[105] See: www.defra.gov.uk/food-farm/land-manage/soil

[106] In 2009, of the 3 million cubic metres of peat sold in the UK as growing media and soil improvers, around 80% was sold in England.

[107] Indicative estimates of the cost of abatement through woodland creation are of the order of £0–£70 per tonne CO_2e.

[108] This is based on the analysis presented in Read, DJ, Freer-Smith, PH, Morrison, JIL et al. (eds) (2009) *Combating Climate Change – A role for UK forests* (the Read Report). Available at: www.forestry/gov/uk/readreport

[109] See: www.defra.gov.uk/statistics/foodfarm/enviro/farmpractice/

WASTE AND RESOURCE EFFICIENCY

Where we are now

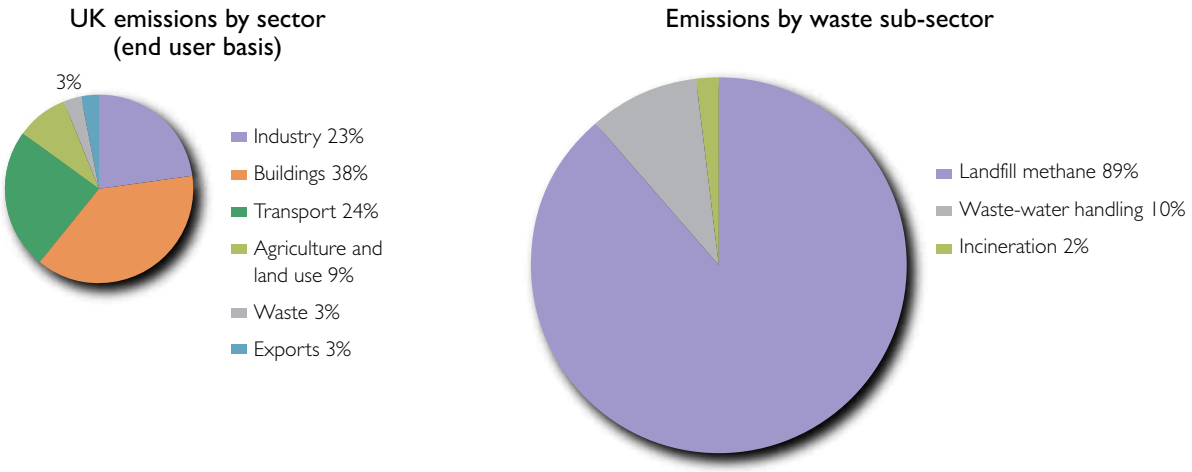
2.204 In 2009, emissions from the waste management sector represented a little over 3% of the UK total.[110] Between 1990 and 2009 emissions were reduced by nearly 70%, primarily due to the landfill tax – which incentivises reductions in the amount of biodegradable waste sent to landfill – and the increased capture and use of landfill gas for energy.

2.205 It will not be possible to eliminate these emissions completely as some biodegradable waste takes a long time to fully decompose, but by 2050 it is estimated that emissions of methane from landfill – which accounted for nearly 90% of emissions from the sector in 2009 – will be substantially below current levels. The Government is working to improve our scientific understanding of these emissions so they can be predicted with more certainty.

2.206 The Government is committed to working towards a zero waste economy, and the three broad strands of the Government's approach to tackle emissions from the sector relate to the following areas:

- **Preventing waste arising** – The best thing that can be done to minimise the greenhouse gas impacts of waste is not to produce it in the first place. This eliminates the need to manage waste, and removes the embedded carbon throughout the supply chain that went into the product, thereby reducing emissions both in other sectors of the UK economy and in other countries.[111] More efficient use of resources – including energy and water – by businesses will help the UK to move to a greener economy and deliver economic and environmental benefits.

Chart 30: Proportion of UK greenhouse gas emissions from the waste sector, 2009



[110] On source and end user basis. The waste management sector comprises emissions from landfill, waste-water handling and waste incineration.

[111] Direct emissions from the management and disposal of waste are only a small proportion of the total greenhouse gas emissions caused by wasteful use of resources. The majority of these emissions occur outside the UK.

- **Reducing methane emissions from landfill** – There are three broad approaches that may be taken: preventing biodegradable waste from arising in the first place; diverting biodegradable waste that is produced away from landfill to other forms of treatment, such as recycling or waste to energy facilities; and reducing methane emissions from landfill sites, for example by increasing the proportion of methane that is captured and converted to energy. There are, however, considerable uncertainties in the way we calculate emissions from landfill, which the Government is working to address.
- **Efficient energy recovery from residual waste** – Recovering energy from waste rather than sending it to landfill displaces energy produced from fossil fuels, avoids methane emissions from landfill and is generally a good source of feedstocks to meet UK bioenergy needs.

How we will make the transition

2.207 Emissions from waste management have already fallen by nearly 70% between 1990 and 2009. In the next decade the Government will continue to take action on reducing waste with the increase of the landfill tax to £80 per tonne in 2014/15. We are also undertaking a consultation on restricting wood waste to landfill. Legacy issues mean that it will not be possible to eliminate emissions completely by 2050, as some biodegradable waste takes longer than this to fully decompose, but by 2050 we expect levels to be substantially below where they are now.

2.208 Chart 33 on page 98 gives a summary of some of the key actions and decision points that will help to reduce emissions from the waste sector and improve resource efficiency.

Preventing waste arising

2.209 The Government's approach to reducing waste is underpinned by the waste hierarchy (see chart 31), a framework that ranks waste management options according to what is best for the environment.[112]

2.210 The further up the hierarchy waste is treated, the greater the emissions savings: preparing for re-use is often a less intensive way of replacing primary production of products than recycling.[113] An example of this is textiles, where preparing 1 tonne for re-use could save 12 tonnes more CO_2e than recycling. However, waste prevention incorporates a wide number of different actions and behaviours, and the barriers to these behaviours becoming embedded are complex and will be different for individuals and businesses. They include the costs of innovation and market development of new products or business models, lack of access to information to enable decisions, and lack of incentives to change behaviours.

2.211 Recent research has identified savings of around £23 billion and 29 $MtCO_2$e a year available to UK business from resource efficiency measures to minimise waste and use of materials that pay back within a year or less, including around £18 billion from waste measures alone. This figure could be more when longer-term investment is considered – an estimated additional £33 billion, resulting in a total opportunity of around £55 million and 90 $MtCO_2$e in total for all measures.[114]

2.212 In addition, using water more efficiently helps both to adapt to the impacts of climate change, where more variable rainfall is expected, and to reduce the greenhouse gases associated with pumping and treatment, and heating.[115]

[112] Guidance on applying the principles of the waste hierarchy can be found at: www.defra.gov.uk/publications/files/pb13530-waste-hierarchy-guidance.pdf

[113] It is possible to deviate from the hierarchy where lifecycle evidence suggests that to do so would have a better environmental impact, such as for lower grade wood where energy recovery is better than recycling due to the level of contaminants; and for anaerobic digestion, which sits above recycling for food waste because it produces both energy and digestate (which can displace artificial fertilisers).

[114] This analysis is based on a 2009 base year and refers to annual savings from low or no cost measures which deliver within one year; all potential longer-term measures up to 2050. See: Oakdene Hollins (2011) *The Further Benefits of Business Resource Efficiency* at: http://randd.defra.gov.uk/Default.aspx?Document=EV0441_10072_FRP.pdf

[115] The water industry currently produces about 1% of the UK's overall greenhouse gas emissions in the supply of water and treatment of waste water.

Measures that increase the efficiency of use of hot water may be financed under a Green Deal, as reductions in the energy used will generate savings.

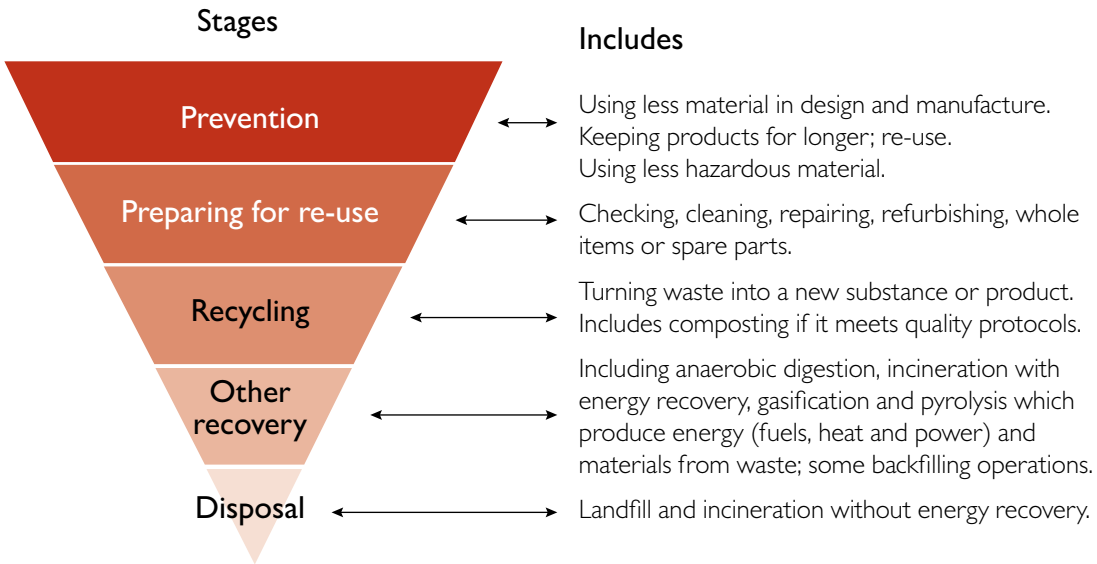
2.213 **Over the next decade**, government action will include the following:

- Development of a **comprehensive Waste Prevention Programme by the end of 2013**, alongside a range of measures under a broader resource efficiency programme to drive waste reduction and re-use, working with businesses and other organisations across supply chains.
- Working closely with business to explore the **potential for responsibility deals in a number of sectors that would cover products and materials identified as having high embedded carbon**. On packaging, the Government intends to launch a consultation on increased recycling targets for packaging producers in the period 2013–17.
- Working to make **corporate reporting of greenhouse gas emissions** – which helps organisations to manage their emissions, and allows informed decisions about how a company is managing climate change risks – more widespread and consistent. Guidance was published in 2009 to help organisations with this process, and the Government will announce whether it intends to introduce regulation in this area later in 2011.

2.214 In addition, the **Waste and Resources Action Programme (WRAP)** works to help businesses realise the benefits of being more resource efficient, through partnerships and voluntary agreements. WRAP is focusing its work up the waste hierarchy to minimise waste production and associated greenhouse gas emissions. One priority for action is to tackle food waste and divert it from landfill, with a goal of aiming to reduce emissions associated with avoidable food and drink waste by 3.2 $MtCO_2e$ by 2015.

2.215 One of the ways this will be achieved is through the **Love Food Hate Waste** initiative, which helps consumers to reduce avoidable food waste. Overall, WRAP achieved like-for-like savings of 5.5 $MtCO_2e$ per annum between 2008 and 2011.[116] WRAP's emissions target for the next period, from 2011–15, is for a further 4.8 $MtCO_2e$ per annum savings (excluding water savings).

Chart 31: The waste hierarchy



[116] From 1 April 2010 WRAP took on additional responsibilities for resource efficiency; therefore the figures quoted compare WRAP performance against original WRAP targets as set out at the beginning of the business plan period.

Reducing landfill methane emissions

2.216 **Over the next decade**, the Government's actions to reduce landfill methane emissions include the following:

- **The landfill tax**, which provides a financial incentive for local authorities and business waste producers to find alternative ways of handling their waste by gradually increasing the costs of landfill and which is the primary mechanism for reducing biodegradable waste to landfill. It was introduced in 1996 and set at £7 per tonne (for non-inert waste); it has increased to £56 per tonne and the Government has announced that it will continue to increase to £80 per tonne in 2014/15.

- A commitment in the Government Review of Waste Policy in England 2011[117] to a **consultation on restricting sending wood waste to landfill**. This is a significant source of biodegradable waste to landfill: on average, every tonne of wood waste diverted from landfill would save around 1 tonne of CO_2e.

- A **review of the case for restricting sending other wastes to landfill**, including textiles and all biodegradable waste, before the end of this Parliament.

2.217 Each of these measures will help to deliver emissions reductions **over the fourth carbon budget**:

- The continued increases to the landfill tax are projected to further reduce methane emissions from landfill to a projected 84% reduction from 1990 levels by 2025.

- Any restriction on sending wood to landfill would likely start reducing emissions during the third and fourth carbon budget periods, depending on how and when it were to be implemented.

- Any further restrictions on sending other waste to landfill would likely take effect – and start reducing landfill methane emissions – during the fourth carbon budget period.

2.218 The steps outlined in the Review of Waste Policy, plus the continued increases to the landfill tax, mean that the Government's central estimate of methane emissions from landfill in 2050 is that they will be around 61% below 2009 levels (see chart 32 below).

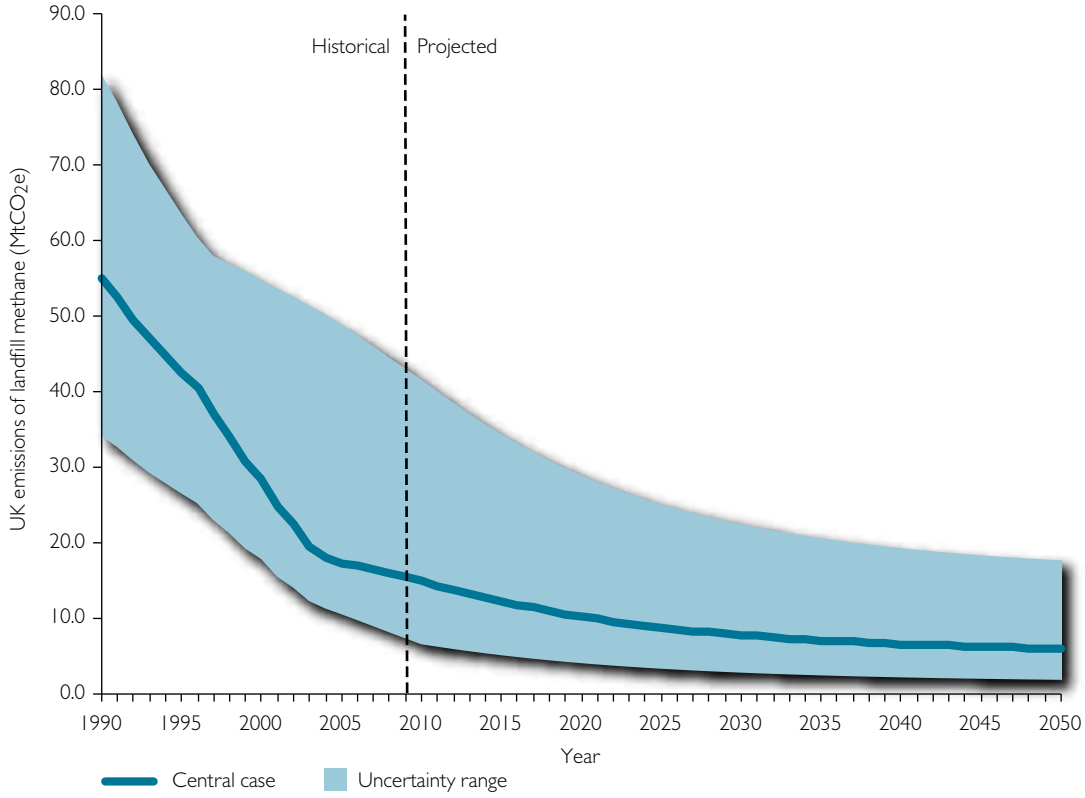
2.219 However, unlike energy-related emissions, methane emissions from landfill are modelled, not measured. Calculations of total emissions from landfill are therefore very sensitive to the amount of methane that is assumed to be captured at landfill sites. While there has been a substantial investment programme in methane capture technology over the last two decades, the precise rate of methane capture remains highly uncertain and could potentially be lower than assumed. This is reflected in the uncertainty range in chart 32, which shows estimated emissions in 2050 of between 1.7 and 17.6 $MtCO_2e$ (equal to reductions of 96.9% and 68.1% respectively from the 1990 central case scenario).

2.220 In addition, the volume of waste generated, the rate of change of this volume and the composition of the waste are dynamic, and experience has shown that these are difficult to model accurately over longer time frames. Developments in key variables such as economic growth, commodity markets, consumption patterns, consumer attitudes and behaviours, and waste treatment technology mean that there are markedly different pathways for how the UK waste system could evolve to 2050.

2.221 The Government is keen to improve the accuracy of modelling projections and has put in place a programme of action to help improve our scientific understanding of both landfill methane formation and the amount of methane that is captured. This includes a survey of landfill sites, taking actual measurements of methane emission,

[117] See: www.defra.gov.uk/publications/files/pb13540-waste-policy-review110614.pdf

Chart 32: Historical and projected emissions of methane from landfill, 1990–2050



Source: UK Greenhouse Gas Inventory and government analysis

oxidation and capture. The results of the survey will inform further opportunities for capturing more methane at landfill sites.

2.222 In addition, the Government is undertaking an ongoing programme of work in conjunction with the Environment Agency (EA) to improve the scientific understanding of landfill methane generation and capture rates at landfill sites. The Government is also committed to working closely with industry and the EA to continue reductions in the amount of methane emitted from landfill sites. This work will explore opportunities to capture methane from closed sites that do not have infrastructure for capturing landfill gas, and resulting improvements to methane capture rates could deliver emissions savings as early as the second carbon budget period.

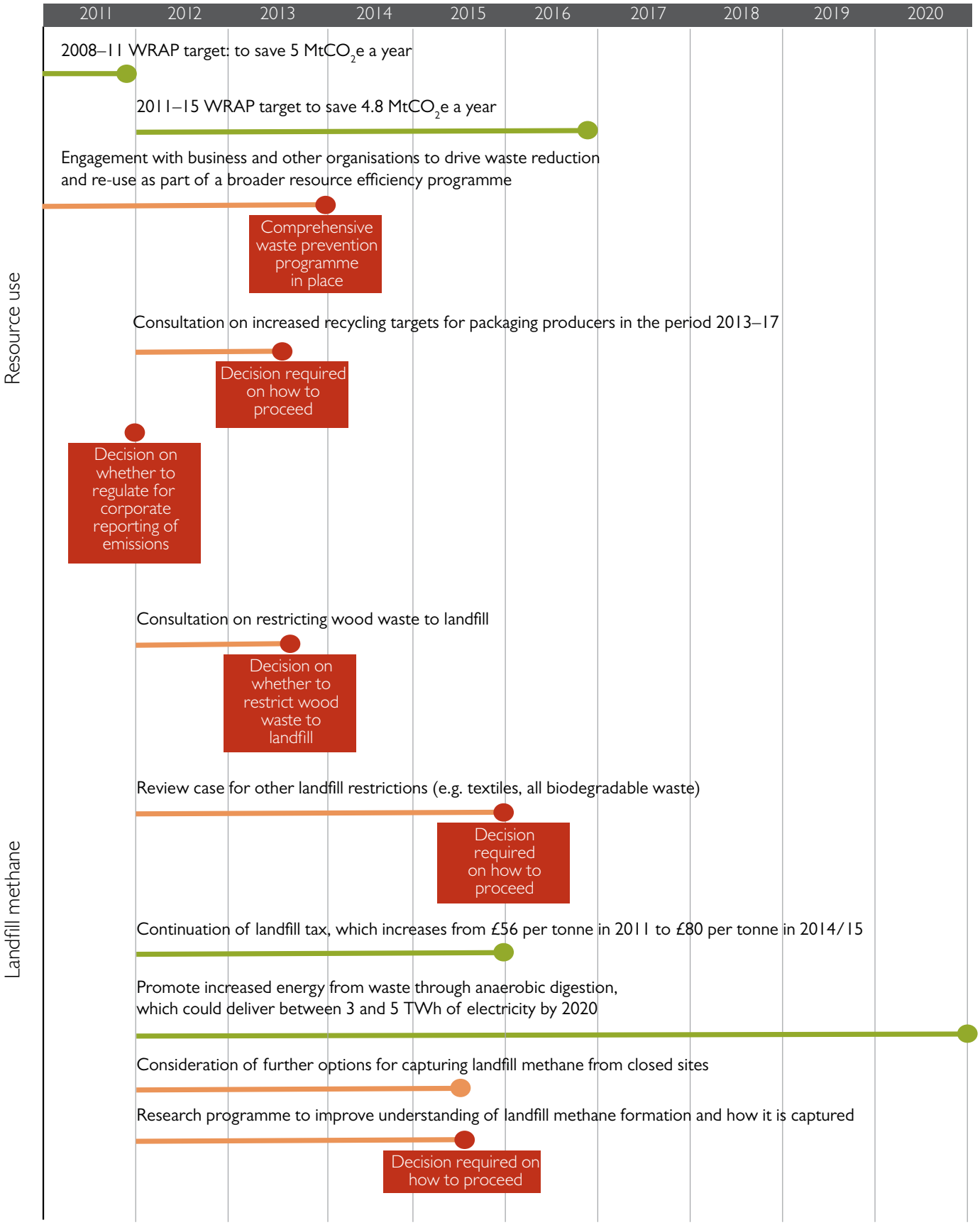
Energy from waste

2.223 The Government's aim is to get the most energy out of waste, not to get the most waste into energy recovery. Through effective prevention, re-use and recycling, residual waste will eventually become a finite and diminishing resource. However, until this becomes a reality, efficient energy recovery from residual waste can deliver environmental benefits and provide economic opportunities.

2.224 Efficient energy recovery from waste prevents some of the negative greenhouse gas impacts of waste in landfill and helps to offset fossil fuel power generation. **Over the next decade**, the Government is taking forward a range of measures through the Review of Waste Policy Action Plan and the *UK Renewable Energy Roadmap*[118] to overcome barriers to deployment of energy from waste through a range of existing and more innovative technologies.

[118] DECC (2011) *UK Renewable Energy Roadmap*. Available at: www.decc.gov.uk/assets/decc/11/meeting-energy-demand/renewable-energy/2167-uk-renewable-energy-roadmap.pdf

Chart 33: Decision points for waste to 2020



Next steps

2.225 The actions set out in the Review of Waste Policy, at each level of the waste hierarchy, will all contribute to reducing the volume of material that ends up in landfill and tackle emissions from the sector.

2.226 The challenge for the Government is how to move beyond the existing trajectory to deliver the vision of a zero waste economy. It is likely that further action will be needed, working closely with local government, industry, civil society, consumers and communities, if the goals are to be achieved. The Government will continue to review how the measures outlined are contributing to the zero waste economy vision and identify areas where we can go further and faster.

Working with the EU and Devolved Administrations

The European Union

2.227 The UK's policies should be seen in the context of the European Union's (EU's) wider objective of transition to a low carbon, resource efficient and climate resilient economy and its political commitment to reduce carbon emissions by at least 80% by 2050, while maintaining secure and affordable energy supplies and preserving the EU's international competitiveness. The interconnected nature of Member States' trading and energy supply relationships means that much of the change needed to achieve these objectives will need to be delivered at the EU as well as the national level.

2.228 The EU has the opportunity to demonstrate to others the benefits of low carbon growth, and to strengthen economic and trading relationships with other countries that want to collaborate on low carbon development. Strong EU leadership will be crucial in building momentum internationally and, by making the transition to a sustainable low carbon economy, the EU can significantly enhance its long-term economic and energy security interests. The Government will work with its partners in Europe to look for opportunities to secure the transition to an EU low carbon economy, encouraging greater ambition in areas including energy, transport, product standards and finance.

2.229 The Prime Minister and the Government are fully committed to increasing the EU's emissions reduction target from 20% to 30% by 2020 compared with 1990 levels. This should act as a means of showing its commitment to the longer-term vision of a sustainable low carbon economy, and driving the investment in new technologies necessary to achieve the level of change that this would require. The Government will share with other Member States evidence which shows that the costs of greater ambition are manageable and can deliver tangible economic and environmental benefits, especially when compared with a scenario of delayed action.

2.230 The Government will work with its European partners to build support for policies to promote energy efficiency, and facilitate investment in new energy infrastructure (with significant investment in low carbon infrastructure) and decarbonisation of transport through development of electric and other low carbon vehicles, as part of the delivery of these ambitious plans.

Northern Ireland

2.231 The Northern Ireland Executive is committed to tackling climate change and to building a sustainable low carbon economy that will bring prosperity for all. By demonstrating leadership, the Executive will inspire business, industry, the public sector and individuals to work together to help reduce UK emissions by 80% below 1990 levels by 2050.

2.232 The Executive views the transition to a low carbon economy as a potentially powerful driver of economic growth, and is committed, through its Sustainable Development Strategy,[119] to build a dynamic, innovative economy that delivers the prosperity required to tackle disadvantage and lift communities out of poverty. The Strategy sets strategic objectives to increase the number of jobs in the low carbon economy; increase the energy efficiency and resource efficiency of businesses; and ensure that our provision of learning and skills responds to the needs of the low carbon economy.

2.233 Although current projections suggest that Northern Ireland is ahead of its 2025 emissions reduction target, the Northern Ireland Environment Minister has pledged greater ambition and has tasked the Committee on Climate Change to consider the shape of further legislation to underpin longer-term targets.

2.234 The agriculture sector in Northern Ireland is an instrumental part of our low carbon future.

[119] See: www.ofmdfmni.gov.uk/index/economic-policy/economic-policy-sustainable-development.htm

It encompasses wider social and economic sustainability factors in addition to environmental considerations, playing a larger role in the local economy when compared with the rest of the UK. The government-led Greenhouse Gas Stakeholder Group is developing a range of primary production-focused mitigation measures based on a review of available scientific evidence to support the sector. A forthcoming strategy will focus on delivering a steady reduction trajectory up to 2020 and beyond. With improved measurement and inventories available from 2015, the sector will be able to prioritise actions to ensure that producers in Northern Ireland are at the forefront of demonstrating the sustainability of food production while ensuring their own business competiveness.

2.235 Within Northern Ireland, we are almost entirely dependent on imported fossil fuels for most of our energy needs. The Northern Ireland Energy Minister leads an Interdepartmental Working Group on Sustainable Energy to ensure a co-ordinated approach across government to the promotion of sustainable energy. Looking to 2050, we are seeking to shift the balance of our energy mix towards cost effective decarbonisation of our electricity supply as far as is practicable. The Executive's Strategic Energy Framework[120] seeks to achieve 40% of electricity consumption from both onshore and offshore renewable sources by 2020. The Offshore Renewable Energy Strategic Action Plan[121] sets out a target of at least 600 MW of offshore wind and 300 MW of tidal energy by 2020 and provides the framework for the current Northern Ireland Offshore Leasing Round. The draft Onshore Renewable Electricity Action Plan,[122] which has been subject to a Strategic Environmental Assessment, looks at potential onshore renewable energy mixes to contribute to that 40% target. In parallel, significant work is ongoing to underpin low carbon/renewables with an electricity infrastructure that is robust, flexible and able to respond to future demand for renewable energy and smart grids/demand-side management.

2.236 The Northern Ireland Executive believes that current transport arrangements and the high level of dependency on the private car, particularly in urban areas, are not sustainable. Active Travel promotes travel alternatives that lead to public health benefits through walking, cycling and reducing our reliance on the car. Travelwise engages with businesses, schools and commuters to promote and encourage sustainable modes of travel. Measures are already in place to reduce carbon intensity in road construction and maintenance, and to recycle construction materials and by-products where feasible. Translink, the main public transport provider, has started a major investment in techniques to reduce fuel use on its bus fleet. A revised Regional Transportation Strategy[123] proposes a range of high-level aims and strategic objectives that will inform how emissions will be reduced into the future. Consideration will also be given to new forms of transportation, such as light rail, and a pilot programme for electric vehicles is under way.

2.237 Northern Ireland has a unique geographical position in the UK. Given the unavoidable reliance on aviation and shipping, both in terms of the economy and wider social considerations, there is a need to ensure that transport-related carbon policy interventions developed at UK and EU level do not have a disproportionate and differential impact.

2.238 Social housing has already seen a significant drive to improve energy efficiency, as this is a key component in reducing not only carbon emissions but also rates of fuel poverty. Other pressures in the private residential sector, such as increased recycling and waste to landfill targets, planning policy and building regulations, and increased energy prices, will increase the need for improved energy efficiency. Behavioural changes and the availability of new renewable technology with condensed payback periods for householders will be key to reducing emissions. The Executive has set a target of a 10% increase in the amount

[120] See: www.detini.gov.uk/strategic_energy_framework__sef_2010_-3.pdf

[121] Following the recent completion of a Habitats Regulations Appraisal, the draft Plan is being finalised for publication. See: www.offshorenergyni.co.uk/data/draft_strategic_action_plan.pdf

[122] See: www.detini.gov.uk/deti-energy-index/draft_onshore_renewable_electricity_action_plan.htm

[123] See: www.drdni.gov.uk/rts_2011_consultation_document.pdf

of heat from renewable sources by 2020, supported by a Northern Ireland Renewable Heat Incentive.[124] In addition, natural gas roll-out continues to around 150,000 gas customers in Northern Ireland and, if greater gas roll-out were to follow, this would reduce emissions in a region where some 70% of energy consumers remain dependent on oil for their heating needs.

2.239 The Cross-Departmental Working Group on Climate Change will support sectoral initiatives by bringing together government departments to ensure that they are working towards a common goal, reporting annually to the Executive to ensure that they are on course to achieve set targets. The group will improve data sources and measurement, and accountability and governance, and strengthen the delivery framework through focused strategies and policies.

2.240 The Northern Ireland Executive is committed to creating a low carbon future, ensuring that by 2050 Northern Ireland is economically competitive, socially prosperous and delivering an environmental legacy to be proud of.

Scotland

2.241 The Scottish Government is committed to the low carbon agenda over the long term. Scotland has a competitive advantage in attracting low carbon jobs, investment and trade which will drive economic growth. Through our world-leading Climate Change (Scotland) Act 2009, we have provided certainty for business and the public about Scotland's low carbon future.

2.242 The Scottish Government believes that decarbonisation of electricity supply, heat use and transport will be key to meeting Scotland's emissions targets, particularly those in the 2020s and beyond. This should be achieved without resorting to new nuclear generation development.[125] Increasing the amount of available clean electricity will be important in lowering the carbon intensity of other sectors of the Scottish economy, notably heat and transport which, as they reduce their reliance on gas, petrol and diesel, will increasingly draw on electricity for power.

2.243 To create a transition to a low carbon economy, continuing development and deployment of technologies that enable more efficient use of the energy we produce will also become increasingly important.

2.244 The two cornerstones of energy supply transition in Scotland are renewables and carbon capture and storage (CCS). The Scottish Government believes that Scotland is well placed to take a leading role in the development and commercialisation of renewables and CCS[126] into the 2020s, and has targeted developing renewable generation in Scotland to be equivalent to 100% of demand by that time.[127]

2.245 Heat makes up about half of all energy demand and is integrally linked to the Scottish Government's aims to improve energy efficiency. The target to provide 11% of heat demand from renewables by 2020 is the platform for renewable heat to play an increasingly significant role in the following decades. The Scottish Government is taking a number of steps to assist the penetration of heat-based technologies in future years.[128]

2.246 Progress towards a decarbonised road transport system by around 2030 will continue, as will efforts to develop more sustainable communities which encourage active travel and other positive travel choices. Digital technologies offer the prospect of an overall reduction in travel demand, while freight policy will continue to encourage more sustainable goods movement.

[124] See: www.detini.gov.uk/the_development_of_the_northern_ireland_renewable_heat_incentive.pdf

[125] The UK Government works in partnership with the Devolved Administrations in Northern Ireland, Scotland and Wales to deliver the targets set by the Climate Change Act 2008. While the administrations have a shared goal of reducing the impacts of climate change, policies on how to achieve this vary across the administrations – the Scottish Government, for example, is opposed to the development of new nuclear power stations in Scotland. It believes that renewables, fossil fuels with carbon capture and storage, and energy efficiency represent the best long-term solution to Scotland's energy security.

[126] Scottish Government (2010) *Carbon Capture and Storage – A Roadmap for Scotland*. Available at: www.scotland.gov.uk/Publications/2010/03/18094835/0

[127] Scottish Government (2011) *2020 Routemap for Renewable Energy in Scotland*. Available at: www.scotland.gov.uk/Publications/2011/08/04110353/0

[128] Scottish Government (2009) *Renewable Heat Action Plan for Scotland: A plan for the promotion of the use of heat from renewable sources*. Available at: www.scotland.gov.uk/Publications/2009/11/04154534/0

2.247 Indications are that fuel prices are likely to increase further over the next decade. Improving the energy efficiency of the homes and heating of those at risk from fuel poverty will therefore continue to be a vital part of the Scottish Government's efforts to reduce emissions and increase energy security. A strategic group will co-ordinate stakeholder input into the delivery on commitments on sustainable housing and help to develop a Strategy for Sustainable Housing in Scotland.

2.248 It is not just the impacts of climate change itself that can have particular consequences for remote, rural and island communities, but also the effects of measures intended to reduce emissions. It will be important to ensure that, in moving to a low carbon economy, the differential impacts of policies on these communities are fully considered and tailored, and flexible solutions found for the future.

Wales

2.249 The Welsh Government remains fully committed to leading and delivering meaningful action to tackle the causes and consequences of climate change. The *Climate Change Strategy for Wales*, published in 2010, confirms its commitment to drive down emissions and sets out the action it will take in specific sectors.[129] The Welsh Government is now taking forward work to deliver on its commitments, and solid progress has been achieved since the Strategy's publication.

2.250 The Strategy confirms the Welsh Government's principal target to reduce greenhouse gas emissions in areas of devolved competence by 3% a year from 2011 against a baseline of average emissions between 2006 and 2010. The Welsh Government is also committed to achieving at least a 40% reduction in all emissions in Wales by 2020 against a 1990 baseline. The Strategy confirms a range of sector specific emissions reduction targets in the following areas: transport, agriculture and land use, waste, residential, public and business.

2.251 The Welsh Government's approach to tackling climate change is managed as part of its wider agenda on sustainable development. The Welsh Government is one of only a few administrations in the world that has a legal duty in relation to sustainable development. As a result, its approach focuses on enhancing people's quality of life, both now and in the future. This principle has informed the selection of measures it has adopted to reduce emissions as the action it is taking to ensure that Wales is well prepared to manage the consequences of a changing climate.

2.252 An example of this is *arbed*, the Welsh Government's flagship strategic energy efficiency programme. By the end of the first phase of *arbed* earlier this year, the scheme had provided £30 million of funding for energy efficient homes, skills and long-term jobs. As a result, at least 6,000 homes have benefited from the *arbed* scheme to date.

2.253 The second phase of *arbed* shares the same objectives as the first phase, but, in order to fulfil EU funding requirements, the delivery model will be adjusted. The first set of project proposals for the second phase of *arbed* will be reviewed by the end of 2011.

2.254 Over the next five years, Nest, the Welsh Government's fuel poverty scheme, is expected to help up to 15,000 households a year in Wales with advice and home energy improvements to reduce their fuel bills, maximise their income and improve the energy efficiency of their homes. Around 4,000 households a year are expected to receive energy improvement packages.

2.255 The three key elements of the Welsh Government's energy policy – energy savings and efficiency, low carbon energy generation and the maximisation of long-term job opportunities for Wales – will ensure that it makes the most of Wales' potential and the predicted investment. Ultimately, the goal is to place Wales at the forefront of the drive towards a low carbon energy economy.

[129] Welsh Government (2010) *Climate Change Strategy for Wales*. Available at: http://wales.gov.uk/topics/environmentcountryside/climatechange/tacklingchange/strategy/walesstrategy/?lang=en

2.256 Wales has the potential annually to produce up to 40 TWh of electricity from renewable sources by 2025, with 25% of this from marine, 50% from wind (both offshore and onshore), and the majority of the remainder secured from sustainable biomass power or smaller local (including micro) heat and electricity generation projects using wind, solar, hydro or indigenous biomass.

2.257 Practical measures include the *Ynni'r Fro* programme, which supports investment in community-scale energy generation projects and gives practical and financial support for installers to gain Microgeneration Certification Scheme accreditation.

2.258 To date, Wales has some 830 MW of renewable energy operational, which represents a doubling in renewable energy operating capacity since 2007. This capacity represents enough electricity to power almost a half a million homes in Wales.

2.259 If the Welsh Government is to deliver its emissions reduction targets, every sector and community in Wales will need to contribute. Consequently, it is working with the Climate Change Commission for Wales and other delivery partners to help achieve this.

2.260 The Welsh Government's approach, set out in its Climate Change Engagement Strategy published earlier this year,[130] focuses on enabling people to act, and providing the tools at a national level which makes action at the local level effective. The Welsh Government will:

- provide the vision of a low carbon future, which will inspire action at all levels;
- develop the capacity for action at the local level; and
- provide the evidence base to inform and focus action.

2.261 To support its engagement work in this area, the Welsh Government launched the Support for Sustainable Living grant scheme in March 2011, which funds engagement on climate change and will also help to develop capacity within Wales to produce demonstrable outcomes from this engagement. It has also enabled access to expert advice and support for delivery and evaluation through its Support for Sustainable Living service. The combination of grant funding and expertise is already enabling local action across Wales.

2.262 In terms of delivery of the Climate Change Strategy itself, the Welsh Government is putting in place a comprehensive monitoring framework to measure the progress it is making on meeting its emissions reduction targets. To do this, it is developing a suite of indicators to track implementation of each of the measures contained in the Delivery Plan for Emission Reduction[131] to ensure that they are delivering the anticipated emissions savings. This framework is consistent with that being developed by the UK Government for monitoring progress against its own carbon budgets.

2.263 The Welsh Government will also be monitoring external factors that drive emissions, such as wider economic performance, so that its performance in delivering its specific commitments can be reported in its annual report early in 2012 within the context of wider emissions trends.

[130] See: http://wales.gov.uk/docs/desh/publications/111102engagementen.pdf

[131] See: http://wales.gov.uk/docs/desh/publications/101006ccstratdeliveryemissionsen.pdf

Part 3: Delivering the fourth carbon budget

Scenarios to deliver the fourth carbon budget

3.1 Part 2 has set out the potential for each sector of the economy to deliver emissions reductions over the fourth carbon budget period. As the Government's approach is to encourage a portfolio of technologies in each sector, there is uncertainty about the exact level of emissions reductions that will be delivered over the fourth budget period. In this part of the report we set out a series of illustrative scenarios that combine different levels of emissions from all sectors of the economy in order to deliver the fourth carbon budget.

3.2 As well as delivering the fourth carbon budget, these scenarios would all put us on track to deliver the 2050 target (as illustrated in the 2050 futures in Part 1).

Delivering non-traded sector emissions reductions

3.3 The non-traded sector consists of those sectors of the economy not covered by the European Union Emissions Trading System (EU ETS). The level of emissions required in the non-traded sector is 1,260 million tonnes carbon dioxide equivalent ($MtCO_2e$) over the fourth budget period, in order to meet the overall budget of 1,950 $MtCO_2e$. This section considers four illustrative scenarios showing how emissions could be reduced to meet this 1,260 $MtCO_2e$ level in the non-traded sector. Further details on these scenarios can be seen at Annex B.

3.4 In these scenarios we focus on those areas that have the most potential to contribute to emissions reductions over the fourth budget period, in line with our vision to 2050. These include:

- replacing inefficient heating systems with more efficient, sustainable ones;
- ensuring a step-change in our move towards ultra-low carbon vehicles, such as electric vehicles; and
- ensuring that our homes are better insulated to improve their energy efficiency.

3.5 In the scenarios that follow, we flex the level of deployment and consequent emissions expected from these major sectors. Other sectors, such as industry and agriculture, are also assumed to deliver additional emissions reductions. However, given their relatively small impact on the fourth carbon budget, we do not flex the amount delivered by these sectors in the scenarios.

Scenario 1: High abatement in low carbon heat

3.6 This scenario assumes a very high level of emissions reductions from the uptake of low carbon heat in buildings and industry, along with significant emissions reductions from other sectors. The scenario would deliver emissions of 1,253 $MtCO_2e$ in the non-traded sector over the fourth carbon budget period.

3.7 This scenario assumes that:

- around 8.6 million low carbon heat installations have been deployed in buildings by 2030, in domestic, commercial and public buildings, delivering 165 terawatt hours (TWh) of low carbon heat, and a further 38 TWh from heating networks;
- significant improvements to the thermal efficiency of buildings, including completing most cavity wall and loft insulations by 2020 and insulating up to 5.2 million solid walls by 2030; and
- average fuel efficiency of new cars and vans in 2030 of 60 gCO_2/km and 90 gCO_2/km respectively, and sustainable biofuel penetration of 8% through the 2020s.

Scenario 2: High abatement in transport and bioenergy demand

3.8 This scenario assumes a very high level of emissions reductions from transport and bioenergy, with comparatively lower reductions from low carbon heat. This scenario reflects a situation where bioenergy is plentiful, with sustainability concerns addressed effectively and technological innovation leading to more advanced feedstocks becoming viable. Significant uptake of ultra-low emission vehicles is driven by increased consumer demand following reductions in cost or improvements in range, or strong policy drivers such as an EU-wide car and van emissions target. The scenario would deliver emissions of 1,248 $MtCO_2e$ in the non-traded sector over the fourth carbon budget period.

3.9 Scenario 2 assumes:

- average fuel efficiency of new cars and vans in 2030 at 50 gCO_2/km and 75 gCO_2/km respectively, and sustainable biofuel penetration of 10% in 2030;
- approximately 7.2 million low carbon heat installations in buildings by 2030, delivering 138 TWh of low carbon heat, and a further 10 TWh from heating networks; and
- significant improvements to the thermal efficiency of buildings, including completing most cavity wall and loft insulations by 2020 and insulating up to 5.2 million solid walls by 2030.

Scenario 3: Focus on high electrification

3.10 This scenario assumes the very high levels of emissions reductions in both low carbon heat (as in Scenario 1) and transport (as in Scenario 2), alongside comparatively lower emissions reductions from domestic energy efficiency upgrades and lower uptake of biomass in industry. This scenario might reflect a situation where consumer acceptance of new technologies, such as electric or hydrogen fuel cell vehicles, and low carbon heat installations, is high, or where exogenous factors, such as high fossil fuel prices, drive a consumer search for low carbon alternatives. Although a situation where low carbon heat installations are deployed in homes that already have insulation would clearly be most cost effective, this scenario represents the possibility of consumer reluctance to take up solid

wall insulation. Finally in this scenario, bioenergy supply is constrained (perhaps due to sustainability concerns), leading to a prioritisation of its use in industry rather than transport and buildings. The scenario would deliver emissions of 1,249 $MtCO_2e$ in the non-traded sector over the fourth carbon budget period.

3.11 This scenario assumes:

- around 8.6 million low carbon heat installations in buildings by 2030, delivering 165 TWh of low carbon heat, and a further 38 TWh from heating networks;
- average fuel efficiency of new cars and vans in 2030 at 50 gCO_2/km and 75 gCO_2/km respectively, and sustainable biofuel penetration of 10% in 2030; and
- most cavity wall and loft insulations completed by 2020 and up to 2.5 million solid walls insulated by 2030.

Scenario 4: Purchase of international credits

3.12 Under this scenario, some effort to hit the 2050 target is delayed until the 2030s and 2040s, with a lower level of emissions reductions over the fourth budget period. This scenario would require greater action (and therefore potentially higher costs) during later decades in order to remain on track to hit the 2050 target. Emissions over the fourth carbon budget period would be reduced to 1,345 $MtCO_2e$ in the non-traded sector, above the 1,260 $MtCO_2e$ budget level.

3.13 This scenario shows that achieving relatively lower levels of abatement in both low carbon heat **and** transport could necessitate the Government relying on other flexibility mechanisms under the Climate Change Act in order to meet the fourth carbon budget. In this scenario, the Government would need to purchase around 85 $MtCO_2e$ worth of carbon credits. At the forecast carbon price of £32/tCO_2e (average over the fourth budget period), this would cost the Government £2.7 billion. This cost will be at least partly offset by the lower cost of delivering less abatement in heat and transport. Alternatively or in addition to buying credits, the Government could bank over-achievement from earlier carbon budgets or borrow forwards from the fifth carbon budget.

3.14 This scenario assumes:

- 1.6 million low carbon heat installations in buildings by 2030, delivering 83 TWh of low carbon heat – achieved through roll-out of a portfolio of heat pumps and biomass boilers in domestic, commercial and public buildings – and a further 10 TWh from heating networks;[132]
- significant improvements to the thermal efficiency of buildings, including most cavity wall and loft insulations completed by 2020 and up to 4.5 million solid walls insulated by 2030; and
- in transport, average fuel efficiency of new cars and vans in 2030 of 70 gCO_2/km and 105 gCO_2/km respectively, and 6% penetration of biofuels in 2030.

[132] In scenario 4, our modelling shows mainly commercial installations take up low carbon heat, with a large heat load per installation. In scenario 1, most of the additional installations come from domestic-level heat pumps and biomass boilers, with smaller heat loads per installation.

Delivering traded sector emissions reductions

3.15 The level of emissions reductions in the traded sector is dictated by the level of the EU ETS cap. In this section we will look at two illustrative scenarios showing how traded sector emissions could be reduced. In both scenarios, the level of emissions reductions in the UK would be sufficient to fall within an EU ETS cap of 690 $MtCO_2e$. This is the level currently assumed for the fourth carbon budget period. However, this will be reviewed in 2014, as set out in the 'Achieving carbon budgets' section on page 21. As a consequence, under these scenarios UK businesses covered by the EU ETS would be net sellers of EU ETS allowances. Both scenarios have been modelled under a central assumption of electricity demand and an assumption of high electricity demand. Further details on these scenarios can be seen at Annex B.

Scenario A: Power sector carbon intensity of 50 gCO_2/kWh

3.16 Under this scenario, emissions over the fourth carbon budget period would be reduced to 592–596 $MtCO_2e$ in the traded sector (based on central and high electricity demand respectively – see Annex B for more detail).

3.17 This scenario assumes that emissions in the power sector are reduced significantly. To illustrate this, we have modelled a situation where the carbon intensity of generating electricity falls to 50 gCO_2/kilowatt hour (kWh) by 2030. The 'Secure, low carbon electricity' section on page 69 sets out further detail on the implications of this scenario for the generation mix. Since this scenario reduces emissions to well below the required 690 $MtCO_2e$ level, it would leave UK businesses in the EU ETS with 94–98 $MtCO_2e$ worth of surplus EU ETS allowances that could be sold to others, generating £4.8–5.0 billion at the forecast carbon price of £51/tCO_2e, or banked for future use.

Scenario B: Power sector carbon intensity of 100 gCO_2/kWh

3.18 Under this scenario, emissions over the fourth carbon budget period would be reduced to 626–629 $MtCO_2e$ in the traded sector (based on central and high electricity demand respectively – see Annex B for more detail).

3.19 Scenario B assumes that emissions in the power and heavy industry sectors are reduced, but at a lower level in the power sector than that assumed in Scenario A. This illustrative scenario assumes that the carbon intensity of electricity generation falls to 100 gCO_2/kWh by 2030. In this scenario, emissions are still reduced sufficiently to meet the 690 $MtCO_2e$ level, leaving UK businesses in the EU ETS with 61–64 $MtCO_2e$ worth of surplus EU ETS allowances that could be sold to others, generating £3.1–3.3 billion at the forecast carbon price of £51/tCO_2e, or banked for future use.

Considerations for achieving the fourth carbon budget

3.20 In developing the scenarios presented in this report, the Government has explored and taken into account the wider impacts on the UK economy that this range of decarbonisation could produce, as well as weighing up costs and benefits. In this section, we set out these considerations in brief; Annex B provides further detail.

Managing uncertainty

3.21 The current EU ETS Directive sets a cap on net emissions from the power and industry sectors for the whole EU, and this cap shrinks by a fixed amount each year from 2013 to ensure that overall emissions reductions are delivered in these sectors across the EU. The Government will review the EU ETS trajectory in early 2014. If at that point our domestic commitments place us on a different emissions trajectory to the EU ETS trajectory agreed by the EU, we will, as appropriate, revise our budget up to align it with the actual EU trajectory. Before seeking Parliamentary approval to amend the level of the fourth carbon budget, the Government will take into account the advice of the Committee on Climate Change (CCC) and any representations made by the other national authorities. A change in the EU ETS cap will not change the level of emissions reductions required outside of the EU ETS.

3.22 While it is not possible to speculate now on what the EU ETS cap will be in the future, we can consider some examples of what it might be, to analyse the potential implications. If the legislation setting out the trajectory of the EU ETS cap is not changed, then the UK cap on emissions in the traded sector over the fourth budget period could be around 860 $MtCO_2e$ and we could amend the fourth carbon budget to a level of 2,120 $MtCO_2e$ (1,260 $MtCO_2e$ in the non-traded sector plus 860 $MtCO_2e$ in the traded sector). Under the two scenarios in the traded sector outlined above, this would mean UK businesses covered by the EU ETS having a greater number of surplus EU ETS allowances to sell – 264–268 $MtCO_2e$ in Scenario A and 231–234 $MtCO_2e$ in Scenario B. The revenues raised from this surplus would depend on the carbon price, which is likely to be a lower price than a scenario where the EU ETS cap is lower. Alternatively, the Government could decide to decarbonise at a slower rate, resulting in lower surplus EU ETS allowances, although this would have implications for the pace of decarbonisation required in later carbon budgets to reach the 2050 target.

3.23 On the other hand, we are pushing strongly for the EU to move to a more ambitious target for 2020. As an example, if the EU agreed to a target to reduce emissions by 30% from 1990 levels by 2020, this could potentially mean a tighter EU ETS cap which reduces the cap on traded sector emissions to 590 $MtCO_2e$.[133] In this instance, the fourth carbon budget could be amended to 1,850 $MtCO_2e$ (1,260 $MtCO_2e$ in the non-traded sector and 590 $MtCO_2e$ in the traded sector). Scenario A would result in emissions falling to 592–596 $MtCO_2e$, 2–6 $MtCO_2e$ above the required level. UK-based businesses covered by the EU ETS would therefore need to buy corresponding EU ETS allowances. Scenario B would result in emissions in the traded sector falling short of the 590 $MtCO_2e$ required in the traded sector by 36–39 $MtCO_2e$ and UK-based businesses under the EU ETS would need to purchase EU ETS allowances. In these scenarios, the price of allowances would be likely to be greater due to the tighter EU ETS cap.

Domestic action and international credits

3.24 The Climate Change Act allows credits purchased from overseas to be used for compliance with UK carbon budgets. A limit on how many credits can be bought in any given carbon budget period must be set 18 months before the start of that period. As announced in May 2011, the Government intends to reduce emissions domestically as far as is practical and affordable. However, keeping open the option of

[133] This assumes that the tighter EU ETS cap agreed as part of an EU deal on moving to a 30% target would continue at the same rate of reduction beyond 2020.

trading is prudent in order to retain maximum flexibility in minimising costs in the medium-to-long term.

3.25 As explained in Part 2, emissions projections suggest that we will reduce emissions to below the level of the first three carbon budgets, and this over-achievement could in theory be banked for later use.[134] It is not government policy to rely on over-achievement in a given carbon budget to help meet future carbon budgets, or to factor it into future plans and there are two reasons why this is a sensible approach. First, the UK is pushing Europe to adopt a more ambitious 2020 target and this would lead to tighter second and third carbon budgets, meaning that we would have less (or even no) over-achievement to bank. Second, there is significant uncertainty in projections – if emissions are higher than projected we may have little or no over-achievement.

3.26 While we are aiming to meet future carbon budgets without counting on any over-achievement in previous carbon budgets, we do see a role for banking to provide flexibility for short-term adjustments and smoothing of unexpected fluctuations in emissions and as a contingency for unexpected events. We are therefore not ruling out the use of banking at this stage and may look to bank any over-achievement into future carbon budgets to maintain this contingency to manage uncertainty. Any future decisions on banking will need to be taken in the light of EU and international decisions.

Costs of meeting the fourth carbon budget

3.27 The fourth carbon budget scenarios have been developed taking into account a number of factors:

- static cost effectiveness – comparing the estimated cost of a measure with the forecast carbon price for the same time period;
- dynamic cost effectiveness – considering what action needs to be taken in the fourth budget period to be on track to meet the 2050 target in the most cost effective way;
- technical feasibility – taking account of likely technological development and necessary build rates; and
- practical deliverability and public acceptability – considering potential barriers to delivery.

3.28 As explained in the 'Achieving carbon budgets' section on page 21, the Government already has a robust policy framework in place to meet the first three carbon budgets that will continue to deliver emissions reductions over the fourth budget period. The total net present cost over the lifetime of the policies included in the current policy package is estimated at £9 billion (excluding the value of greenhouse gas (GHG) emissions savings in the non-traded sector). Including the value of GHG savings in the non-traded sector results in the package delivering a net benefit, on central estimates, of £45 billion.[135] The fourth carbon budget is not expected to lead to any additional costs over the course of this Parliament. Beyond that, the cost of meeting the fourth carbon budget will depend on the policies that are implemented over the coming decade.

3.29 The Impact Assessment on the level of the fourth carbon budget explained how an 'early action' pathway – where greater emissions reductions are made early on – is more likely to be cost effective than an emissions pathway that leaves greater levels of emissions reductions to later years.[136] Over the fourth budget period, this

[134] The Climate Change Act allows banking and borrowing and this offers a further flexibility mechanism in meeting our carbon budgets. Banking is where the Government reduces emissions to below the level of the carbon budget and 'banks' the savings into future carbon budgets, making them easier to meet. Borrowing is where the Government takes part of a future carbon budget and brings it forward to cover higher emissions in the current carbon budget period. No more than 1% of the future carbon budget can be borrowed and the future carbon budget is reduced (i.e. made tougher to meet) by the same amount as is borrowed. Before banking or borrowing the Government must obtain and take into account the views of the CCC and Devolved Administrations.

[135] Excludes EU ETS.

[136] The Impact Assessment is available at: www.decc.gov.uk/media/viewfile.ashx?filetype=4&filepath=What%20we%20do/A%20low%20carbon%20UK/Carbon%20budgets/1685-ia-fourth-carbon-budget-level.pdf&minwidth=true. Further detail on the economic benefits of early action is set out at Annex B.

may require implementing some measures that might not be cost effective when considering the fourth carbon budget alone, but would support a more efficient transition to meeting the 2050 target.[137] Doing so is likely to avoid higher costs in the longer term for a number of reasons. For instance, early innovation can help to bring new technologies to market and drive down costs, as well as avoiding expensive lock-in to sub-optimal transition technologies. Our current evidence suggests that the net cost of meeting the fourth carbon budget ranges from £26 billion to £56 billion (excluding the value of the reduction in greenhouse gas emissions).[138] This includes the costs and benefits over the lifetime of the measures (which often stretches well beyond the fourth budget period), discounted to today's prices. When the benefits of the carbon savings that will be delivered by our scenarios are also taken into account, the net present value ranges from a net benefit of £1 billion to a net cost of £20 billion.

3.30 Action to meet the fourth carbon budget can be achieved without large impacts on overall economic output. The macro impact of meeting the fourth budget level is estimated to be an average cost of around 0.6% of GDP a year over the period 2023–27 (the average cost of meeting the first three carbon budgets is estimated at around 0.4% of GDP a year). This compares favourably with the expected cost of not tackling global climate change (see Annex B for more detail). For example, the Stern Review (2006) estimated the cost of not tackling climate change to be between 5% and 20% of global GDP.

3.31 Importantly, the modelling results do not account for the benefit of tackling global climate change, which will lead to future changes in temperature and shifts in precipitation patterns. This benefit includes avoiding risks to future UK growth.

3.32 Annex B provides further details on the breakdown of costs for the non-traded sector Scenarios 1–4 and traded sector Scenarios A and B, and an explanation of how we have combined scenarios to produce the cost estimates above. The costs quoted above are subject to significant uncertainty given the range of assumptions we need to make about the evolution of future economic growth, fossil fuel prices and technology costs so far out into the future. Sensitivity analysis of fossil fuel price and technology cost assumptions shows that the overall costs of delivering the fourth carbon budget could vary significantly. See box 10 overleaf for more detail on sensitivities.

3.33 This uncertainty highlights the need to continue to appraise costs and abatement potential as the evidence base evolves. The Government will continue to draw up detailed impact assessments for individual policies before they are introduced, to assess as accurately as possible the costs and benefits of the specific policies necessary to deliver carbon budgets.

3.34 In addition, the portfolio approach outlined earlier in this report ensures that the Government retains the flexibility to achieve a cost effective transition: if costs do not fall as fast as we have assumed in one sector, we would have to rely on greater savings from other sectors in order to meet the fourth carbon budget.

[137] More information on the cost effectiveness of the abatement potential considered for the fourth carbon budget scenarios can be found at Annex B.

[138] The costs of delivering the fourth carbon budget scenarios will depend on how the traded and non-traded sectors are combined. Scenarios 1–4 in the non-traded sector imply different levels of electricity demand. To understand the cross-economy picture it is important to combine these with the traded sector scenario that best reflects the implications for electricity demand from levels of electrification in the transport and heat sectors. For example, Scenario 3, which includes high levels of electrification in heat and transport, has the effect of increasing electricity demand by about 10% in 2030. This scenario is compatible with either traded sector Scenario A or B under high electricity demand. Levels of abatement in Scenario 4 suggest that Scenario A or B under central demand would be more appropriate.

Box 10: Case study on transport costs

The fourth carbon budget scenarios have been modelled on the basis of assumptions about the improvement to fleet average new car and van CO_2 emissions. This improvement could be delivered by a number of different vehicle mixes, all of which will have different cost implications. The costs also depend heavily on the assumptions we make regarding factors such as technology costs, fossil fuel prices and the rebound effect (where people drive more as cars become more efficient and therefore cheaper to drive). For example, under central assumptions, **Scenario 3** in the non-traded sector has a net present value (NPV) of **–£2 billion** (i.e. a net cost). But this number could vary widely under different assumptions:

- Battery costs today are reported up to around $1,000/kWh. In our analysis we assumed battery costs falling to $300/kWh in 2030. If battery costs were lower in 2030 – $150/kWh (compared with the CCC's assumption of $200/kWh) – then the NPV of Scenario 3 would be £7 billion (i.e. a net benefit). If battery costs only came down to $800/kWh then the NPV of Scenario 3 would be –£36 billion (i.e. a net cost).
- In respect of fossil fuel prices, our analysis was based on the Government's central view of fossil fuel prices. However, under high fossil fuel price assumptions, Scenario 3 would have an NPV of £4 billion (i.e. a net benefit), whereas under low fossil fuel price assumptions the NPV of Scenario 3 could be –£10 billion.
- We believe that a rebound effect from more efficient vehicles is likely. However, if we were to assume no rebound effect then Scenario 3 would have a zero NPV (i.e. the benefits would roughly equal the costs), as the additional costs associated with the rebound effect, such as increased congestion, would be avoided.

These are all individual effects – in reality, a number of the assumptions could differ from our central forecasts, meaning that the scale of change to the cost numbers could be greater still.

Innovation

3.35 Innovation will be crucial to delivering the cost reductions we expect to see in technologies (such as ultra-low emission vehicles) that are critical to delivering the fourth carbon budget. This innovation will transform UK infrastructure to support the transition to a low carbon economic base. The long-term certainty provided to business by carbon budgets is a necessary but not sufficient factor in ensuring that investment in innovation takes place: success in this area over the coming years will depend on the policies that are implemented.

3.36 The Government directly supports innovation through measures that support the research, development and demonstration (RD&D) of low carbon technologies. In the 2010 Spending Review, the Department of Energy and Climate Change was allocated over £150 million to support innovation in energy generation and demand-side technologies. Programmes for innovation in offshore wind (£30 million), marine energy (£20 million) and buildings (£35 million) have already been announced and, subject to value for money assessments, these will be launched in the coming months. Together with other innovation funding streams, total public funding for low carbon energy innovation delivered by members of the Low Carbon Innovation Group (LCIG) will amount to over £800 million during the Spending Review period.[139]

3.37 The Government also indirectly supports innovation by creating long-term, credible markets

[139] LCIG comprises representatives of the Department of Energy and Climate Change, the Department for Business, Innovation and Skills, the Carbon Trust, the Energy Technologies Institute, the Technology Strategy Board and the Research Councils.

for low carbon technologies and by removing barriers to their uptake, giving businesses and industry the confidence to invest in RD&D. The EU ETS and Electricity Market Reform in the power sector, or EU new vehicle emissions standards in the transport sector, are examples of policies which seek to create long-term certainty in markets.

3.38 Low carbon innovation also creates opportunities for UK businesses to capture a greater share of the global low carbon market. This market was worth more than £3.2 trillion in 2009/10 and is projected to reach £4 trillion by 2015 as economies around the world invest in low carbon technologies across a broad range of sectors. The UK share of the market was more than £116 billion in 2009/10, and could be much larger.[140] The Government provides support for UK businesses to maximise these opportunities and grow their low carbon exports, in particular through UK Trade & Investment's Green Export Campaign and services for business.

Cost, price and bill impacts and competitiveness

Direct impacts

3.39 A key factor when delivering the fourth carbon budget is understanding the potential impact on consumers, businesses and industry through energy prices and bills. Some policies, such as home energy efficiency measures or improving process efficiency in industry, can help to reduce bills. Today, the bulk of increases in domestic energy bills have been caused by the rise in wholesale gas prices, with costs of climate change and energy measures only contributing a small proportion of the overall increase. See box 11 below for more details. The Government is committed to keeping these impacts under review and updated estimates of the impact of policies on energy prices and bills will be published alongside future Annual Energy Statements.

Box 11: Energy bill impacts

Alongside the Annual Energy Statement on 23 November 2011, the Department of Energy and Climate Change published a comprehensive updated assessment of the estimated impacts of energy and climate change policies on energy prices and bills.[141] This covers policies and proposals put forward by the previous Government, as well as changes to those policies and new policies announced by the current Government. Only those policies in place or that have been planned to a sufficient degree of detail (i.e. with quantified estimates of costs and benefits) have been included in the modelling. It does not estimate the impacts of scenarios to meet the fourth carbon budget as the policy mechanisms to deliver these have yet to be determined. The key messages were:

- Recent increases in energy bills have been largely driven by rising international prices for fossil fuels, particularly gas, and not by energy and climate change policies. Energy bills are likely to continue on an upward trend over time, with or without policies, due to rising fossil fuel prices and network costs.
- Government policies are estimated to be adding just 2% on average to a typical household energy bill in 2011, compared with a bill in the absence of policies. By 2020 households will, on average, save money (£94 or 7%)[142] on their energy bills compared with what they would have paid in the absence of policies. The impact of policies in helping people to save energy, or use it more efficiently, is expected to more than offset the impact that policies delivering low carbon investment will have on energy prices.

[140] BIS (2011) *Low Carbon and Environmental Goods and Services Report for 2009/10*. Available at: www.bis.gov.uk/assets/biscore/business-sectors/docs/l/11-992x-low-carbon-and-environmental-goods-and-services-2009-10

[141] See: www.decc.gov.uk/en/content/cms/meeting_energy/aes/impacts/impacts.aspx

[142] Real 2010 prices.

Box 11: Energy bill impacts *(continued)*

The UK ranks well internationally for household energy prices. When compared with the EU 15, UK consumers have faced the lowest domestic gas prices for the last three years (2008–10) and the third or fourth lowest electricity prices for the past two years.

The impact of policies on energy bills for businesses is typically larger than for households because households are supported by a greater number of energy efficiency policies than are available for the business sector. For most businesses, however, direct energy costs are a relatively small proportion of total costs. For example, in 2009 purchases of energy and water accounted for around 2.7% of total costs for the UK manufacturing sector. This means that a 10% rise in direct energy costs increases total costs by just 0.27%. In contrast, employment costs represented around 20% of total manufacturing sector costs in 2009.

Businesses that are medium-sized users of energy currently face energy bills that are on average 18% higher as a result of policies. By 2020 the impact of policies is estimated to be 19%.

Businesses that are large energy-intensive users – where energy costs represent a significant proportion of their total operating costs – face varying impacts depending on, among other things, their mixture of gas and electricity use, the extent to which they consume on-site generated electricity (exempt from a number of policy costs, such as the Renewables Obligation) and their ability to use their buying power to negotiate lower prices. Policies are estimated to be adding 3–12% to energy bills for these users in 2011 and between 2% and 20% in 2020.

Average UK gas prices for all sizes of industrial users have been the lowest in the EU 15 since mid-2009. UK electricity prices have historically been similar to the EU 15 median for both medium and large industrial users.

The estimated impact of policies on household and business energy bills has fallen since the previous analysis that the Department of Energy and Climate Change published in July 2010. This reflects, among other things, the Coalition Government's proposals on Electricity Market Reform (EMR), the Green Deal and proposed new cost effective levels of support for large-scale renewable electricity, as well as the decision to make a £40 million saving in 2014/15 on spending for the small-scale Feed-in Tariffs scheme. It also reflects the decision to fund the Renewable Heat Incentive from general taxation rather than through a levy on fossil fuel suppliers, and to consider several alternative funding options for the Government's CCS commitments rather than through their own levy.

3.40 The Government is paying careful attention to distributional impacts of the transition to a low carbon economy. We are working to ensure that consumers are able to find information that allows them to compare and switch suppliers to get the best deals. In the domestic sector we are particularly conscious of lower income households at risk of fuel poverty. The Government is taking a range of actions, through mechanisms such as the Warm Home Discount Scheme and Winter Fuel Payments, to ensure that vulnerable households are protected.

3.41 In the business sector, increased costs as a result of higher energy prices and climate change and government policies represent a potential challenge for energy-intensive industries. The Government recognises these issues, and the difficulties some face in remaining internationally competitive while driving down domestic emissions. Therefore, in addition to the measures set out in the 2011 Budget, the Government is taking steps to reduce the impact of policy on the cost of electricity for energy-intensive industries whose international competitiveness is most

affected by energy and climate change policies, and to support energy-intensive industries in becoming more energy efficient, where it is cost effective for them to do so.

3.42 In the short term, cost effective energy and resource efficiency measures can deliver both economic and environmental gains. The Carbon Trust found that a 35% improvement in the energy efficiency of UK buildings by 2020 would realise over £4 billion worth of benefits. Such energy efficiency measures could also stimulate activity in the construction sector where lack of effective demand is seen as the immediate constraint on growth. The Government continues to explore the opportunities presented by the low carbon transition and to help UK businesses to capitalise on these. The UK has a comparative advantage in traditional environmental goods and services such as recycling and water treatment, for example, and the strongest growth areas (both in terms of sales and employment) in the environmental goods and services sector are emerging sectors such as wind, solar, photovoltaics and carbon finance.

3.43 In the longer term, establishing credible and consistent long-term commitments through the carbon budget framework helps to reduce uncertainty about the strength of the market for green alternatives, improving incentives for innovation. The low carbon transition will also increase UK resilience to volatility in international fossil fuel prices and the negative impacts on the economy that these can create. The macro economic implications of the transition are considered in more detail at Annex B.

Indirect impacts – carbon leakage

3.44 Not all other countries have yet matched the scale of the UK's low carbon ambitions. There is a risk that imposing relatively higher costs on domestic producers of energy-intensive goods, through climate change policies, will lead companies to consider shifting production and investment to regions of the world with less stringent environmental policies. This potential for 'carbon leakage' is a concern. There is no advantage – either to the UK economy or for global emissions reductions – in businesses relocating to countries where emissions continue unabated.

3.45 There are a number of options to manage the risk of carbon leakage. For instance, in the EU Emissions Trading System, which requires significant reductions from the power and heavy industry sectors, the risk of leakage is addressed and largely mitigated through the provision of free allowances to sectors that are considered to be at risk of leakage. Thus heavy industry is provided with an incentive to reduce emissions, without risks to competitiveness.

Energy security

3.46 There are three different, linked challenges that relate to security of electricity supply:

- **diversification of supply:** how to ensure that we are not over-reliant on one energy source or technology;
- **operational security:** how to ensure that, moment to moment, supply matches demand, given unforeseen changes in both; and
- **resource adequacy:** how to ensure that there is sufficient reliable capacity to meet demand, for example during winter anticyclonic (high pressure) weather conditions when demand is high and wind generation low for a number of days.

3.47 Increasing our sources of low carbon generation as we meet the carbon budgets will help to address the first challenge, though higher levels of intermittent generation potentially increase the second and third challenges. In addition, by 2020 the UK could be importing nearly 50% of its oil and 55% or more of its gas.

3.48 Our strategy for meeting the carbon budgets takes these impacts into account – more detail can be found in the 'Secure, low carbon electricity' section on page 69 and at Annex B.

Sustainability

3.49 The Government's strategy for meeting the fourth carbon budget takes into account wider

impacts on sustainability (including potential biodiversity considerations in relation to changes in land use for bioenergy, and the cumulative and indirect environmental impacts of a range of changes to our future energy mix). These impacts are considered in more depth at Annex B.

Consumption emissions

3.50 Finally, the focus of UK climate change policy is on the production of emissions. The Government recognises that the 'consumption' perspective – which accounts for all the emissions produced globally to support UK consumption (including emissions in other countries as a result of the production of goods that we import into the UK) – is increasingly important.

3.51 The Government is working to better understand the impact of consumption emissions. This includes annual monitoring of total emissions associated with UK consumption,[143] and analysis of where these emissions occur and which products they are associated with.[144] This evidence will be used to help inform and target a range of actions including support for UK businesses to measure and reduce emissions throughout their supply chains, and the standards and labelling schemes which apply to products on the UK market.

Managing our performance

3.52 Ensuring delivery of the emissions reductions necessary to deliver carbon budgets requires a robust framework to track progress and flag when issues or policy changes mean that we risk going off track.

3.53 The Climate Change Act provides an effective system of legal accountability. The independent Committee on Climate Change (CCC) publishes an annual report in which it scrutinises the Government's progress in meeting carbon budgets. The Government has to lay a response to the points raised by the CCC before Parliament by 15 October each year. The statutory requirement to produce a report on policies after a new budget has been set also forms part of the accountability regime under the Climate Change Act. This report meets that obligation for the fourth carbon budget.

3.54 In addition, the Government published the draft Carbon Plan in March 2011 to provide further transparency and accountability about the key actions that each government department and the Devolved Administrations are taking in each sector during the lifetime of this Parliament.[145] Annex C updates the Carbon Plan action summary milestones, including those that relate to the flagship actions in each sector set out in Part 2 of this document. These therefore assist Parliament and the public in assessing whether the Government is making sufficient progress in achieving the actions necessary to deliver carbon budgets.

3.55 All departments that lead or have an impact on the majority of policies that affect emissions are held accountable for delivery through a framework of regular monitoring and reporting against their actions and indicators of progress.[146] The wider actions of all government departments are kept

[143] Embedded Carbon Emissions Indicator: http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&ProjectID=17729&FromSearch=Y&Publisher=1&SearchText=emissions%20indicator&SortString=ProjectCode&SortOrder=Asc&Paging=10#Description

[144] UK Consumption Emissions by Sector and Origin: http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&ProjectID=17718&FromSearch=Y&Publisher=1&SearchText=consumption%20emissions&SortString=ProjectCode&SortOrder=Asc&Paging=10#Description

[145] See: www.decc.gov.uk/en/content/cms/tackling/carbon_plan/carbon_plan.aspx

[146] These are the Department for Business, Innovation and Skills, the Department for Environment, Food and Rural Affairs, the Department for Communities and Local Government, the Department for Transport, the Department of Energy and Climate Change and HM Treasury.

under review, with particular attention paid to new initiatives that may have a knock-on effect on emissions. The Government as a whole then reports progress against the actions in the Carbon Plan on a quarterly basis via the Number 10 website, to support Parliament and the public in holding the Government to account.