Review of the Fourth Carbon Budget - Call for Evidence

www.theccc.org.uk/call-for-evidence

Response from the Centre for Energy Policy and Technology, Imperial College London (ICEPT)

August 2013

Prepared by Dr Robert Gross, Phil Heptonstall, Jamie Speirs and Becky Mawhood.

Dr Robert Gross

Director, Centre for Energy Policy and Technology

Imperial College London SW7 1NA

robert.gross@ic.ac.uk

ABOUT ICEPT

ICEPT is an interdisciplinary research centre focused upon the interaction of technology and policy. From its base at Imperial College, the centre is uniquely placed to gather insights into technological and scientific developments relevant to contemporary debates in energy policy. The centre also has policy analysis expertise, drawing upon a wide range of system modelling, scenario and technology assessment techniques. ICEPT runs the Technology and Policy Assessment function of the UK Energy Research Centre (UKERC). The reports it produces have been widely cited in papers and reports, from select committees and in policy documents.

This submission draws upon a forthcoming UKERC meta-analysis of estimates of the costs of wind, gas, nuclear, solar and CCS undertaken by ICEPT. This draws upon expertise developed by the authors into the relative costs/performance of various technologies through a wide range of research projects going back to the early 2000s. This submission also draws on UKERC reports on the potential of carbon capture and storage, the costs of offshore wind in UK waters and work for the EU Joint Research Centre on gas resources, as well as wider sources.

Question and Response form

When responding please provide answers that are as specific and evidence-based as possible, providing data and references to the extent possible. Please limit your response to a maximum of 400 words per question.

Questions for consideration:

A. Climate Science and International Circumstances

The Committee's advice assumes a climate objective to limit central estimates of temperature rise to as close to 2°C as possible, with a very low chance of exceeding 4°C by 2100 (henceforth referred to as "the climate objective"). This is broadly similar to the UNFCCC climate objective, and that of the EU.

In order to achieve this objective, global emissions would have to peak in the next few years, before decreasing to roughly half of recent levels by 2050 and falling further thereafter.

The UNFCCC is working toward a global deal consistent with such reductions, to be agreed by 2015. Earlier attempts (e.g. at Copenhagen in 2009, before the fourth budget was recommended or legislated) have failed to achieve a comprehensive global deal to limit emissions.

It is difficult to imagine a global deal which allows developed countries to have emissions per capita in 2050 which are significantly above a sustainable global average, implying the need for emissions reductions in the UK of at least 80% from 1990 levels by 2050.

The EU has not yet agreed a package beyond 2020, but the European Commission is consulting on a range of issues relating to development of climate and energy targets for 2030. In its 2011 Roadmap for moving to a competitive low-carbon economy, the Commission suggested a reduction in emissions of 40% on 1990 levels by 2030, as being on the cost-effective path to an 80-95% reduction by 2050. The UK Government has signalled its support for a 40% reduction by 2030, and for an increase to 50% in the context of a global deal.

China has made ambitious commitments to 2020 which would, if delivered, cut carbon-intensity relative to GDP by around 45%.

The United States could achieve its Copenhagen Accord commitment to reduce emissions by 17% on 2005 levels without the need for further federal legislation.

The Committee on Climate Change
1st Floor,
7 Holbein Place,
London SW1W 8NR
Tel: 0207 591 6262 Fax: 0207 591 6180 www.theccc.org.uk

Question 1: ***Does the scientific evidence justifying the climate objective remain the same as in 2010? In particular, is there new evidence on climate change impacts?***
No response.

Question 2 ***Have the emissions pathways consistent with achieving this objective changed? In particular, is there new evidence on climate sensitivity to emissions?***
No response.

Question 3 ***Does the climate objective remain in play given international developments? Has the likelihood of getting global agreement changed significantly since the budget was set, and if so why?***
No response.

Question 4 ***How have the prospects for a new EU package for 2030 changed since the Committee's advice and the setting of the budget? What implications do the latest expectations have for the fourth carbon budget?***
No response.

Question 5 ***What flexibilities are appropriate to reflect possible future changes***

in EU and international circumstances?
No response.

B. Technology and economics

In recommending the level of the fourth carbon budget, the Committee developed scenarios which embodied cost-effective emissions reductions to meet the 2050 target.

These scenarios, set out in detail in the Committee's report *The Fourth Carbon Budget – Reducing emissions through the 2020s*, include substantial investment in low-carbon power generation, roll-out of low-carbon heat (heat pumps and district heating), development of the markets for ultra-low emissions vehicles and a combination of energy efficiency measures and fuel switching in industrial sectors.

They were based on official emissions projections together with an assessment of the cost and feasibility of abatement options. Since 2010, official emissions projections have been significantly reduced in the industry and waste sectors, meaning that meeting the legislated 4th carbon budget would require less effort than originally envisaged.

Question 6 ***Is there any new evidence to suggest that the type of scenarios upon which the budget was based are no longer feasible or cost effective?***
Our response focuses on future cost estimates for power sector technologies. We are also concerned about the slow deployment of some technologies, the impacts of which are outlined in our response to question 8. We draw on a forthcoming UKERC publication written by the authors and colleagues, *Presenting the Future* (Gross et al., Forthcoming), which considers the role and importance of electricity cost estimates for policymakers and the energy industry, and the methodologies employed to forecast future costs. The UKERC review demonstrates that there is clear evidence that the cost of electricity generation can fall as deployment rises – but the evidence also suggests that cost reductions may not follow a smooth downward trajectory (Gross et al., Forthcoming). Both the potential for cost reduction and the level of uncertainty about

the pace and scale of cost reductions vary considerably between power generation technologies (ibid). Since the mid-2000s the estimated cost of all technologies has increased significantly (with the exception of solar PV) (Figure 1), but many contemporary forecasts anticipate a return to cost reductions in the coming years and decades (Figure 2). The UKERC review discusses the reasons cost projections made in the early 2000s turned out to be optimistic. It notes that more recent analyses demonstrate a trend towards improved 'appraisal realism', with many studies taking more explicit account of the uncertainties inherent in forecasting costs (ibid.).

The prospects for on-going cost reductions are highly dependent on the specific characteristics of individual technologies (Gross et al., Forthcoming). The evidence reviewed by UKERC demonstrates that technologies which are relatively new to widespread application, modular and have scope for mass production and technological innovation are more likely to achieve ongoing cost reductions. Cost reductions may be more difficult to realise in technologies which are inherently complex, need to achieve economies at the project-level and are subject to a greater regulatory burden. The review also highlights the uncertainties around cost reduction and potential for a range of factors either wholly exogenous (world events, commodity prices) or largely unrelated to 'learning' (market/price factors, supply chain constraints) to overwhelm cost reductions through innovation and mass production or scale effects.

Policy has an important role to play in achieving cost reductions. The need to support innovative technologies until they reach competitive commercial maturity is widely accepted. Support for technologies in the early stages of commercial deployment should be on the understanding that technological developments enabling cost reductions (and gradual removal of support) will be realised. Such an approach has been successfully initiated with the UK offshore wind industry. In 2011 DECC's estimate for the LCOE of offshore wind was £174/MWh (Arup, 2011), yet the 2013 strike price has been set at just £155/MWh (DECC, 2013) and the industry is aiming to substantially reduce costs over the next decade (The Crown Estate, 2012). Policymakers must beware of pushing deployment of innovative technologies too fast, since this too can increase costs at least in the short run (Watson et al., 2012, Greenacre et al., 2010). Technical progress and costs should be closely monitored, and ambitions set out over a time period that is appropriate to the task. We argue for example that targets for offshore wind should extend beyond 2020 (Greenacre et al., 2010).

UKERC's review indicates that costs are both more uncertain and in some cases likely to be higher in the 2020s than was assumed in the CCC central scenarios. The

CCC's (2010) analysis of sensitivity to capital costs being 25% higher than their central case medium investment scenario goes a considerable way towards allowing for the cost escalations and uncertainties described in our review. However our analysis suggests that the CCC (2010) estimates of the costs of nuclear and coal CCS could still be rather low in comparison to estimates of contemporary costs and some estimates of costs in the 2020s. On the other hand the costs of some technologies appear to be falling more rapidly than was expected (for example PV) and/or to have been anticipated well in 2010 (wind). For all technologies the literature shows a considerable range of cost projections out to 2030, in other words there remains a fair amount of uncertainty about how costs will turn out. It is not clear therefore whether anything revealed in UKERC's review *fundamentally* changes the conclusions drawn by the CCC in their analysis in 2010. In particular it is unlikely that the macro-economic impacts of decarbonising the power sector will change very much, if at all, relative to the estimates presented by the CCC in their 25% higher capital cost scenario. However we would recommend that the model runs undertaken in 2010 are redone using the latest estimates of electricity generation cost and indeed costs in other sectors. This will ensure that the changes in both recent outturns and expectations of future costs reviewed by UKERC are fully factored into the CCC's analysis of the fourth budget period.

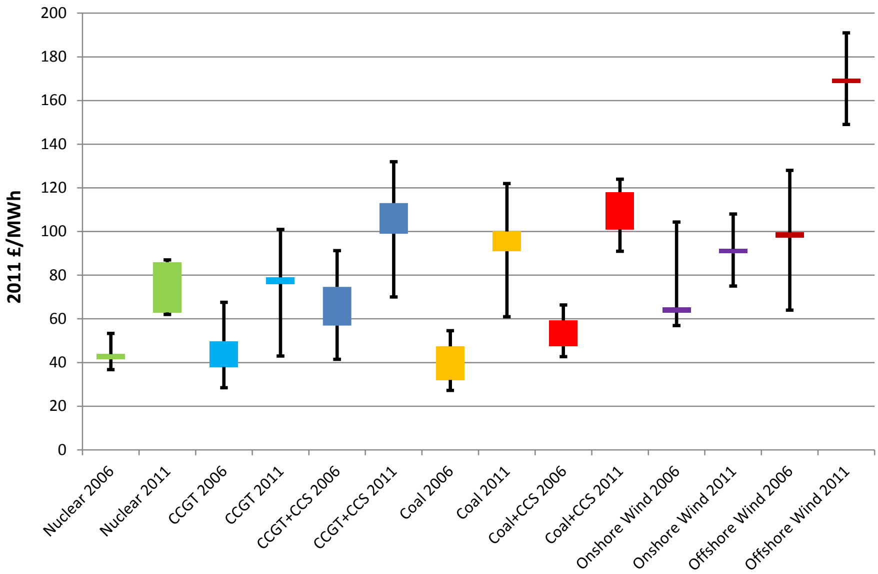

Figure 1 Comparison of 2006 and 2011 cost estimates. Source: Gross et al. (Forthcoming).
Note: The cost analyses on which this chart is based typically calculate a range of levelised costs based on a central set of assumptions and an extended range based on wider variations in the input parameters. In Figure 1 the central assumptions are represented in the coloured blocks and extended range in the black lines extending from each block. The exceptions are the 2011 entries for onshore and offshore wind which reflect the low, medium and high estimate approach adopted in the Arup 2011 analysis.

Figure 2 LCOE estimates, in-year mean and UK-specific forecasts (UKERC analysis). Source: Gross et al. (Forthcoming).

Note: The historic contemporary estimates are shown in the left-hand data series and the forecasts are shown in the right-hand data series. Trend lines are shown as solid lines for contemporary estimates, and as dotted lines for the forecast data. Note that all values are converted and inflated to 2011 GBP using historic exchange rate data from the Bank of England spot exchange rate against £ sterling and annual average long run inflation data from the UK Office of National Statistics.

References:

ARUP 2011. Review of the generation costs and deployment potential of renewable electricity technologies in the UK. Study Report for DECC. London: Department of Energy and Climate Change.

DECC 2013. Electricity Market Reform: Delivering UK Investment. London: Department of Energy and Climate Change.

GREENACRE, P., GROSS, R. & HEPTONSTALL, P. 2010. Great Expectations: The cost of offshore wind in UK waters – understanding the past and projecting the future. London: UKERC Technology and Policy Assessment Function.

GROSS, R., HEPTONSTALL, P., GREENACRE, P., CANDELISE, C., JONES, F. & CASTILLO CASTILLO, A. Forthcoming. Presenting the Future: An assessment of future costs estimation methodologies in the electricity generation sector. London: UKERC Technology & Policy Assessment Function.

The Committee on Climate Change
1st Floor,
7 Holbein Place,
London SW1W 8NR
Tel: 0207 591 6262 Fax: 0207 591 6180 www.theccc.org.uk

THE CROWN ESTATE 2012. Offshore Wind Cost Reduction Pathways Study. London: The Crown Estate.
WATSON, J. E., KERN, F., GROSS, M., GROSS, R., HEPTONSTALL, P., JONES, F., HASZELDINE, S., ASCUI, F., CHALMERS, H., GHALEIGH, N., GIBBINS, J., MARKUSSON, N., MARSDEN, W., ROSSATI, D., RUSSELL, S., WINSKEL, M., PEARSON, P. & ARAPOSTHATHIS, S. 2012. Carbon Capture and Storage - Realising the potential? London: UKERC.

Question 7 ***In particular, does the possibility of shale gas in the UK change the economics of the fourth carbon budget?***

The US shale gas experience has generated interest in the potential to significantly reduce domestic gas prices in the UK through the exploitation of domestic shale gas resources. The US gas price fell significantly between 2006 and 2012, largely attributed to the increasing production of shale gas (Figure 3). There are several reasons that shale gas production created such a negative pressure on US gas prices. First, the pace of shale gas exploration and production was relatively unencumbered by environmental legislation and public opposition, due to low population density (Stevens 2012). Second, the onshore exploration and drilling industry in the US is highly mobile and well suited to quick development of hydrocarbon resources, largely due to the capacities built up through on-shore exploitation of conventional oil and gas (Stevens 2012; Rogers 2013). Third, the US had limited capacity to access other gas markets around the world through LNG export terminals or pipelines, limiting its ability to balance a glut in natural gas via international trade (Rogers 2013). These conditions are unlikely to hold true for the UK. The UK is more densely populated, which is likely to foster relatively greater public opposition, and has a host of environmental legislation and land ownership laws that are likely to impact on the pace and cost of shale gas development relative to the US. Europe is also less well-endowed than the US in terms of onshore exploration and production companies, drilling rigs, and other industry capacity (Stevens 2012). Finally, the UK is part of a larger and more interconnected gas market, with two-way LNG capacity and pipeline interconnection to Ireland, continental Europe and Scandinavia, making it easier to trade gas when domestic prices are low, mitigating any potential glut in the market. For these reasons it is less likely in the UK that shale gas production will produce a significant reduction in future domestic gas prices. The authors have reviewed the range of estimates for unconventional gas resources in Europe and internationally, and the factors that affect the economics and feasibility of production (McGlade et al 2012). Subsequent analysis by BGS and others has increased understanding of resources. However the uncertainty over a wide range of factors related to shale gas extraction remains large.

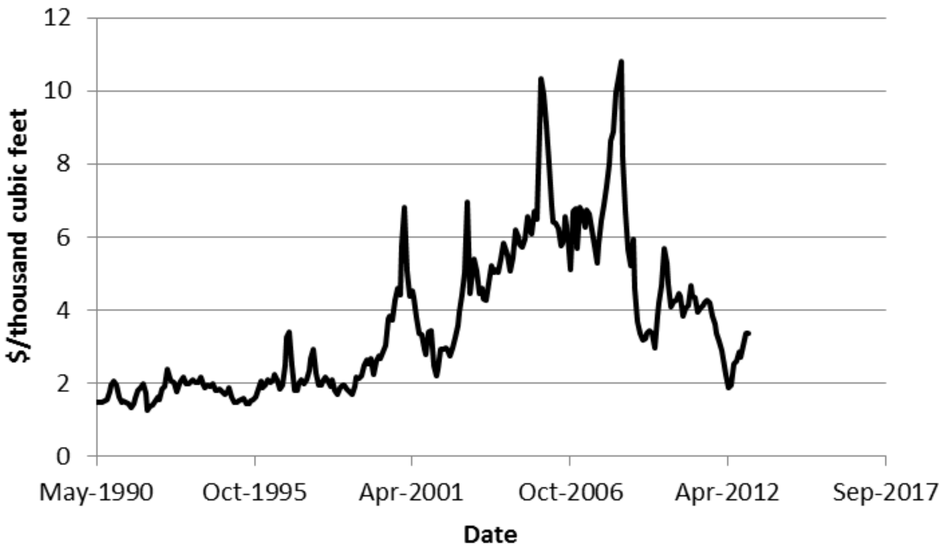

Figure 3: Historical US natural gas wellhead price in dollars per thousand cubic feet from 1990 to 2012. Source: EIA

The literature on future UK gas price scenarios suggests that future gas prices are unlikely to be significantly reduced through UK shale gas production. Figure 4 compares four different gas price scenarios over the period to 2030: the Fourth Carbon Budget price assumptions (CCC 2010); DECC scenarios published in 2012 and 2013 (DECC 2012; DECC 2013); and scenarios from a recent publication by Navigant, commissioned by DECC on the impact of unconventional gas on UK gas prices (Rathbone and Bass 2013). In Figure 4 the coloured area represents the range of scenarios from the low to the high price case. The black line represents the central case. In the Navigant scenarios, the central case assumes that Europe produces very little unconventional gas, though it does include rising exports of gas from the United States.

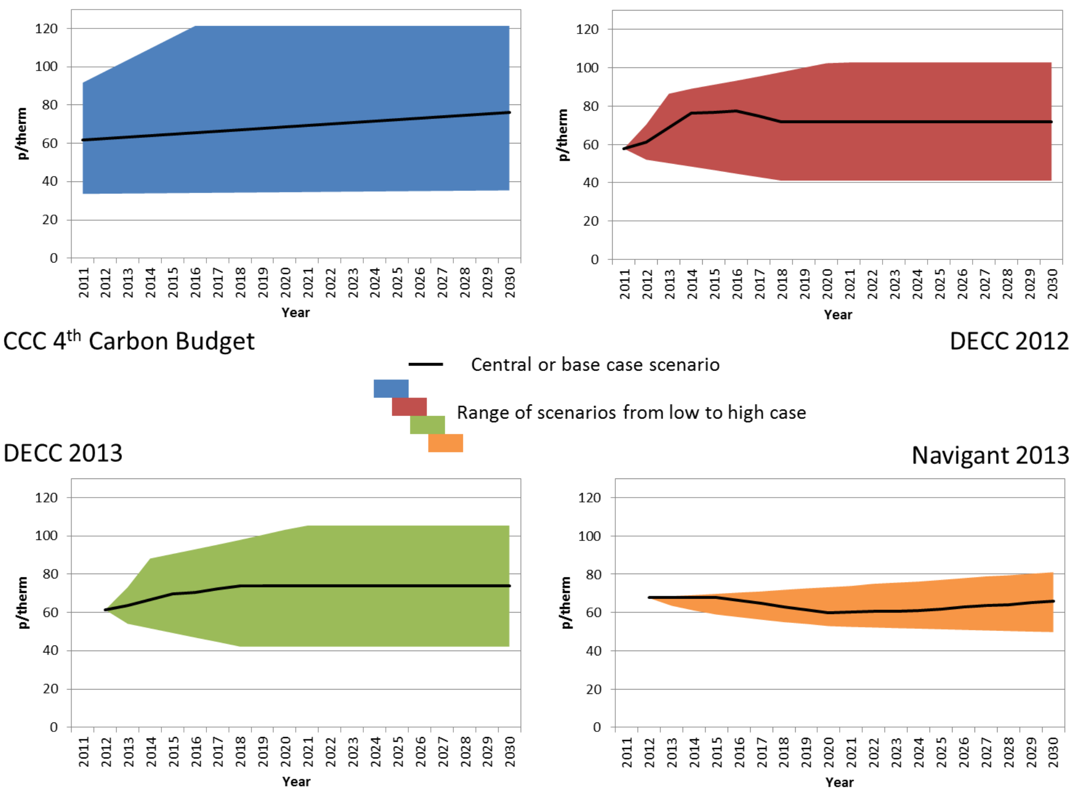

Figure 4: Comparison of four sets of UK natural gas price scenarios between 2011 and 2030 in pence per therm. Source: CCC (2010); (DECC 2013); (DECC 2012); (Rathbone and Bass 2013)
Notes: currency year varies with CCC (2010) in 2009 pence, DECC (2012) in 2011 pence, and DECC (2013) and Navigant (Rathbone and Bass 2013) in 2012 pence.

Figure 4 suggests that the range of uncertainty has reduced since the scenarios from 2010 and 2012 but that the central or base case scenarios have remained in the 60 to 70- pence per therm range. Indeed the average price of the four, relatively flat central scenarios in Figure 4 vary by only 8 pence per therm, with the lowest, Navigant, 7.4% lower on average than the CCC 2010 scenario between 2011 and 2030, and 13.5% lower in 2030. This modest variation can be considered in the context of historical gas prices, which have been as low as 10 pence per therm in recent decades, approximately 80% lower than the current UK natural gas price (Figure 5).

The Committee on Climate Change
1st Floor,
7 Holbein Place,
London SW1W 8NR
Tel: 0207 591 6262 Fax: 0207 591 6180 www.theccc.org.uk

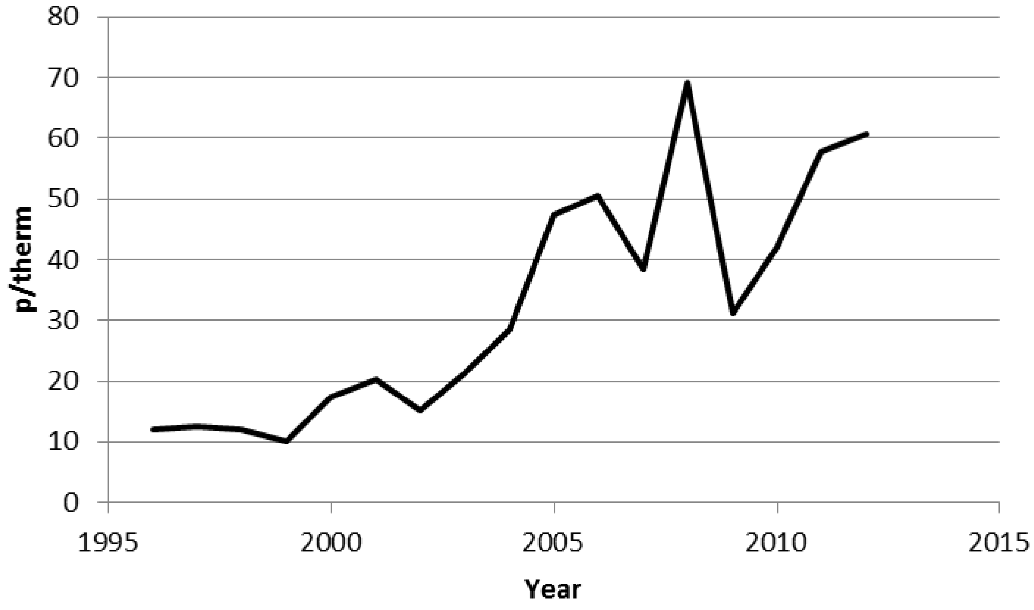

Figure 5: Historical UK National Balancing Point (NBP) natural gas prices between 1996 and 2012 in pence (2012) per therm. Source: BP Statistical Review of World Energy (BP 2013)
Notes: Based on Heren NBP index. Converted from dollars using 0.64 exchange rate as of 16th August 2013

In summary the Fourth Carbon Budget analysis considered a relatively wide range of future gas price assumptions when compared to more recent scenarios. There is also a relatively small variation in central gas price scenarios between those used by the CCC and the most recent price scenarios, including those that explicitly consider the impact of unconventional gas. It is therefore unlikely that the CCC's original recommendations regarding the Fourth Carbon Budget could be significantly altered on the basis of the evidence surrounding the economic implications of shale gas production in the UK.

References:

BP (2013). Statistical Review of World Energy.
CCC (2010). The Fourth Carbon Budget - Reducing emissions through the 2020s. London, Committee on Climate Change.
DECC (2012). DECC Fossil Fuel Price Projections. London, Department for Energy and Climate Change.
DECC (2013). DECC Fossil Fuel Price Projections. London, Department for Energy and Climate Change.
McGlade et al (2012) Unconventional Gas - A review of estimates. A working paper by Christophe McGlade, Jamie Speirs and Steve Sorrell, Sept 2012.

Rathbone, P. and R. Bass (2013). Unconventional Gas: The potential impact on UK Gas Prices, Navigant for DECC.
Rogers, H. (2013). UK Shale Gas - Hype, Reality and Difficult Questions, Oxford Institute for Energy Studies.
Stevens, P. (2012). The 'Shale Gas Revolution': Developments and Changes. London, Chatham House

Question 8 ***Should the budget be tightened to reflect headroom due to significantly lower emissions projections (e.g. due to slower than expected economic growth) since 2010?***

Although there is headroom, we do not believe that the Fourth Carbon Budget should be tightened. Policy stability is recognised as one of the most important drivers of private sector investment in renewable energy (Mitchell 2011). Increasing uncertainty in the policy environment could increase the policy and political uncertainties which investors already face, and which already threaten the timely achievement of the budget's aims. Policy related uncertainties increase the cost of decarbonisation by discouraging investment and thus slowing deployment (which itself tends to drive down costs, as discussed in question 6). To expedite deployment, policy frameworks need to bolster investor confidence - by identifying and addressing risks that the private sector would not tackle in the absence of intervention. This is the objective of the EMR CfDs and of direct support for CCS demonstration. It is also important for high level policies, such as longer term targets and goals, to sustain through time.

Whilst the economic situation has introduced a degree of headroom in the period since 2010 the development and deployment of key technologies has already been slower than expected (we are aware of delays in the deployment of key energy efficiency and transport technologies but focus here on power generation). In particular, it has proven difficult to deploy nuclear and CCS at the pace envisaged in 2010:

- The budget anticipated operation of the first new nuclear plants from early 2018. However development consent for Hinkley C was not granted until March 2013, and protracted negotiations between EDF and DECC over the level of support are ongoing. Construction and commissioning is expected to take 6 years, making operation before 2019 unlikely. Such delays may undermine the confidence of potential investors in other new plant, slowing the pace of nuclear deployment.

- The budget anticipated operation of up to four CCS demonstration projects from 2016, with the aim of fitting CCS to 18 GW of coal and 20 GW of CCGT during the 2020s. At the time of writing there is no firm agreement to fund a specific demonstration project – making operation in 2016 highly unlikely. CCS presents a difficult investment proposition compared with other electricity generation technologies, and investors have lacked confidence that mechanisms recognising its unique characteristics will be implemented within the timescales required (Watson, Kern et al. 2012). The delays to demonstration-stage CCS projects will have knock-on effects for commercial implementation.

It is not possible, or perhaps indeed appropriate, to quantify the 'balance' between the headroom created by the recession and the delays to the deployment of key low carbon options. However there is a strong theoretical and pragmatic argument for holding a line on the carbon targets in the face of unanticipated events. Doing so can help in sustaining investor confidence and facilitating the realisation of emissions reduction targets.

References:

Mitchell, C. (2011). Chapter 11: Policy, Financing and Implementation. IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation. Cambridge and New York, Cambridge University Press: pp. 865-950.

Watson, J. e., F. Kern, et al. (2012). Carbon Capture and Storage - Realising the potential? London, UKERC.

C. Other issues

As required by the Climate Change Act, in designing the fourth carbon budget we considered impacts on competitiveness, fiscal circumstances, fuel poverty and security of energy supply, as well as differences in circumstances between UK nations. Previous high-level conclusions on these were:

- **Competitiveness** risks for energy-intensive industries over the period to 2020 can be addressed under policies already announced by the Government. Incremental impacts of the fourth carbon budget are limited and manageable.

- **Fiscal impacts**. The order of magnitude of any fiscal impacts through the 2020s is likely to be small, and with adjusted VED banding and full auctioning of EU ETS allowances could be neutral or broadly positive.

- **Fuel poverty**. Energy policies are likely to have broadly neutral impacts on fuel poverty to 2020, with the impact of increases in electricity prices due to investment in low-carbon generation being offset by energy efficiency improvement delivered under the Energy Company Obligation. Incremental impacts through the 2020s are likely to be limited and manageable through a combination of further energy efficiency improvement, and possible income transfers or social tariffs.

- **Security of supply** risks due to increasing levels of intermittent power generation through the 2020s can be managed through a range of flexibility options including demand-side response, increased interconnection and flexible generation. Decarbonisation of the economy will reduce the reliance on fossil fuels through the 2020s and thus help mitigate any geopolitical risks of fuel supply interruption and price volatility.

- **Devolved administrations**. Significant abatement opportunities exist at the national level across all of the key options (i.e. renewable electricity, energy efficiency, low carbon heat, more carbon-efficient vehicles, agriculture and land use).

Question 9 ***Is there any new evidence to suggest that (incremental) impacts of the fourth carbon budget on competitiveness, the fiscal balance, fuel poverty and security of supply have become unmanageable?***
No response.

Question 10 ***Is there any new evidence on differences in circumstances between England, Wales, Scotland and Northern Ireland that suggest the need to change the budget?***
No response.

The Committee on Climate Change
1st Floor,
7 Holbein Place,
London SW1W 8NR
Tel: 0207 591 6262 Fax: 0207 591 6180 www.theccc.org.uk

Question 11 ***Is there anything else not covered in your answers to previous questions that you would like to add?***
No response.