



Department
of Energy &
Climate Change

Developing DECC's Evidence Base

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Executive summary

The Department of Energy & Climate Change (DECC) works to make sure the UK has secure, clean, affordable energy supplies that fully support the UK economy, and promotes international action to mitigate climate change. We need evidence to help us see what really works; to understand growth and consumer issues; to choose between different ways of delivering our objectives; and to be well prepared for the future.

This document sets out, for the first time, our priority interests for developing evidence to underpin policy development and to learn from delivering policies. It covers what we'd like to know and the work which will need to get underway in the next 3 to 5 years.

The extent of our portfolio and the range of challenges we face mean that we will need to draw on a wide range of evidence covering social, technical and economic aspects. Our policies are informed by a wide evidence base: we undertake analysis, develop models, and commission external research to underpin decision making. To ensure that DECC plans, quality assures and uses the evidence effectively in decision making we have formal processes, roles and responsibilities. In particular this ensures that evidence is gathered and used to reduce uncertainty, thereby helping ensure effective policies and reducing risk. We recognise however that uncertainties will remain, and that we will need to continually learn from policy implementation.

Given the scale and complexity of the challenges, cost-effective access to an extensive, relevant and robust evidence base is crucial. Therefore, in addition to DECC-commissioned work, we will draw on existing and new evidence developed by other researchers. By setting out clearly our research interests, we hope to inform the direction of the work of institutions who seek to produce policy-relevant research and help increase the impact of independent researchers. We will continue to publish our research findings, and will make openly available more of our data and models so that they can be used by researchers and others, and new insights developed from them. By sharing our knowledge and being clear about our research interests we aim to stimulate a fruitful dialogue and collaboration to further inform our evidence base.

Our priorities

In recent years we have introduced many new or revised policies. We will therefore prioritise research and **evaluation** of them, and to ensure that we learn from this experience. We will also continue to monitor and assess the impact of policies on energy use, prices and bills, and the investment, jobs and growth supported by them.

Improving our **understanding of people and institutions** will be another broad priority area. In particular we will develop our understanding of the use of heating in homes, and energy use in non-domestic settings. In these different settings we are interested in what drives or prevents

switching to alternative heat sources, or uptake of energy efficiency measures including the effective use of heating controls. We will continue to improve our market intelligence and our understanding of investor behaviour to ensure government's interventions effectively address market failures. We anticipate that many of the broader questions, such as energy-related decision-making in organisations and understanding community response to new energy infrastructure are likely to be predominantly informed by independent research.

We will assess the contribution of low carbon generation and energy efficiency improvements to **economic growth, jobs and investment**.

We will also continue to develop our understanding of **deliverable, cost-effective pathways to 2030** and beyond. Such analysis will underpin the 5th Carbon Budget, and will be needed to make timely decisions on a range of policies given the lead times for major energy infrastructure. We will continually seek to improve our understanding of how to assess and include uncertainties in our decision making, to better reflect the long-term context of our policy decisions.

As well as these cross-cutting priority areas we will also build our evidence base in specific areas of policy development and implementation. These are summarised below.

Improving energy efficiency across the economy will help lower carbon emissions, improve our energy security and improve the productiveness of our economy. Increasing energy efficiency and driving the uptake of low carbon heat will be important for meeting the 4th Carbon Budget – and new policies may be required. Evidence will therefore be required to help evaluate current policies as well as consider new policy options in both the domestic and non-domestic sectors.

To inform our objectives to **improve energy efficiency and move to lower carbon heat in homes**, as well as helping the fuel poor, we will continue to improve our understanding of actual energy use in homes, the real impacts of technologies to improve energy efficiency, and social factors affecting energy use. Our capacity to model policy interventions effectively will be improved, in particular through the development of the National Household Model. This model will be openly available, and so can inform a wider range of research. We will develop a better understanding of fuel poverty by building on the Hills Review.

The evidence base for **energy efficiency and low carbon heat** is less developed in **business, industry and the public sector**, due to the heterogeneity of the sectors and the commercial sensitivity of some data. It is therefore a priority to build our evidence on the real potential for energy efficiency and low-carbon heat considering social, technical and financial factors. We will improve our understanding of the potential for decarbonisation and energy efficiency of the industrial sector, including the opportunities for industrial CCS. We want to understand more about how different types of organisations make energy-related decisions (for example investment decisions) to ensure our policies are effective. We will also be taking forward work to consider the implications of international and national carbon reduction and energy efficiency measures on UK business and industry.

A transition to **low carbon electricity generation** is critical to meeting long term decarbonisation objectives as well as for energy security. Our priority will be to monitor and evaluate the delivery and impact of policies designed to achieve this. This includes assessing the impact of costs on consumers, deployment levels of low carbon technologies, and the impact on financing costs. In order to get the right mix of appropriate cost-effective support, innovation and cost-reduction to meet our long term objectives, we will also continue to strengthen our understanding innovation and cost reduction opportunities. We will continue to expand our understanding of the full costs, including full carbon costs of all electricity generation technologies. We also wish to develop our evidence on positive community engagement practices and the impact of benefits packages.

Fossil fuels remain an important part of our energy mix and are expected to remain so (when coupled with CCS in the longer term). Understanding domestic and international oil, gas and coal markets allows the UK to manage our energy security, particularly during times of peak demand. It will also help us improve our modelling of projected fuel prices beyond 2030. As UK exploration of shale gas gets underway, we are considering what further research and monitoring is needed as part of this.

Our **energy markets** and physical **networks** join the energy producers and consumers and enable the system to function effectively. We will assess the impact of our policies to reform the electricity market, and continue to monitor and assess other developments in the energy and carbon markets. In particular we will consider what opportunities exist to strengthen market competition.

We need to make sure our networks are reliable as we decarbonise our supplies, and as demand changes as a result of new technologies. The energy system must function effectively across all energy sources, in the near future and after 2030. We will therefore improve our understanding of electricity system balancing impacts and the options for future energy storage capacity. We will consider how peak electricity demand may evolve over the near future and the opportunities for demand side response to reduce this. Looking at the likely longer term impacts we will consider the role of the gas networks, and the implications of the changes on these networks; options for heat and electricity and other energy vectors to help keep the whole system running effectively; and the role of interconnectors.

DECC and its Non Departmental Public Bodies (NDPB's) are also charged with **managing the civil, public sector nuclear legacy safely**. This includes the safe management of radioactive waste through interim storage and development of permanent geological disposal and the on-going management of other nuclear materials, including the UK's civil plutonium stocks. In each of these areas we will continue to use and develop evidence to support our policies and monitor the current situation. We will work closely with the Nuclear Decommissioning Authority (NDA) and relevant regulatory and Government advisory bodies in this, alongside consultation with other learned bodies as appropriate. We will also continue to work with other government departments and other governments to ensure we support counter-proliferation of nuclear weapons.

The UK remains at the leading edge of policy-relevant **climate science**, thanks to joint DECC-Defra investment in the Met Office Hadley Centre. We will build on this, and the success of the first phase of the AVOID research programme by commissioning a second phase, to provide

scientifically-robust analytical underpinning to the international negotiations process leading up to the pivotal 21st UNFCCC Conference of the Parties (COP21) in 2015, at which the structure of a global effort to tackle greenhouse gases is to be agreed. Together with the Department for International Development, we will gather evidence to inform decisions on future allocations from the UK Government's International Climate Fund, whilst evaluating its effectiveness to date. We will further develop the inventory of greenhouse gas emissions. As well as a requirement of international obligations, this work allows us to understand the origins and magnitudes of UK emissions, and enables Government to develop and appraise policies designed to control or reduce these emissions.

Next steps

To deliver strong evidence to support effective policy development and deployment across this important agenda requires co-ordination internally and externally, making the best use of resources. Internally, DECC will set up several cross-cutting 'thematic evidence boards' to ensure that DECC plans for our medium-term evidence needs and prioritises work to ensure key needs are met. These boards will provide a focal point for liaison to external researchers who are working on the topics identified in this document. We will explore with Research Councils, learned bodies and others how we can best work together to ensure that DECC is aware of developments, and is always striving to use the best evidence.

We will continue to develop evidence plans that underpin this document. We intend to publish a revision in 3 years based on these evolving plans, and prioritisation of our needs.

Please contact evidence1@decc.gsi.gov.uk with any queries.

1. Introduction

The Department of Energy & Climate Change (DECC) works to make sure the UK has secure, clean, affordable energy supplies and promote international action to mitigate climate change. We are working towards these goals through boosting investment in our energy infrastructure as we make the transition to a low carbon economy, helping to support jobs and growth and supporting energy consumers.

1.1. Evidence helps us formulate and deliver effective policies towards these goals by understanding the opportunities for change, assessing options, and managing risks associated with uncertainties. Given the breadth and scale of the challenge, getting the relevant evidence cost-effectively requires us to fully exploit existing knowledge, commission new research in a prioritised way and communicate our interests to others who are seeking to undertake research with impact.

The purpose of this document

1.2. This is DECC's first multidisciplinary assessment of our medium-term evidence needs, and bringing together of our current plans. It helps the Department identify synergies between work areas, allowing them to join up and achieve better value for money and better outcomes in undertaking analysis or commissioning research. It will be used to improve our links and collaboration with external research communities. It will also provide the basis for considering DECC's future research and analysis priorities.

1.3. We have a strong track record of developing and using evidence to inform policy decisions and will continue to build on this. In 2012-13 we invested £15m in building our evidence base directly to support policy; £15m on climate science; and £19m on innovation-related research at 'Technology Readiness Levels' (TRLs) 1-3¹ including an investment in the Jules-Horowitz reactor. The Nuclear Decommissioning Authority² also spent around £6m on R&D up to and including TRL3. This document mainly covers research and analysis which directly support policy. The quality of our evidence is of paramount importance as is the way we use it. We will continue to build on our ability to use evidence, taking account of uncertainties, and inevitable gaps and conflicting evidence to support effective policy decision-making.

Scope and approach

1.4. This document is concerned only with DECC's evidence needs over the next 3-5 years. It does not cover evidence requirements for topics that are the responsibility of other

¹ For more information about TRLs see, for instance:
<http://www.publications.parliament.uk/pa/cm201011/cmselect/cmsctech/619/61913.htm>

² This excludes spending on research and development by the site licence companies.

government Departments, but which have a bearing on climate change or energy security. Nevertheless, we regularly work across departmental boundaries, promoting a shared understanding between Departments of the evidence needed for effective policy making and setting and reviewing of Carbon Budgets. We also recognise that transport and agriculture contribute significantly to both energy use (transport accounted for 38 per cent of final energy consumption in 2012³) and greenhouse gas emissions (agriculture contributed nearly 10 per cent to our greenhouse gas emissions in 2011⁴).

1.5. Addressing complex challenges in climate and energy policy requires combined expertise from across a range of disciplines. DECC routinely uses evidence from, and has expertise in commercial, customer insight, economics, engineering, operational research and the natural, physical and social sciences. The Strategy represents the outcome of a systematic internal review setting out our major evidence priorities for the next 3-5 years.

1.6. The areas we identify in Sections 3 and 4 reflect the intersection between our assessment of gaps in the evidence and our priorities in energy and climate policy. The review is part of work within DECC to embed greater planning and foresight into our evidence investment. The high level nature of this document means that we have traded-off detail with coverage.

1.7. Finally in Section 5 we set out our commitment to open policy making and transparency. We are keen to do what we can to enable the research community outside DECC to engage with our agenda and to support the development of better evidence for policy.

1.8. Given the high level nature of the description of our interests we have not attempted to prioritise specific projects as this is more appropriately done at the level of detailed planning. We have however highlighted some priority areas. Throughout the descriptions we have indicated where we anticipate we will undertake or directly commission the research, and where we may not have such a direct role. In determining our priorities for undertaking, commissioning or working in partnership with others we will consider the impact (the significance of the questions in informing policy decisions, and how far the work will go in addressing these questions) and the cost of proposed work to DECC.

Next steps

1.9. To ensure that this is a step on the journey to improving our evidence base, we are creating internal 'thematic evidence boards' – teams who are responsible for ensuring we obtain the evidence set out in section 4 in particular areas. We anticipate that the agenda will evolve as we explore these areas in greater detail and we therefore plan to publish an update in the next 2-3 years. These boards will work directly with the relevant policy teams to lead the development of evidence for current and emerging policy priorities.

³ Excludes non-energy uses. Source: 2013 Digest of UK Energy Statistics, Table 1.1. Available here: <https://www.gov.uk/government/publications/energy-chapter-1-digest-of-united-kingdom-energy-statistics-dukes>

⁴ Source: 2011 UK Greenhouse Gas Emissions: Final Figures. Available here: <https://www.gov.uk/government/publications/final-uk-emissions-estimates>

1.10. We are also keen to work with external funders and research organisations to understand how we can collaborate. We aim to work with the research councils, industry and learned societies, as well as academia and private or community sector research organisations to take this forward.

1.11. We encourage researchers to contact us to understand the thinking behind the summary presented here and to develop research and analysis which will impact on policy. We will also explore how we can develop new research capacities to meet changing demands over the next 10 to 20 years. We will explore effective means of working together, such as building on the success of the AVOID partnership to see if the same approach can work elsewhere (see box).

AVOID

The *Avoiding Dangerous Climate Change (AVOID)*⁵ research programme was established to provide advice to the UK government on avoiding levels of global greenhouse gas emissions that cause potentially dangerous climate change.

A unique approach was adopted by the AVOID programme: government stakeholders, involved from the earliest stages, maintained direct communication with researchers, ensuring priorities and timescales aligned with policy needs. The programme was also able to draw on more detailed and in-depth research already being undertaken by researchers within the consortium, focussing their results on DECC priorities. The programme was co-funded by Defra and conducted by a multi-disciplinary network of scientists at the Met Office Hadley Centre, the Walker Institute, the Grantham Institute, and the Tyndall Centre, along with other national and international collaborators, in China, India and the USA.

2. Context

DECC's highest level objectives are reflected throughout the work we do, and are considered in designing and evaluating all policies. Our work addresses climate change and energy security, and does so whilst considering growth, affordability, and distributional effects.

Climate change

2.1. The overwhelming scientific consensus is that anthropogenic climate change is happening. Emissions of greenhouse gases since the industrial revolution are very likely responsible for more than half of the global warming observed over recent decades and associated climate changes. The risks to our environment and societies world-wide will increase in coming decades and will be with us for centuries to come unless we take rapid action to reduce emissions of anthropogenic greenhouse gases.

⁵ See: <http://www.avoid.uk.net/>

2.2. The UK's approach is set out in the Climate Change Act which requires UK emissions reductions by 34% by 2020 and at least 80% by 2050. It also puts in place a system of five-yearly 'carbon budgets' to keep the UK on an emissions pathway to 2050. Many of DECC's policies are designed to ensure that we make our contribution to reducing carbon emissions and meeting our carbon budgets. In particular this includes increasing energy efficiency, and increasing the share of electricity and heat supplied from low carbon technologies.

2.3. The inventory of greenhouse gas emissions we produce, required for reporting against our international commitments, also allows us to understand the origins and magnitudes of UK emissions, and enables Government to develop and appraise policies designed to control or reduce these emissions (see Energy and Emission Statistics box below).

2.4. Global action is required to combat climate change. The UK plays an active role in international negotiations. We use scientific and economic evidence to inform our position in international negotiations, and to help influence others.

Energy and Emission Statistics in DECC

Statistics⁶ are essential to DECC's evidence base. The *Digest of UK Energy Statistics*⁷ (DUKES) is at the heart of our evidence on energy production, transformation and use, and forms a major input to our energy modelling. These statistics have developed with changes in the energy market, and include new analysis on renewable energy. Through our support of the Joint Organisations Data Initiative (JODI)⁸ our energy data also supports transparency in international energy markets.

While official energy data series are long established, it is only since the creation of DECC that significant detailed statistics have been developed on energy use and efficiency. This work began with *Energy Consumption in the UK*⁹ which looks specifically at different ways in which energy is used. We developed measures of local energy use¹⁰ via innovative work with energy suppliers to use meter data. The last 2 years have seen substantial advance in data on efficiency through the development of the National Energy Efficiency Data-framework (see NEED box – page 19). This unique project links several large data sources to produce new key evidence on drivers of energy use and energy efficiency. These data are now making a real difference in DECC's understanding of domestic energy use.

⁶ See: <https://www.gov.uk/government/organisations/department-of-energy-climate-change/about/statistics>

⁷ See: <https://www.gov.uk/government/organisations/department-of-energy-climate-change/series/digest-of-uk-energy-statistics-dukes>

⁸ See: <http://www.jodidata.org/>

⁹ See: <https://www.gov.uk/government/organisations/department-of-energy-climate-change/series/energy-consumption-in-the-uk>

¹⁰ See: <https://www.gov.uk/government/organisations/department-of-energy-climate-change/series/high-level-indicators-of-energy-use-at-regional-and-local-authority-level>

DECC also manages the UK Greenhouse Gas Inventory,¹¹ which is our key source of emissions data. The inventory provides a comprehensive dataset covering all the UK's emissions sources by drawing together statistics from a range of sources, including our energy statistics.

Statistics produced from the inventory allows us to understand the origins and magnitudes of UK emissions, and enable government to formulate and assess policies designed to control or reduce these emissions. These statistics are also used to assess progress towards our international and domestic targets for reducing greenhouse gas emissions, specifically the UK's commitments under the Kyoto Protocol and our binding carbon budgets under the Climate Change Act.

Energy security

2.5. Our approach to energy security is based on competitive markets combined with effective regulation to deliver diversity of supply and robust infrastructure for consumers. The changes we are making to the electricity markets demand a range of analysis and research to understand their effectiveness.

2.6. DECC's policies aim to increase energy security through a variety of means – for example increasing energy efficiency which can help lower our exposure to international energy market price rises and volatility; designing the market to ensure that sufficient supply and distribution capacity is available in the future; developing resilience measures to prevent supply disruptions. We will continue to develop our evidence to inform on-going policy development and continue monitoring the energy markets.

Investment and Jobs

2.7. Energy is one of the biggest opportunities to kick-start growth and support jobs. It has a bigger infrastructure investment pipeline than transport, broadband, water and waste combined. Many energy investments are ready to begin now. As well as the large infrastructure projects, we will also see changes in homes and businesses across the country which will also create new business opportunities.

2.8. Our policies aim to expedite that growth by increasing investment flows in low carbon energy and more energy-efficient goods and services as well as making the most of our existing oil and gas reserves. At the same time we are making sure the costs and benefits of our policies are distributed fairly so that we protect the most vulnerable and fuel poor households and address competitiveness problems faced by energy intensive industries.

¹¹ See: <https://www.gov.uk/government/organisations/department-of-energy-climate-change/series/uk-greenhouse-gas-emissions>

3. Cross-cutting themes

There are four priority themes which cut across much of DECC's work. They are discussed in more detail below, and elements are picked up throughout the document. Because many DECC's policies are now being, or will shortly be, implemented, **policy monitoring and evaluation** will become increasingly important to ensure that we understand the impacts of our policies and are revising them as needed in line with the best available evidence. The challenges ahead are significant. To achieve the changes in choices and behaviour we need, we need to improve our **understanding of people, institutions and markets**. We need to ensure that we develop our policies fully aware of their **contribution to economic growth and their distributional impacts**. Given the timescales that will be required for this scale of change, and their complex interdependencies, we need to consider key strategic issues ahead, in particular the **deliverable and cost-effective pathways to 2030 and beyond**.

Policy monitoring and evaluation

3.1. In order to meet DECC's challenging objectives we are implementing an ambitious and innovative portfolio of policies and programmes: it is essential that these policies and programmes are robustly evaluated and the findings made available and used as widely as possible.

3.2. Given the innovative nature of our policies, it is likely that new evaluation methods will be required. Although monitoring and evaluation is not mentioned specifically in all discussions throughout this document, it is a key part of our major policies and programmes.

3.3. For DECC, there are three primary reasons to evaluate: first to learn and adapt policy to increase the likelihood of success now and in the future; second for accountability, providing evidence of how the policy worked in practice and its impact, to inform public debate and respond to parliamentary and other scrutiny; third to understand 'what worked', and use this to inform future policy development.

3.4. To further improve the quality of our evaluation evidence we are interested in exploring the following areas:

- how best to evaluate complex and complicated policies

- how we can look across our and other government departments' policy portfolios to understand the interactions
- how we can best gather and use data to minimise the impact on organisations while achieving greater coherence and consistency in the range of data we collect
- how to understand regulatory burdens.

Understanding people, institutions and markets

3.5. People are the agents of change in the energy system. We aim to improve our understanding of how people behave, whether as individuals at home or work, or as part of communities, businesses or whole supply chains or workforces.

3.6. Although woven into all the identified evidence areas identified, we have drawn together the issues highlighted in the sections below in order to set out an agenda for research which can directly engage researchers working in the wider social sciences including those working outside the topic of energy. We encourage greater multidisciplinary and interdisciplinary working across socio-economic and technical sciences to generate stronger evidence that takes better account of people in their technological and physical contexts.

3.7. We see the following five challenges in developing evidence in this area:

- Understanding how the use of homes and workplaces (and the technology within them) by people affects patterns of energy demand and how we can intervene to generate positive change, such as moving to low carbon sources of heating, or enhancing the effectiveness of heating controls.
- Understanding how our policies interact from the perspective of people and institutions: for instance, identifying risks and opportunities with the delivery of smart metering, the Green Deal and the Renewable Heat Incentive
- Understanding investment-related behaviour and choices: for example, incentives to invest in new energy technologies, energy networks and building fabrics in response to new market mechanisms.
- Understanding delivery chains and business models operating in the energy supply and energy efficiency sectors and how they might evolve as a result of energy market developments. This includes suppliers of technologies and services to homes or institutions, and in the development of new energy supply infrastructure.
- Understanding communities both how they respond to new energy developments and what promotes positive engagement with energy investment and consumption, such as 'collective switching'.

Growth, affordability and distributional impacts

3.8. We wish to more comprehensively understand the impacts of our policies on society and economy, particularly by assessing their effects on economic output and the distribution of income. These impacts may also be further broken down, by looking closely at the effects on investment and employment levels. Quantitative analysis would enable us to track more closely the macroeconomic impacts of our policy portfolio, and how these are distributed across different groups and sectors. We will therefore continue to develop a methodology that may be used to achieve this.

3.9. As part of these efforts, we would like to understand and measure the contribution of our policies that directly and/or indirectly impact the innovation chain. This may include evaluating the impact of direct support to the early stages of the chain on the economy and technology costs including learning-by-research, as well as the impacts of deployment support including economies of scale, learning-by-doing.

3.10. We will continue to assess the direct and indirect impacts on household and consumer bills and costs of energy and further develop our understanding of the distributional impacts of our policies. In particular we are keen to understand how we can better protect the most vulnerable and fuel poor households. We will also continue to undertake a range of work to assess the likely and actual impact of our policies (including those on energy efficiency, demand-shifting and decarbonisation) on business and industrial consumers, especially those most exposed to international competition.

Deliverable and cost-effective pathways to 2030 and beyond

3.11. The Fifth Carbon Budget will be set in June 2016. Carbon budgets, and other targets like the 2020 renewable energy target, require us to consider trade-offs across different sectors to steer the UK on a low carbon, energy secure pathway towards 2030 and beyond. It will be important to understand cost-effective ways to make this transition.

3.12. To identify feasible and least cost pathways that build on the analysis set out in the Carbon Plan¹² (2011), we need to understand what is achievable, including the technical constraints and opportunities. We also need to understand interactions between different sectors (such as how action on heat influences the requirements for electricity generation); and to understand the trade-offs between action in different sectors (such as between taking action to tackle emissions from industrial processes, or from freight transport). In understanding these trade-offs we also need to understand how policies interact – for example, on a national and European level.

3.13. In addition, the long economic and physical lives of many assets that produce or use energy mean the impacts of today's choices need to be considered in relation to possible future trajectories. Technical, economic and social uncertainties inherent on such timescales need to be factored in. This includes understanding the risks and benefits of retaining options for later action, or committing now to a particular course. We need to understand when decisions must

¹² See: <https://www.gov.uk/government/publications/the-carbon-plan-reducing-greenhouse-gas-emissions--2>

be taken, and to form a view on the technically deliverable, cost-effective pathways, factoring in the inherent uncertainties.

4. Evidence priorities by thematic area

This section provides an overview of our key evidence needs, by related areas. By considering evidence needs across related areas, rather than by specific policies we have drawn out common themes of interest related to our long term objectives. We consider the following areas: energy use and efficiency; energy production transformation and distribution; climate science and international negotiations; and nuclear legacy and counter-proliferation issues.

Energy use and Efficiency

4.1. Using energy more efficiently is critical to achieve our long term energy and climate objectives. Energy efficiency creates savings for consumers, reduces GHG emissions, contributes to security of supply and helps economic growth. Both individuals and organisations can reduce energy use, and save money through changing when they turn equipment on, and how it is used, as well as by choice of more energy efficient goods, or by installing technologies specifically designed to reduce energy use. Our policies are designed to overcome barriers and generate a stronger, self-sustaining market in energy efficient goods and energy efficiency services.

4.2. There is still a significant opportunity to optimise the energy use of both domestic and business customers. Domestic and non-domestic (comprising industrial, public and commercial) settings contribute over 60% to both final energy consumption¹³ and GHG emissions¹⁴. We have estimated in the Energy Efficiency Strategy, that around 11% of final energy consumption, and 41 MtCO₂ could be saved in 2020, through socially cost-effective investment in energy efficiency, although there are significant uncertainties in the evidence base. A significant proportion of this is expected to be delivered by current policies, but opportunities remain. ¹⁵

¹³ Source: 2013 Digest of UK Energy Statistics, Table 1.1. Available here: <https://www.gov.uk/government/publications/energy-chapter-1-digest-of-united-kingdom-energy-statistics-dukes>. In 2012 domestic settings were responsible for 31%, nondomestic settings 30% and transport 38% of final energy use.

¹⁴ Source: 2011 Greenhouse Gas Emissions statistics. Available here: <https://www.gov.uk/government/publications/final-uk-emissions-estimates>

The Greenhouse Gas Inventory excludes emissions from fuel use in international aviation and shipping. On this basis, domestic settings contribute 24%, non-domestic 44% and transport 24% .

¹⁵ DECC's Energy Efficiency Strategy 2012 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/65602/6927-energy-efficiency-strategy--the-energy-efficiency.pdf The calculation of energy saving is based on an energy use projected on a business as usual basis.

4.3. We also need to transform how we use and generate heat. We use more energy for heating than for transport or the generation of electricity. We use energy to heat and cool our homes and workplaces, and in manufacturing processes. It is responsible for almost half of our final energy consumption and a third of GHG emissions. To meet our 2050 commitments, energy efficiency will not be enough. We also need to substantially decarbonise heat through a step change in the deployment of low carbon heating technologies to buildings.

4.4. In order to set us on a trajectory to 2050, and to meet our 4th Carbon budget targets, savings will be required in sectors outside EU Emissions Trading System (EU ETS), over and above policies that are already in place. Evidence is therefore needed to maximise the impact of existing policies, to achieve the full energy efficiency potential, and to decarbonise heat. This section covers efficiency, energy and heat use in domestic and non-domestic settings. It sets out our future research requirements to ensure a joined-up and effective package of measures for homes, and public and private sector organisations including industry.

Priority work

4.5. In domestic settings we aim to maximise the impact of the Green Deal and the Energy Company Obligation (ECO). Over the short and medium term we aim to ensure effective roll out of Smart Metering, and help renewable heat deployment deliver maximum benefits via the domestic Renewable Heat Incentive (RHI). We are therefore focusing on:

- Evaluations of Green Deal and ECO, Smart Metering, domestic RHI and non-domestic RHI.
- Developing our understanding about the use of heat and related technologies and materials in the home, and in particular how people use them.

4.6. For non-domestic settings, there are several important policies: non-domestic RHI; Climate Change Agreements; the CRC Energy Efficiency Scheme, the EU ETS, and the roll-outs of advanced and smart metering. The new Energy Savings Opportunity Scheme (ESOS) is currently under development. We will therefore focus on:

- Developing our evidence base specifically to evaluate, review and – where appropriate – reform these policies and how they operate together. We have committed to reviewing the RHI from 2014 and CRC and ESOS in 2016.
- Further developing fundamental evidence on energy use and opportunities in non-domestic buildings, industrial processes and organisational behaviour.

4.7. We also will seek to understand whether and how financial incentives can deliver Electricity Demand Reduction (EDR) in both domestic and non-domestic settings. We will pilot the proposed approach, which will help us understand the likely effectiveness of the proposed EDR policy and to develop suitable monitoring and verification approaches. We will also learn from this evaluation how best use pilots for developing evidence.

Energy use in homes

4.8. To date, research in this area has focused on domestic buildings. We are keen to build on the extensive knowledge available to take better account of occupant behaviour and wider social factors, to focus on homes: the combination of people and domestic buildings. Homes are a critical area where DECC policy can have a significant influence: people at home consume nearly a third of total UK energy and this share is rising over time.¹⁶ The majority of energy consumption in homes is gas use for heating (space and water) and cooking. This accounts for over two-thirds of total end use energy demand, while electricity consumption accounts for most of the remainder.¹⁷ Although gas consumption is increasingly efficient, we still need to decarbonise. In 2011, domestic energy use (including both gas and electricity use) accounted for 131MtCO₂e being released into the atmosphere (24% of total emissions), approximately 5tCO₂e per household.¹⁸

4.9. Our main priorities in this area include helping households reduce their energy demand, helping protect them from rising energy costs, and decarbonising household heating. We have identified four topics for development in this area.

Evidence development areas of specific interest to DECC

i. Real world data on measures, technologies and their impact

4.10. A key challenge for DECC will be to increase our understanding of how technologies, measures, and buildings perform in the real world rather than the lab. We are also interested in how combinations of measures interact to generate energy savings and the wider consequences of installing measures (such as changes to well-being, upkeep costs, overheating, or damp). This work will build on NEED (see box on page 19), 'Powering the Nation'¹⁹ and other major studies in this area (see box on page 20).

4.11. We are interested in how heating controls and other tools can make it easier for people to heat their homes more efficiently and cost-effectively. To do this we will expand our understanding of how people currently heat their homes (in particular spatial and temporal internal temperature patterns for different occupiers) including use of their heating systems and other appliances, and how people respond to different control options.

4.12. We expect to further develop our evidence base and analysis on new technologies to help deliver efficiency savings as well as help balance the grid (see Energy Markets, Networks and Whole System Analysis section on page 32). We will build on the significant amount of trialling and other research already underway in both the business and research communities. These consider how smart meters, new tariffs, autonomous home control systems, and potentially other technologies and approaches (e.g. local generation) might help reduce the

¹⁶ See: <https://www.gov.uk/government/publications/housing-energy-fact-file-2012-energy-use-in-homes>

¹⁷ Source: 2013 Digest of UK Energy Statistics, Table 1.1. Available here: <https://www.gov.uk/government/publications/energy-chapter-1-digest-of-united-kingdom-energy-statistics-dukes>

¹⁸ MtCO₂e is 'million tonnes of CO₂ equivalent'. Based on 23 million households in the UK. Source: 2011 UK Greenhouse Gas Emissions, Table 3. Available here: <https://www.gov.uk/government/publications/final-uk-emissions-estimates>

¹⁹ See: <http://www.energysavingtrust.org.uk/Publications2/Corporate/Research-and-insights/Powering-the-nation-household-electricity-using-habits-revealed>

overall demand or shift the time of demand. We will work with relevant bodies, in order to ensure that we understand how this opportunity can best be exploited considering both the technological and the social aspects.

4.13. We also need to get a better understanding of the real potential for heat networks to provide low carbon warmth to buildings, and its implications. This is explored in more detail under the 'networks' section (page 33).

National Energy Efficiency Data-framework (NEED)

DECC established the NEED²⁰ project to develop its understanding of energy use and the impact of energy efficiency measures in domestic and non-domestic buildings. The project brings together data from existing sources, including meter point energy consumption data and information on energy efficiency measures installed in households, and links this to information about property characteristics to provide a rich resource for analysis.

We produce a range of outputs which are used by industry, academia and the general public. This includes data at local authority level; the NEED Table Creator²¹ for making bespoke data tables; and an energy consumption comparison tool for industry²².

We are working to include new data in NEED. This includes Energy Performance Certificates, Green Deal and ECO data, Smart meter installation data, Renewable Heat data and Feed-in-Tariff's data. In parallel we are consulting with users and suppliers on steps to release an anonymised domestic dataset to further open up the NEED data to the research community.

Work is underway to assess the quality of NEED data in the non-domestic sector. If successful this will enable DECC to produce detailed statistics of energy consumption for detailed sub-sectors and make comparisons of energy use per floor space between different type of buildings and businesses. DECC plans to publish an update on this work in early 2014.

ii. Broader social factors affecting energy use and investment in the home

4.14. Building on the Domestic Energy Use study,²³ we wish to get a better understanding on how social (e.g. lifestyles, practices and norms) and psychological (e.g. beliefs, values and attitudes) factors affect energy-related behaviour and the potential to reduce carbon emissions, to help design effective policies. We would also like to understand how both financial and non-financial factors affect relevant decisions (e.g. savings associated with new technologies, approaches to marketing or peer support, and the decision to invest). We will explore the possibilities and benefits of a longitudinal panel survey of householders.

²⁰ See: <https://www.gov.uk/government/organisations/department-of-energy-climate-change/series/national-energy-efficiency-data-need-framework>

²¹ See: <https://www.gov.uk/government/statistical-data-sets/need-table-creator>

²² See: <http://www.comparemyenergy.org.uk/>

²³ See: <https://www.gov.uk/government/publications/domestic-energy-use-study>

4.15. We are also interested to understand how we can best work with the range of businesses and others who interact with householders, and who influence their energy use. This includes opportunities to change the way people use and heat their homes, and the use of energy-using and energy-saving technologies. As part of this work we would be keen to have a better understanding of the skills of installers, assessors and others in delivering the full range of energy efficiency and low carbon heating measures.

Important current research projects and programmes

Energy in homes

There are two core studies currently underway:

- the **Energy Follow-up Survey** (reporting in late 2013) is a major technical and social study of energy use in homes. It looks in detail at the dwelling and occupant characteristics of a follow up sample of 2,616 homes from the English Housing Survey tracking indoor temperatures and electricity monitoring in subsamples of homes. It is one of the richest datasets in this field for the UK, supporting core understanding of homes for effective policy development.
- a study looking at the real world savings from **solid-wall insulation** (reporting in 2015) aims to improve our understanding of heat losses from solid wall properties so that we can better model and predict energy savings, improving targeting and giving confidence that installed measures generate real energy and emissions savings – critical for Green Deal and ECO policies.

Energy in non-domestic settings

There are two core projects being undertaken here:

- a major study will **update the evidence base around energy use in non-domestic buildings**. Reporting in early 2015, it will provide a more current, disaggregated view of energy end use across different sub-sectors (e.g. offices, retail) as well as estimate the abatement potential. The results will support policy and improve the quality of DECC modelling in this area.
- the **industrial energy efficiency evidence programme** aims to improve our evidence in three areas; historic trends in energy consumption and energy efficiency in industrial processes, the economic and technical potential for energy efficiency potential and the economic, technical and social barriers to taking up energy efficiency.

iii. A better understanding of fuel poverty, building on the Hills Review

4.16. The Hills Review provided a new framework – based on the Low Income High Costs (LIHC) indicator - for understanding and assessing the scale of fuel poverty.²⁴ We are keen to build on this by developing more sophisticated methodologies to better capture the ‘co-

²⁴ See: <https://www.gov.uk/government/publications/final-report-of-the-fuel-poverty-review>

benefits' associated with support for fuel poor households. For example the positive health impacts we might expect to flow from warmer homes but which we currently fail to capture within current standard cost-benefit analysis.

4.17. We will also continue to develop a richer understanding of fuel poor homes. This will ensure policies are shaped and delivered more effectively, including the extent to which different approaches (such as energy efficiency programmes or directly supporting energy bills) have a material impact on fuel poverty and the economic and general well-being of those households classed as 'fuel poor'.

4.18. We are exploring how fuel poor households under the LIHC approach can be better targeted and supported. We published 'Fuel Poverty: a Framework for Future Action'²⁵ in July 2013. That document sets out some guiding principles for future policy development and indicates how we intend on using the new LIHC indicator to shape fuel poverty policies. We will continue to build on this evidence base as we develop the new fuel poverty strategy.

iv. Improved understanding of policy impacts and interactions via energy models

4.19. For the domestic sector we will continue to develop the National Household Model (NHM) to better support policy options analysis. This helps us make best use of the evidence on energy use in homes and align data and assumptions in existing domestic policy modelling. Through 2014 we plan to link the NHM to a separate district heat model enabling us to explore the potential for heat networks. We will continue to build on this suite of models to develop non-domestic buildings and industry models with the long term aim of linking these to create a National Heat Model.

4.20. To underpin the development, delivery and assessment of a number of DECC policies, we make extensive use of the Building Research Establishment Domestic Energy Model (BREDEM) family of models and the Simplified Building Energy Model (SBEM) for non-domestic buildings. BREDEM-derived models include the NHM, the Green Deal Occupancy Assessment, the Standard Assessment Procedure (SAP) and a reduced version of SAP (RdSAP) used for the creation of Energy Performance Certificates (EPCs). We will continue to assess the appropriate range, functionality and efficacy of the tools and models needed to best support our energy efficiency policies.

4.21. The importance of SAP led to the government establishing the SAP Scientific Integrity Group (SAPSIG) in 2012 to protect SAP's integrity, coherence and impartiality. SAPSIG's main role is to peer review proposed changes to the models, quality assuring the technical details. SAP will continue to be fully reviewed typically on a three yearly basis, coinciding with amendments to Part L of the Building Regulations for England. However, new technologies can still be included outside that cycle (see SAP Appendix Q²⁶ for details). We will continue to support annual updates to the RdSAP and Green Deal Occupancy Assessment.

²⁵ See: <https://www.gov.uk/government/publications/fuel-poverty-a-framework-for-future-action>

²⁶ See: <http://www.ncm-pcdb.org.uk/sap/>

4.22. We will continually improve our models by including the results of field trials on real performance for important measures. In addition to this, we aim to develop much better ways of modelling the human or behavioural elements of homes, attempting to capture interactions between people and technology. New data about drivers and barriers to investment in new measures, in situ technology performance and interactions with householders and other technology will present new opportunities for developing our models in ways which better serve the needs of policy development.

4.23. The availability of advanced metering technology in the UK smart meter roll-out programme will allow access to improved usage data that could allow us to refine policy for developing the UK electricity network in order to meet our 2020 targets. As a part of this, we will work with the energy companies (suppliers and/or Distributed Network Operator companies) during the roll-out stage of the smart meter programme to understand how we could use anonymised smart meter data in our engineering network models.

Energy use in non-domestic settings

4.24. Our policies aim to help business and industry reduce energy demand and GHG emissions, through energy efficiency measures and low carbon heat. We aim to do this by providing the right conditions for business and industry to invest in new technologies, and to change processes and ways of working. Energy use in non-domestic settings accounts for around a third of our annual final energy consumption²⁷ and over 40 per cent of UK greenhouse gas emissions (when emissions from agriculture are excluded).²⁸

4.25. Despite the significant opportunities in this sector, the heterogeneity of the activities, technologies, sizes and organisational structures presents an evidence challenge and means that our understanding in this area is less developed than in the domestic sector. We have identified five topics for development in this area.

Evidence development areas of specific interest to DECC

i. Potential for energy efficiency and low-carbon heat

4.26. We seek to develop a much better understanding of the technical and economic potential for energy efficiency, low carbon heat and combined heat and power across all sectors. We are taking forward projects to improve the evidence base for energy efficiency in non-domestic buildings and industrial processes (see box on page 20) and will be taking forward work to identify opportunities for improved efficiency of heat use. This will also help build a detailed understanding of current patterns of energy use in different sectors, and sizes of operations. In addition, we are interested to identify sector-specific opportunities for the key technologies, and to understand the technical and economic constraints to this.

²⁷ Source: Energy Consumption in the UK, Chapter 1: Overall data tables (table 1.13). Available here: <https://www.gov.uk/government/publications/energy-consumption-in-the-uk>. Non-domestic defined as industry and services consumption

²⁸ Non-domestic is defined as Business and industrial processes. 2011 UK Greenhouse Gas Emissions, Table 3. Available here: <https://www.gov.uk/government/publications/final-uk-emissions-estimates>

4.27. We will also develop our evidence base on the potential for further non-domestic electricity demand shifting, in order that time-of-use opportunities in this sector may help balance the grid and reduce peak capacity requirements.

ii. In situ performance and effective implementation of technologies

4.28. We want to learn more about how technologies perform in-situ, and consider the impacts of design, installation and use. We will identify key technologies to assess in more detail, initially aiming to take forward work on large heat pumps, biomass boilers, heating controls, and the operation of space heating/cooling in non-domestic buildings.

4.29. As well as the choice of technology, the overall energy consumption is also determined by how the technologies are used (eg timing of switching or process optimisation) and maintained. Energy management systems (including those supported by advanced and smart metering) provide a way of considering the energy use of the whole building or process, and often lead to energy reductions. We are especially interested in quantitative evidence in this area. We are also interested in explorations of how design and installation of new technologies impacts on subsequent patterns of use.

iii. Industrial energy efficiency and decarbonisation

4.30. The 'Energy Efficiency Strategy'²⁹ (2012) set out a need for a stronger evidence base to underpin the development of targeted policies to drive further energy efficiency improvements across the industrial sector. As a first step in a longer programme of work we are commissioning a feasibility study on how best to build the evidence in this area to further strengthen policy decision-making (see box on important research, page 20).

4.31. In 'The Future of Heating: Meeting the challenge'³⁰ (March 2013), the government announced a new programme of work, led jointly by DECC and BIS to reduce the carbon intensity of heat in the industrial sector. We will work with the 8 most heat-intensive sectors of industry (iron and steel, oil refining, chemicals, food and drink, paper and pulp, cement, glass, and ceramics) to develop evidence-based options to decarbonise in the coming decades. We will use the evidence to explore low carbon and energy efficiency pathways to 2050 via the Industrial Sector Low Carbon Roadmaps project announced in 'The Future of Heating.'

4.32. Decarbonising industry has specific challenges and reductions in energy demand may meet thermodynamic limits. We want to better understand the potential for capture and storage of CO₂ emissions from this sector. Industrial CCS has the potential to substantially decarbonise industries where emissions are generated in the chemical processes, and in high temperature processes where complete switching from fossil fuels is unlikely to be feasible. These industries include iron and steel, cement, chemicals, refineries, glass and bricks. DECC and BIS are working with the industrial sector to identify the barriers and opportunities to industrial CCS and the potential role for government. We are also interested in research into how the industrial and manufacturing sectors may be more effectively decarbonised in the UK, through resource efficiency and business redesign.

²⁹ See: <https://www.gov.uk/government/publications/energy-efficiency-opportunities-in-the-uk>

³⁰ See: <https://www.gov.uk/government/publications/the-future-of-heating-meeting-the-challenge>

4.33. In addition, DECC will identify the scale of the opportunity for re-using waste heat from industrial processes, and to better understand the technical and economic potential. These findings will have implications for the potential for low carbon heat networks (see page 34).

iv. How organisations function and make energy-related decisions

4.34. For an intervention to have any impact, organisations need to either invest in new technologies and materials or promote changes in practices, processes or operating models. Getting a better understanding of how investment decision-making works in practice, understanding what drives behaviour, including the role of key individuals, organisational culture, customers, regulation, finance, and financial investors will be important in designing policy interventions that work.

4.35. Our evaluations of current policies will shed some light on this area. We are interested in further research in this field, building on our rapid evidence assessment³¹, potentially drawing on expertise outside the energy domain. We are also interested in the effectiveness of new business models (including energy service companies, ESCos) in realising energy efficiency and carbon reduction opportunities, and what constraints or preconditions there are. We are interested to learn how advanced and smart metering can support better energy management.

4.36. Drawing lessons together on this opens up the possibility of developing tools or frameworks akin to 'MINDSPACE'³² (which is focused on individual decision-making) to capture evidence-based approaches for influencing organisational behaviour. There may also be potential for developing a 'typology' of organisations based on a range of factors: how they make decisions, risk appetite or the kinds of opportunity to act on energy efficiency and so on.

v. Implications of international and national carbon reduction and energy efficiency measures on UK business and industry

4.37. At the national level, we are keen to develop a more detailed understanding of how energy efficiency and decarbonisation policies affect business and industry, including the wider impacts on productivity. In particular we want to assess the different ways of measuring the competitiveness impacts of our policies, including the EU Emissions Trading System (EU ETS). To do this we will improve our understanding of cost pass-through and potential for carbon leakage in key sectors, analysing the impact of future EU ETS cap levels and longer term greenhouse gas emissions reductions targets.

³¹ See: <https://www.gov.uk/government/publications/factors-influencing-energy-behaviours-and-decision-making-in-the-non-domestic-sector>

³² See: <http://www.instituteforgovernment.org.uk/our-work/better-policy-making/mindspace-behavioural-economics>

Energy Production, Transformation, Distribution and Markets

4.38. We need to ensure our future energy system provides both a low carbon and secure energy supply. In 2012, 57 per cent of our primary energy supply came from UK sources. 35 per cent of primary energy supply was transformed into electricity, with a further 35 per cent refined into petroleum products. In 2011, power stations accounted for over a quarter of emissions³³, of which nearly two thirds were from coal use – roughly double the emissions from the use of gas in power stations.³⁴

4.39. To deliver a diversified low carbon generation mix in the future, we are reforming the electricity market to support the deployment of renewable technologies, nuclear and carbon capture and storage. This transition has implications for the markets themselves, and for the networks and the UK energy system in its entirety.

4.40. Our focus to date has been on developing the design of policy instruments to facilitate the transition to a low carbon energy future. We aim to attract new sources of capital and ensure security of supply, while keeping the cost to consumers as low as possible. This includes the grandfathering of the **Renewables Obligation framework** and developing (through **Electricity Market Reform**) **Contracts for Difference** and the **Capacity Mechanism**, alongside the **Carbon Price Floor**, and **Emissions Performance Standards**.

Priority work

4.41. As these policies are implemented, we will:

- Evaluate policies and their impact;
- Monitor market developments, including on deployment levels of low carbon technologies, the impact of contracts for difference on financing costs, carbon pricing and fossil fuel usage;
- Continue to strengthen understanding of innovation and cost reduction opportunities for low carbon infrastructure, and opportunities to strengthen competition;
- Further our understanding of system balancing impacts, and future network storage needs
- Develop our understanding of the evidence on positive community engagement practices, and the impact of benefits packages.

³³ Source: 2011 UK Greenhouse Gas Emissions, Table 3. Available here: <https://www.gov.uk/government/publications/final-uk-emissions-estimates>

³⁴ Source: The National Atmospheric Emissions Inventory. Available here: <http://naei.defra.gov.uk/> and the data selector for greenhouse gases: <http://naei.defra.gov.uk/data/data-selector>

Low carbon electricity generation

4.42. Generating electricity from low carbon sources is critical for the UK to decarbonise in the longer term. In 2012 over 30 per cent of primary electricity demand was met by low carbon sources: 19 per cent from nuclear and 11 per cent from renewable sources (hydro, wind and bioenergy).³⁵ As well as meeting our overall decarbonisation objectives, increasing the fraction of electricity from renewables will help us meet the target of 15 per cent of all energy consumption by renewable sources by 2020. Our analysis suggests that carbon capture and storage (CCS) could play an important role in the future mix, alongside nuclear and renewables, but further research, development and demonstration is needed before it can fulfil its potential.

4.43. Our policies are aimed at making sure we meet our ambitious targets by ensuring sufficient investment in low carbon generation while minimising costs to taxpayers and consumers. We have identified four topics for development in this area as well as closely linked issues on electricity networks (see page 32).

Evidence development areas of specific interest to DECC

i. The impact of costs on consumers

4.44. Although low-carbon generation currently requires financial support, in the longer term such investment can reduce our exposure to fluctuating international fossil fuels prices and interruptions to supply and help ensure the UK meets its carbon emissions targets. We will assess the effects of support for low-carbon technologies and other policies on consumers, and to further build our evidence base to ensure future policies are effective and provide value for money.

4.45. The changes brought about by Electricity Market Reform³⁶ (EMR) aim to work with the current electricity market – encouraging competition to help minimise the costs to consumers and deliver the necessary investment to ensure security of supply and to meet our low carbon targets. Our reforms include the introduction of Contracts for Difference (CfDs), which has been designed to provide efficient long term support for all forms of low carbon generation – including nuclear, renewables and carbon capture and storage. CfDs will provide a greater certainty and stability of revenues by removing exposure to volatile wholesale prices – and therefore protect the customer from unnecessarily paying for support when electricity prices are high. We will assess how well EMR has achieved its objectives around helping to reduce the costs of financing for low carbon developments, and maximising value for money for the consumer. The mechanisms brought about by EMR will be supported by measures to encourage new entrants and new sources of finance to the electricity market: the intention is to give customers more choice as smaller electricity companies compete alongside established firms. We will assess the accessibility of EMR to independent generators.

³⁵ Source: 2013 Digest of UK Energy Statistics, Table 5.6. Available here:

<https://www.gov.uk/government/publications/electricity-chapter-5-digest-of-united-kingdom-energy-statistics-dukes>

³⁶ For more information about the package of reforms being introduced as part of EMR, see:

<https://www.gov.uk/government/publications/electricity-market-reform-policy-overview--2>

Innovation

A core part of DECC's innovation policy is the development of Technology Innovation Needs Assessments (TINAs). TINAs for a range of technologies have been developed by the Low Carbon Innovation Co-ordination Group³⁷ (LCICG) which brings together the major public sector-backed organisations that support low carbon innovation in the UK, including DECC. TINAs inform DECC's innovation funding, much of which supports the development of technologies in 'Technology Readiness Levels' (TRLs) 4 and above.³⁸ For example:

- The Offshore Wind TINA informed DECC's decision to make available up to £15m to the Offshore Wind Component Technologies Development and Demonstration Scheme to help companies test and demonstrate technologies that can help cut deployment costs in the run up to 2020 and beyond.
- The Electricity Networks and Storage TINA informed DECC's launch of an Energy Storage Technology Demonstration Competition in 2012 offering up to £17m to develop and demonstrate innovative, pre-commercial energy storage technologies which can address grid-scale storage and balancing needs in the UK electricity network.

In addition to the above programmes, DECC works closely with the National Nuclear Laboratory (NNL) and international partners to ensure the UK remains at the forefront of nuclear technology innovation. Key collaborations include a contribution of £12.5m to the cost of construction of the Jules Horowitz materials test reactor, which is funded by an international consortium and led by CEA France, and a £1.4M contribution to NNL to lead the engagement of a consortium of UK partners in a 9 month programme of R&D to help inform future direction of the UK's nuclear energy strategy.

Building on the TINA evidence, the LCICG is now developing a Low Carbon Innovation Strategy, with the aim of publishing this in late 2013 or early 2014. The Strategy will provide a shared vision of LCICG's aims, principles, approach and priorities within low carbon technology families for public investment between now and 2020.

ii. The supply chain, economic growth, jobs and investment

4.46. The supply chain for low-carbon technologies is a key factor in their deployment. We want to help the supply chain develop in order to drive down costs and maximise the potential benefits to the UK. We will further develop and improve our understanding of the supply chain, particularly where there may be bottlenecks and blockages, to then help facilitate deployment.

³⁷ See: <http://www.lowcarboninnovation.co.uk/>

³⁸ For more information about TRLs, see:
<http://www.publications.parliament.uk/pa/cm201011/cmselect/cmsctech/619/61913.htm>

4.47. We estimate that there are low-carbon electricity investment opportunities worth up to £110bn from now to 2020. DECC's Office of Renewable Energy Deployment collates information on investment intentions announced by industry, and has recorded announcements of more than £31bn worth of investment in renewables between 2010 and September 2013, with the potential to support over 35,000 jobs. We are keen to understand growth and employment opportunities in the renewables and nuclear sectors and CCS in more detail including greater understanding of the jobs market and potential displacement effects from other industries. We are also keen to understand where any skills gaps exist, in terms of particular technologies or in types of role.

iii. Innovation and cost reduction for low carbon technologies

4.48. Technology cost reduction is crucial to delivering affordable low-carbon energy. Despite having already achieved significant reductions, especially for the more established renewable energy technologies such as solar PV, low-carbon technologies generally cost more than conventional technologies. Several recent reports have identified opportunities for cost reduction in various low carbon technologies, for example those set out for nuclear power in the Nuclear Industrial Strategy³⁹ and work undertaken as part of the TINA's (see box on innovation on page 27). We are keen to continue to develop our understanding of the opportunities for cost reductions in different technologies (including less mature technologies) and the uncertainties in this.

4.49. We anticipate that the cost of low-carbon electricity generation will continue to fall as a result of domestic and international public support throughout the innovation chain and increased deployment of these technologies. For example, in the offshore wind sector initiatives such as the Offshore Wind Cost Reduction Taskforce and Offshore Wind Programme Board have identified areas for potential cost reduction as a result of collaboration with industry. As part of the Offshore Wind Industrial Strategy⁴⁰ the Crown Estate will launch a Cost Reduction Monitoring Framework, designed to monitor cost reductions and share best practice across industry.

4.50. Carbon-capture and storage (CCS) for power generation applications is a technology that has yet to be demonstrated at commercial scale in the UK. To develop our understanding of the technical and commercial risks, DECC has a budget of £1bn to fund up to two CCS Projects. We expect to gain significant learning from engineering and design studies, which will be freely available to interested parties. This evidence base will help inform our future investment decision on proceeding to construction and policy design. In addition, informed by the work of the CCS Cost Reduction Task Force we are taking forward a range of measures to reduce the costs of deploying CCS, including our CCS Innovation Programme.

4.51. In order to inform our longer-term thinking and ensure that we are well placed to respond to any significant technological developments, we will keep abreast of understanding in other potential energy resources, such as the possible role of synthetic fuels, international solar arrays, and nuclear fission.

³⁹ See: <https://www.gov.uk/government/publications/nuclear-industrial-strategy-the-uks-nuclear-future>

⁴⁰ See: <https://www.gov.uk/government/publications/offshore-wind-industrial-strategy-business-and-government-action>

iv. Other wider costs and benefits of low-carbon power generation: communities and the environment

4.52. We recognise the importance of the wider impacts that deployment of new renewable and low carbon electricity infrastructure may have on the environment (such as impacts on marine life from offshore developments). To ensure our analysis adequately reflects these, we aim to continue to develop our understanding of the wider environmental and other impacts of deployment (including system costs, biodiversity, and air quality) and options available for these mitigating impacts. We also want to take forward our understanding of the carbon embedded in all our energy supplies, through considerations of Life-Cycle Analysis of all electricity generation.

4.53. Biomass will make an important contribution to the decarbonisation of the energy system, and needs further analysis. We intend to expand our understanding and evidence on sustainable supply, demand, innovation and alternative (non-energy) uses for biomass in order to inform both future reviews of the '2012 UK Bioenergy Strategy'⁴¹ and future policy decisions. We also want to know how to ensure land carbon stocks are monitored and protected, as pressure on land for biomass (for both energy and non-energy uses) increases in the future.

4.54. Deploying both large-scale and distributed low carbon energy infrastructure is best done with the positive participation of local communities, both for commercial developments and wholly community-owned generation infrastructure. To inform the forthcoming Community Energy Strategy that will be published in December (covering generation as well as energy reduction, management and purchasing) we commissioned review of existing evidence concerning the delivery and impact of community energy projects. The objective of the review was to draw together existing knowledge about the drivers, barriers and benefits of community energy and to identify gaps in the evidence. We would be interested in any work that sought to fill some of the evidence gaps highlighted in this review, or to establish the scale of current community energy activity in the UK.

Fossil Fuels

4.55. Fossil fuels remain the core fuels of the energy system in the UK. In 2012, nearly 90% of our total energy needs were derived from fossil fuels (gas 34%, oil 34%, coal 19%).⁴² The use of these fuels was responsible for over 80% of UK greenhouse gas emissions in 2011.⁴³

4.56. The UK oil and gas industry helps provide energy security as well as jobs. In 2013/14 it is expected to contribute around £7 billion to the Exchequer. Our policies aim to minimise our import dependence and make the most of our indigenous resources whilst minimising the impact on the environment.

⁴¹ See: <https://www.gov.uk/government/publications/uk-bioenergy-strategy>

⁴² Includes non-energy use of fossil fuels. Source: 2013 Digest of UK Energy Statistics, Table 1.1, available here: <https://www.gov.uk/government/publications/energy-chapter-1-digest-of-united-kingdom-energy-statistics-dukes>

⁴³ Source: 2011 UK Greenhouse Gas Emissions, Table 3. Available here: <https://www.gov.uk/government/publications/final-uk-emissions-estimates>

4.57. Fossil fuels also remain important in our electricity generation: coal and gas together provided two-thirds of the UK's electricity generation in 2012 (gas 28%, coal 39%)⁴⁴ and these power stations accounted for nearly a third of UK CO₂ emissions⁴⁵. The government expects that gas will continue to play a major role in our electricity mix over the coming decades, alongside low-carbon technologies as we decarbonise our electricity system. We currently expect very few coal power stations to be operational beyond the early 2020s

4.58. In order to ensure on going security of supply, and to ensure we have the right infrastructure in place to help ensure a low carbon transition, we have identified four topics for development in this area.

Evidence development areas of specific interest to DECC

i. Global fossil fuel reserves, prices and improving projections

4.59. Understanding oil, gas and coal markets (including winter gas supplies) is a critical element for ensuring the UK is well-placed to manage our energy security, particularly during times of peak demand. Our analysis in this area has four aims over the coming years: i) to continue to monitor these markets; ii) develop our intelligence in trends for domestic and international oil, gas and coal supply and reserves; iii) better understand potential supply shocks and 'slow-burning' issues; and iv) and understanding the emerging supplies coming from global unconventional oil and gas production. This analysis will also feed into our understanding and improvements in modelling of projected price movements beyond 2030.

ii. Unconventional oil and gas production

4.60. The review of the scientific and engineering evidence on shale gas extraction conducted by the Royal Academy of Engineering and the Royal Society⁴⁶ in 2012, made recommendations to regulators, operators, DECC and the Research Councils. This review concluded that the health, safety and local environmental risks associated with hydraulic fracturing ("fracking") can be managed effectively in the UK through implementation of best practice and regulation. It also recommended that further research was undertaken on uncertainties of production activities, including the impacts in the context of climate, energy and economic policies; the carbon footprint of shale gas; and public acceptability. DECC will keep abreast of the wider evidence base in these areas, as well as undertaking specific studies.

4.61. DECC has been closely monitoring analysis of and data on global production and reserves of unconventional oil and gas. This represents an area for additional work over the medium-term as new information on prospects for production and reserves become available. We will also build our knowledge of UK resources, through commissioned geological studies.

⁴⁴ Source: 2013 Digest of UK Energy Statistics, Chapter 5. Available here: <https://www.gov.uk/government/publications/electricity-chapter-5-digest-of-united-kingdom-energy-statistics-dukes>

⁴⁵ Source: 2011 UK Greenhouse Gas Emissions, Table 3. Available here: <https://www.gov.uk/government/publications/final-uk-emissions-estimates>

⁴⁶ See: <http://royalsociety.org/policy/projects/shale-gas-extraction/report/>

Following on from the first detailed study by the British Geological Survey⁴⁷ of the potential volume of shale gas contained in the rocks of the Bowland Basin, DECC has commissioned a similar study of the Jurassic shales in the Weald Basin of southern England.

4.62. DECC has published a study⁴⁸ on the potential greenhouse gas implications associated with exploration for and extraction of shale gas; and the effect of shale gas use on local and global GHG emissions rates and cumulative emissions. We are considering if any further research and monitoring is needed and what that might comprise.

4.63. DECC has a role to play in supporting public engagement by ensuring that there is access to evidence-based information which can address questions raised and inform the public debate. We will be undertaking a piece of research with Sciencewise⁴⁹ to investigate how best to explain the science and engage the public on issues related to shale gas exploration, in order to inform developing government plans on engagement.

iii. The role of downstream oil and gas

4.64. Refined oil products support our society and economy in functioning effectively by enabling the transport of people and goods, heating off-grid households with oil and liquefied petroleum gas, and the supply of feedstocks for other processes such as chemicals. We therefore need to ensure that the UK has a downstream oil supply chain that meets our demand, is resilient and supports jobs and growth.

4.65. In support of this, we aim to develop our capability to review the role of the downstream oil sector in contributing to resilience and security of product supply, including how best to manage the UK's strategic oil stocks. In addition we will continue monitoring the international downstream oil market trends and prospects globally and in the UK. A key question here is the role of domestic production and imported products in meeting refined product needs.

iv. Transitioning to a low carbon economy

4.66. Our analysis shows that under all scenarios the Government expects to see a continued need for new investment in gas plant to maintain adequate capacity margins, meet demand and provide supply-side flexibility. In the longer term gas has the potential to provide significant amounts of low-carbon electricity when fitted with Carbon Capture and Storage (CCS).⁵⁰ We need to continue to build the evidence on the barriers and drivers of investment in new combined-cycle gas turbine plant.

4.67. The existing UK coal-fired power stations will continue to play an important role in ensuring security of supply as we transition to a low carbon electricity system. To help coal play

⁴⁷ See: <https://www.gov.uk/government/publications/bowland-shale-gas-study>

⁴⁸ See: <https://www.gov.uk/government/publications/potential-greenhouse-gas-emissions-associated-with-shale-gas-production-and-use>

⁴⁹ See: <http://www.sciencewise-erc.org.uk/>

⁵⁰ See: <https://www.gov.uk/government/publications/gas-generation-strategy>

the right role in our energy mix, we will continue to monitor the economics of coal-fired power generation and the impacts of environmental regulations on the existing coal fleet.

4.68. As we progress towards a low-carbon energy future it will be important to monitor the impact of the decline in electricity generation from fossil-fuel plants on the security of electricity supply. We also wish to understand better the role of transition technologies, including natural gas combined heat and power, as steps on the pathway to a low carbon economy.

Energy Markets, Networks and Whole System Analysis

4.69. The UK relies on energy generators, networks and markets working seamlessly together to meet our fluctuating energy needs efficiently and cost effectively. In order to achieve our long term goals, in particular to decarbonise the energy system, we also need to address market failures, and expected technological changes.

4.70. In 2012 Electricity represented 19% of our final energy consumption⁵¹ and 27.3% of our GHG emissions is from electricity⁵². We have set out the Electricity Market Reform (EMR) to unlock the opportunities to decarbonise electricity. It is the biggest change to the electricity market since privatisation. EMR aims to transform the UK's electricity sector to one where low-carbon generation can compete fairly with conventional, fossil fuel generation – ensuring we build the right mix of generation for the long-term. The key mechanism will be incentives to encourage investment in low carbon generating capacity (Contracts for Difference) and to ensure reliable supply (the Capacity Market). Contracts for Difference aim to promote fair competition in this sector while delivering the stability needed for new low carbon infrastructure to come online. The Capacity Market aims to maintain a level of energy security consistent with the Reliability Standard set out in the recently-published EMR Delivery Plan.

4.71. We expect that electricity will have an increasing role in meeting our needs. It will be supplied by generators with different characteristics and locations to those currently in operation. Our needs vary daily and annually – and these characteristics will also change in the future. As a result the electricity system will face new challenges as it continually meets the fluctuating demand using adequate supply (often referred to as system balancing). These changes will impact both electricity and gas networks.

4.72. In tandem, we will also need to consider the entire energy system holistically, as changes in how we supply heat will have impacts on both the electricity and gas infrastructure directly as well as new infrastructure such as networks for captured CO₂.

We have identified four topics for development in this area.

⁵¹ Source: Energy Consumption in the UK, Chapter 1: Overall data tables, Table 1.06. Available here: <https://www.gov.uk/government/publications/energy-consumption-in-the-uk>

⁵² Source: <https://www.gov.uk/government/publications/provisional-uk-emissions-estimates>

Evidence development areas of specific interest to DECC

i. Markets and market structure

4.73. We will undertake work to understand how effectively our policies are being delivered and their impact on consumers, investors and market structure via evaluations of EMR and its components.

4.74. We will also continue to monitor the operation of the wholesale and retail energy markets in order to identify emerging trends in markets that are important for policy development. This monitoring will assess both the impacts of current policies such as the implementation of Electricity Market Reform and forthcoming changes that will impact the operation of the market. Forthcoming changes include the full implementation of Ofgem's Retail Market Reforms and their package to improve liquidity in the wholesale electricity markets; the move to a Single European Energy Market through the implementation of network and market codes developed by the European Commission; the roll out of smart metering; and the development of policies to promote demand reduction and demand-side response.

4.75. We aim to develop a deeper understanding of the state and evolution of competition, investor behaviour and business models (e.g. Energy Service Companies, power generators and developers of power generating capacity) in wholesale and retail energy markets. This will ensure our policy levers (such as Electricity Market Reform and Smart Metering) bring about the kind of transformation in the energy system we require.

4.76. The EU Internal Energy Market will become an increasingly important part of UK energy markets and will be critical in helping us meet our objectives cost effectively. Effective integration of markets across the EU, for example through 'market coupling', will help increase competition and put downward pressure on energy prices. We will therefore aim to build a clearer understanding of the opportunities the Internal Energy Market presents for the future and on the policies that may be needed to deliver these.

ii. Electricity networks and system balancing

4.77. As we seek to transform the UK into a low-carbon economy and meet our 2020 renewable energy target, the electricity system in the UK will face significant challenges. The generation mix will evolve from one dominated by large power stations providing predictable and mostly flexible electricity to a mix with a greater proportion of both variable/intermittent and constant/less flexible generation with low marginal costs for each kWh generated.

4.78. We would like to improve our understanding of the extent to which the current grid can cope with these changes so that the supply is balanced with the continually changing demand at all times. This includes challenges of increased intermittency and distributed generation, and the impact on renewable deployment, as well as the impact of any increased nuclear capacity. We wish to understand the potential contributions to system balancing to 2020 and beyond that could be made by electricity demand-side response (DSR), smart grids, interconnectors, and energy storage technologies (including heat and electric vehicles), and the implications for the practical arrangements for the system balancing.

4.79. We will improve our assessment of the network and associated costs and benefits of DECC policies. This includes the impacts of increased distributed electricity generation and demand-shifting, the impacts on constraint costs, and the role of smarter grid technologies and smart meters (and their interaction with consumers) in reducing and/or deferring network reinforcement costs.

4.80. Finally, international interconnectors will play an increasingly important role in our electricity security of supply in the future. We know from previous research⁵³ that the future operation of interconnectors to the UK is likely to be complex and the cost of electricity to consumers difficult to predict. The major issues identified include the difficulty in predicting prices due to the way flows are determined by relative price differentials at times of system stress and the impacts of changes to rules governing interconnectors and their flows. EU Network Codes currently being developed under the EU Target model, and Ofgem's proposed reform of cash out pricing under the Electricity Balancing Significant Code Review, should improve the contribution of interconnection to security of supply in the future. However, we are eager to see the external research community take forward innovative research to help us assess the possible contribution of interconnectors to security of supply.

iii. Other networks

4.81. As set out in 'The Future of Heating: Meeting the challenge',⁵⁴ we see an important role for low carbon heat networks in our towns and cities, where individual on-site renewable heating systems may be less appropriate. We are now addressing the barriers to deployment of heat networks through a Heat Networks Delivery Unit, as well as working with Local Authorities, industry and consumer bodies to understand issues around regulation, ownership and charging structures.

4.82. The Department is also working on a range of other issues including consumer protection, heat metering and network innovation. We are taking forward work to strengthen the evidence base on heat networks, including developing a heat networks model (and linking to the national housing model, paragraph 4.19), and developing the National Heat Map.⁵⁵ We are also keen to strengthen the evidence base generally to ensure network investments will deliver on claimed savings.

4.83. The gas network is a critical part of the UK energy system infrastructure. As we move towards a low carbon energy future, changes may be required in the gas network. In particular, we are keen to understand the impact electricity and heat policies will have on the gas network, and explore how the gas network may be adapted to better serve wider energy objectives.

⁵³ See, for example: <https://www.ofgem.gov.uk/electricity/wholesale-market/electricity-security-supply>

⁵⁴ See: <https://www.gov.uk/government/publications/the-future-of-heating-meeting-the-challenge>

⁵⁵ See: <http://tools.decc.gov.uk/nationalheatmap/>

iv. Whole system analysis, and the role of energy storage

4.84. In order to achieve our objectives, and as a result of our policies, our energy mix will change, and different energy vectors will be used for different purposes. We wish to improve our understanding of total primary energy requirements and vectors, especially in the context of decarbonised transport and heat sectors. This includes the potential role of hydrogen; the technical and economic potential of both heat and electricity storage (with a focus on understanding potential cost reductions – see Innovation box on page 27), and the likely implications for the electricity and gas systems; potential increases in electricity demand due to more electric vehicles and heat pumps, and the opportunities and limitations of these technologies as energy storage media.

Nuclear Legacy and Counter-proliferation Issues

4.85. Dealing with the historic nuclear liabilities, securely, safely and effectively is a key government responsibility, accounting for over half DECC's total expenditure and likely to rise. Much of the evidence in the area of nuclear legacy is generated by the Nuclear Decommissioning Authority (NDA, see box below).

4.86. As one of the pioneers of nuclear technology, the UK has accumulated a substantial legacy of radioactive waste and materials. Information on radioactive waste in the UK is published regularly through the 'UK Radioactive Waste Inventory'.⁵⁶ We have identified four topics for evidence development in this area.

Nuclear Decommissioning Authority (NDA)

The NDA is a non-departmental public body sponsored by DECC and created under the Energy Act 2004. Its core objective is to ensure that the historic civil public sector nuclear legacy sites are decommissioned safely, securely, cost effectively and in ways that protect the environment. It has the power to carry out research to support the activities for which it is responsible. For more details see the NDA's strategy.⁵⁷

Research and development (R&D) is essential for successful delivery of the decommissioning mission. This can be required to inform strategy (e.g. underpinning the strategic options for the management of the UK's stockpile of separated plutonium), deliver innovation (e.g. collaborating with the Technology Strategy Board, Engineering and Physical Sciences Research Council and DECC in developing new technologies for the decommissioning of nuclear power stations) and ensure the appropriate skills are available to deliver the mission (e.g. through working with the Research Councils and academia).

⁵⁶ See: <http://www.nda.gov.uk/ukinventory/>

⁵⁷ See: <http://www.nda.gov.uk/strategy/>

NDA and the Site Licence Companies (who are contracted to manage and operate the historic civil legacy sites) need to ensure that the decommissioning delivery plans are technically underpinned by sufficient and appropriate R&D by working effectively with the wider supply chain. The decommissioning market is currently a key funder of R&D.

The decommissioning market, both in the UK and internationally, has recently been identified as offering significant opportunities for the UK supply chain including SMEs.⁵⁸ Further work is required to understand the full potential of these opportunities and those best placed to realise them for the UK.

There are many challenges in the decommissioning field: R&D is needed to support understanding around how to provide the best solutions for site restoration, integrated waste management and spent fuels and nuclear materials management.

Evidence development areas of specific interest to DECC

i. Safe management of lower level waste

4.87. Low level waste (LLW) accounts for more than 90 per cent of the UK's waste legacy by volume though less than 0.1 per cent of the radioactivity. It is produced from nuclear facilities and non-nuclear activities (e.g. hospital use of radiopharmaceuticals) as well as through minerals extraction and processing activities. Low activity LLW may be disposed of in suitably permitted and licensed facilities, with more active LLW wastes managed in the UK Low Level Waste Repository. We will continue to monitor and evaluate the effectiveness of our policies, covering: how far the conventional waste hierarchy is adopted for radioactive waste management (notably increased waste minimisation and recycling); the stability and efficiency of the supply chain for LLW management services; and work on optimising strategic national infrastructure such as the National LLW Repository.

ii. Safe management and disposal of high level waste

4.88. The UK's higher activity radioactive waste is to be managed in the long-term through geological disposal, coupled with safe and secure interim storage, and on-going research and development to support its optimised implementation. The Nuclear Decommissioning Authority's (NDA) Radioactive Waste Management Directorate⁵⁹ (RWMD) is responsible for planning, implementing and undertaking research and development in geological disposal (see the NDA box on page 35), working with the geological disposal policy team in DECC.

4.89. Our policy of geological disposal is based on international experience, and on research carried out by the Committee on Radioactive Waste Management (CoRWM) – an independent

⁵⁸ See: <https://www.gov.uk/government/organisations/department-for-business-innovation-skills/series/nuclear-industrial-strategy>

⁵⁹ Further information about the work of RWMD, including some history of geological disposal and ongoing research and development work is available at <http://www.nda.gov.uk/aboutus/geological-disposal/index.cfm>

advisory and scrutiny body for government. Prior to 2006 CoRWM undertook an extensive research and consultation exercise, gaining input from experts and deliberative fora, the public, as well as considering different approaches to reach conclusions.

4.90. In order to implement and develop our policy of a consent-based approach to site selection (where communities volunteer to host a geological disposal facility and then work in partnership with the NDA and government to find a suitable site) we will develop our understanding on how to engage effectively with the local communities. The ways in which communities access to impartial advice and evidence will be one of the considerations in developing new approaches.

4.91. Alongside this, we recognise the need to take account of new developments in storage and disposal options, as well as possible new technologies and solutions. The NDA keeps options other than geological disposal under review.

iii. Appropriate plutonium management

4.92. Civil plutonium in the UK is currently stored pending a decision on its future management. Based on the best available evidence we announced our preferred policy that plutonium should be reused in the form of Mixed Oxide Fuel (MOX) in new nuclear build reactors. We are, through the NDA, continuing to build and test that evidence base as well as exploring what other credible options are available. At the same time we are ensuring that other related policies do not unduly impact on future options for plutonium management.

4.93. Specifically, for our preferred option we will need to show that there is a high confidence that the capability to manufacture MOX fuel can be successfully procured, that there is the availability of suitable reactors in which the use of MOX can be licensed and that acceptable commercial arrangements are in place. Similar evidence to this will be required should we decide on an alternative path, but more generally we will also have to ensure that our chosen policy can meet health, safety and environmental requirements and that it is affordable and represents value for money.

iv. Counter proliferation

4.94. To develop the 'UK Counter Proliferation Strategy'⁶⁰, we use a range of evidence sources, from classified material to publically generated information developed by non-governmental organisations. We support all three objectives in this programme: i) denying access to chemical, biological, radioactive and nuclear (CBRN) materials and expertise by terrorists; ii) preventing acquisition by states of capabilities and their means of delivery (whether conventional or CBRN) which would threaten stability and UK vital interests, including our armed forces overseas; and iii) supporting, strengthening and extending the rules-based international system of counter proliferation treaties, regimes and organisations that underpins global security and prosperity. In addition to making full use of our in-house and commissioned technical research to support our analysis, we work closely with the Foreign and Commonwealth Office and the Cabinet Office who share responsibility for quality and appropriateness of evidence used to support policy in this area.

⁶⁰ See: <https://www.gov.uk/government/publications/national-counter-proliferation-strategy-2012-2015>

Climate Science and International climate change negotiations

4.95. The UK plays a leading role in promoting international action on climate change, working through the European Union, the G8, and the UN Framework Convention on Climate Change (UNFCCC), to find ways to reach global agreement on actions to address the issue. We use world-leading science evidence to inform the development of our policies and to influence the international debate. We have identified four topics for development in this area.

Evidence development areas of specific interest to DECC

i. Develop and expand the UK Greenhouse Gas Inventory

4.96. The UK Greenhouse Gas Inventory⁶¹ enables us to monitor and report our greenhouse gas emissions. This allows us to fulfil our international reporting obligations under the Kyoto Protocol, whilst monitoring progress against our own Carbon Budgets, as set out in the Climate Change Act. We will develop the methodologies that underpin the Inventory to ensure that, wherever possible, these address the needs of UK government policy alongside those of the UNFCCC.

4.97. Our network of monitoring stations provides atmospheric concentrations data which enable us to verify our inventory estimates of UK emissions. We will develop this verification work so that it improves our understanding and quantification of UK emissions sources.

The Met Office Hadley Centre

The Met Office Hadley Centre⁶² Climate Programme is delivered under a 4-way memorandum of understanding between DECC, the UK Government Departments for the Environment, Food and Rural Affairs (Defra) and Business, Innovation and Skills (BIS) and the Met Office and its research is undertaken in partnership with the UK academic climate science community and other groups, world-wide. It is the lynch-pin of the UK's national climate science capability.

Directed by government-wide climate science evidence requirements, the Climate Programme is designed to provide DECC (and Defra) with authoritative, timely and high-quality scientific evidence and analysis to inform the UK government's efforts to counter the risks of dangerous climate change. It delivers evidence through five policy channels: Climate modelling and attribution, thresholds, energy policy and technology choices, UK and international mitigation policy, UK and International adaptation policy.

This world-leading science base gives strength and credibility to the UK's position in international climate change negotiations and enables the UK government to

⁶¹ See: <https://www.gov.uk/government/organisations/department-of-energy-climate-change/series/uk-greenhouse-gas-emissions>

⁶² See: <http://www.metoffice.gov.uk/climate-change/resources/hadley>

influence the global climate change debate. The current programme also provides information needed to inform future energy policy and the transition to a low carbon economy.

ii. Develop our understanding of the climate system and the impacts of climate change

4.98. We aim to develop a better understanding of the climate system's sensitivity to greenhouse gases. The research we sponsor and the evidence it delivers in collaboration with other research programmes helps us to understand better how the climate system works in detail, at global, regional and national scales, and possible climate futures and their impacts. It also addresses a range of related issues including for example, how climate change will affect the number and intensity of extreme weather events and the possibility of abrupt and rapid climate change such as significant methane release from melting permafrost, significant changes to monsoon systems, or to the Atlantic Ocean circulation.

4.99. Related to our understanding of the climate system is a need to understand and quantify the risks of climate change to different regions and countries including social and economic impacts. We aim to understand what might be unacceptable risks of climate change and consequent impacts, for different communities, what the world would need to do to avoid such levels of climate change, and which international and UK mitigation and adaptation actions are feasible given social, economic and technical considerations.

4.100. We will work with the United Nations Environment Programme's Programme of Research on Climate Change Vulnerability, Impacts and Adaptation (PROVIA)⁶³ to develop an international process for the assessment of the potential impacts of climate change at the country level, using a common approach and methodology.

4.101. Given the scale of the challenge we face, climate geo-engineering and negative emissions technologies are receiving increasing attention. It is vital that, through scientific research, we understand both the potential and the risks associated with such approaches. Thus, we encourage research into geo-engineering⁶⁴ and will work with the research councils and other partners to develop our understanding of the potential impact on the climate system of various proposed techniques and the significant governance issues around geo-engineering research.

4.102. Finally, the overarching questions for the second phase of the AVOID Programme (see AVOID box on page 10) are the same as for the first, but includes six refreshed areas of research, developed in consultation with policy stakeholders across HMG and with co-funders DEFRA and NERC: emissions trajectories to 2.5, 3 and 4 degrees; a comprehensive assessment of the impacts associated with these trajectories; an investigation of possible rates of decarbonisation; the feasibility of negative emissions technologies (Bio-Energy with Carbon Capture and Storage); emissions from land; and the risks to countries of imported impacts.

⁶³ See: <http://www.unep.org/provia/HOME/tabid/55173/Default.aspx>

⁶⁴ See: <https://www.gov.uk/government/publications/geo-engineering-research-the-government-s-view> for an overview of the UK Government position on geo-engineering

iii. Evidence to inform international multilateral climate negotiations and bilateral engagement

4.103. To inform bilateral engagement and wider international negotiations we will continue to undertake analysis of various countries' and non-national state actors' climate change mitigation policies and what effect these will have in limiting emissions of greenhouse gases. To do this we will need to undertake work to develop and maintain the DECC in-house Global Carbon Finance (GLOCAF) model while exploring key negotiating issues to help facilitate an ambitious and effective outcome. This will also benefit from work which helps us understand global trends and action in other countries, helping place UK action in an international context, developing best practice for the UK, and understanding how global trends might affect the UK.

iv. Effective targeting and measuring the results from the International Climate Fund

4.104. A key aim will be to develop the evidence and analysis to ensure that the UK's £3.87billion **International Climate Fund** (ICF) is targeted effectively to maximise results and deliver value for money in supporting developing countries to reduce their emissions, adapt to a changing climate and protect their forests. An important part of this work will be tracking progress and evaluating the effects of the ICF at project, country and portfolio level. We will therefore have in place effective monitoring and evaluation frameworks for current and future spend including impact results and ensuring lessons are learnt.

4.105. We will also ensure that most DECC funded projects will have an independent evaluation, and we will undertake strategic evaluations at the fund level.

5. Open policy-making, data and research in DECC

DECC collects, creates and exploits a wide range of evidence and data across its energy and climate change portfolio from a variety of sources. We are keen to share our research and data: its wider use by citizens, researcher and analysts, business and the not-for-profit sector has a vital part to play in helping us reach our goals. There are currently 51 of the Department's key data publications (see box on Statistics on page 11) available on data.gov.uk,⁶⁵ while much of the Department's analysis and commissioned research is and will continue to be published on the DECC section of the gov.uk website.⁶⁶

5.1. In designing future policies, we will aim to widen access to the data associated with or generated through policy delivery, including data from our scheme administrators. We'll explore how and whether smart meter data can provide more timely consumption data for households

⁶⁵ See: <http://www.data.gov.uk/>

⁶⁶ See: <https://www.gov.uk/government/organisations/department-of-energy-climate-change>

across the UK, in way that helps develop better policies for consumers. But we will do so carefully, particularly where commercial and personal data are concerned, to ensure we comply with the Data Protection Act and avoid releasing data that would undermine stakeholder and consumer confidence. To help manage the risks associated with sharing sensitive information, we have established a Data Access and Ethics Panel, which now decides on proposals for data sharing and reuse.

5.2. We will expand our approach to open policy making by making a presumption in favour of ensuring our new models are accessible to external users and to publish model documentation and assumptions for all DECC's business critical models (where this does not conflict with policy development, data protection or commercial confidentiality restrictions). In addition to improving transparency, this will also help others contribute effectively to the policy debate, including by developing additional analysis or tools. Building on the success of the 2050 calculator (see box below) we are developing DECC's National Household Model with a view to facilitating external engagement (e.g. using open source approaches, and web-enabling access) in the future.

5.3. The scale of change that is likely to be required to the UK in order to meet our objectives means that we must engage stakeholders and the public in the decision-making process, to ensure we have their consent to the subsequent decisions. DECC has developed the 2050 calculator (see box) as one tool to support this engagement, but other tools and approaches are likely to be required.

The 2050 Calculator

The 2050 Calculator⁶⁷ is a scenario testing tool that allows users to explore different ways of reducing UK emissions by 2050. The 2050 Calculator sets a new standard for transparency with over 150,000 people so far having used it. Both the model and its assumptions are published on the internet and worked with hundreds of stakeholders. Journalists are enthusiastic; the Guardian calling it '...probably one of the most open and transparent pieces of policy-making ever undertaken by the British government'.⁶⁸

The transparency of the UK calculator led not only to free quality assurance from global experts in the field, but also tangible diplomatic benefits. For example, the Chinese government published their own version of the 2050 calculator – a major breakthrough in transparency and Sino-UK climate change co-operation.

⁶⁷ See: <http://2050-calculator-tool.decc.gov.uk/>

⁶⁸ See: <http://www.theguardian.com/environment/blog/2012/jan/10/christopher-booker-decc-future-energy>

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