

Clean Energy Innovation in the UK and the role of the UK Energy Research Centre

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1. Introduction

In common with many other countries, energy policies in the UK have traditionally been driven by three main goals: reducing environmental impacts, including greenhouse gas emissions; maintaining or improving reliability and security; and ensuring that energy is affordable for citizens and businesses. During the past few years, these goals have been complemented by an emphasis on the potential economic opportunities of the transition to a low carbon energy system for industrial development and job creation. There has also been political controversy about the costs of energy, which has led to policy changes including a cap on electricity and gas prices paid by household consumers.

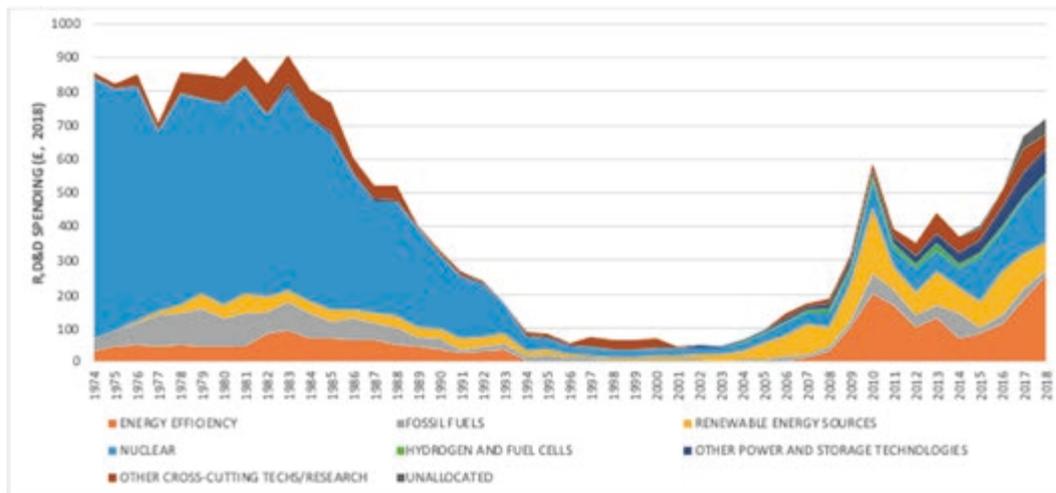
Since the early 2000s, the UK has implemented a series of increasingly ambitious targets for the reduction of greenhouse gas emissions. An initial long-term target of a 60% reduction in emissions from 1990 levels by 2050 was strengthened in 2008, with the implementation of the world's first Climate Change Act. This Act legislated a more stringent 80% emissions reduction target for 2050 alongside a series of five-year carbon budgets, designed to limit emissions over the medium term. Current carbon budgets cover the period to 2032. In June 2019, the UK became the first major economy to implement a net zero target, which requires net zero greenhouse gas emissions by 2050.

So far, the UK has made significant progress towards these targets. Greenhouse gas emissions in 2018 were 44% lower than in 1990, and the UK has comfortably met the first two carbon budgets (covering the period 2008-17). However, the government's official advisers – the Committee on Climate Change – have pointed out repeatedly that there are large policy gaps which mean that the UK is not on track to meet the fourth and fifth carbon budgets (covering the period 2023-2032) or the long term target for 2050.

Most progress to date has focused on the power sector due to the rapid decline of coal and increase in the share of renewables. Low carbon electricity from renewables and nuclear power accounted for 53% of electricity generation in 2018, with most of the rest coming from natural gas. Emissions from industry have also fallen due to industrial restructuring and some energy efficiency improvements. However, progress in other sectors has been slower or non-existent. Emissions from buildings have fallen to some extent because of energy efficiency improvements, but reductions have stalled in the last few years due to a lack of effective policy. Transport emissions have remained flat.

Innovation has been an increasingly important component of the UK's approach to energy policy and greenhouse gas emission reductions. Government funding for energy research, development and demonstration (R,D&D) has experienced a revival since the mid-2000s (see Figure 1). There have also been some successful policies for cleaner energy technology deployment that have supported 'learning by doing' innovation and cost reduction – particularly in the power sector. Whilst levels of R,D&D funding have not yet returned to those of the late 1970s and early 1980s, government is now supporting a much more diverse range of cleaner technologies than was previously the case. As Figure 1 shows, this includes much more emphasis than in the past on energy efficiency, renewable energy and energy systems (including storage).

Figure 1. UK government energy R,D&D spending (1974 – 2018)



The UK Energy Research Centre (UKERC) was established in 2004 following a government review of energy research that coincided with a greater focus on tackling climate change. This review called for the establishment of a new national energy research centre as well as a multidisciplinary approach to energy research. UKERC is publicly funded by the UK government's Research Councils, which are now part of a new body known as UK Research and Innovation (UKRI). UKERC is the flagship research centre of the UKRI energy research programme.

UKERC has a unique role in the energy research landscape in the UK. Its remit includes two main areas of activity. First, it carries out world-class interdisciplinary research into sustainable future energy systems. Much of this research is driven by real-world energy system challenges, particularly the need to transition to a net zero energy system and economy. It is designed to be directly relevant to policy makers and other stakeholders. Second, UKERC helps to build cohesion within the UK energy research community – and between academia, policy, industry and other sectors. UKERC frequently works with other, more specialist research centres that focus on specific technologies or aspects of the energy system – including centres working on bioenergy, energy networks, energy systems integration and energy demand. UKERC also acts as a gateway between UK research and international energy research, policy and other communities (see section 4 below).

2. R&D activities related to clean energy technology

UKERC does not conduct R&D on individual clean energy technologies. Such R&D is carried out by more specialist research centres throughout the UK, and by the private and third sectors. As noted in the introduction, UKERC's role is to carry out research on the whole energy system – and to work with other, more specialist centres where that is mutually beneficial. UKERC's 'whole systems' approach to energy research has three main dimensions:

- research that encompasses the energy system, including demand, networks and supply;
- research that is interdisciplinary, and draws on perspectives from engineering, social and natural sciences; and
- research that goes beyond 'traditional' energy system boundaries, and builds bridges with other research communities, such as those that focus on natural capital and resources, or poverty and social justice.

UKERC is currently at the start of its fourth five-year phase of funding. During this phase, UKERC's research programme will focus on seven main research themes:

1. UK Energy in a Global Context. The shale revolution in North America, the Paris Agreement, and the fall in the cost of renewable power and increasing emphasis on demand management and electrification of transport has changed the global context of UK's low carbon energy transition. This theme explores this changing global context and the potential implications of Brexit for the UK energy system.
2. Local and Regional Energy Systems. Many scenarios predict a future clean energy system with a high proportion of decentralised energy, locally-integrated multi-vector systems, and diverse business structures including local ownership and control. This theme explores the socio-technical parameters and potentials of this challenge, with the aim to inform decisions that serve local and whole system goals.
3. Energy, Environment and Landscapes. The trend towards energy system decarbonisation and decentralisation has created a growing awareness of the potential interactions with the environment and land use. This theme applies ecosystem service and natural capital approaches to understand the environmental implications of changes in the UK energy system, and to provide new tools for decision-makers.
4. Energy Infrastructure Transitions. Energy system change requires decisions to be made about the transformation of existing energy infrastructures and the development of new ones, all for a future in which the energy transition pathway remains uncertain. Research in this theme focuses on infrastructure resilience, finance, governance and public attitudes to change.
5. Energy for Mobility. The transport sector is responsible for 40% of UK final energy consumption, 98% of which is fuelled by oil. This theme targets areas where transport decarbonisation efforts are generating particularly acute technological and governance challenges for the energy system, especially at the local level.
6. Energy Systems for Heat. With almost half of UK energy consumption being heat related, net-zero by 2050 relies on drastic action. This theme analyses heat decarbonisation pathways at national and local levels, characterises key uncertainties, and explores challenges and opportunities.
7. Industrial Decarbonisation. This theme is exploring future pathways to the decarbonisation of industry through detailed bottom-up analysis of current and new technologies, material and project outputs, trade patterns and infrastructure. Building on previous research, the theme takes a whole-systems approach to industrial energy use and goes beyond the major energy intensive sectors.

3. Specific Research activities in hydrogen, CCUS, and related technologies

Over the past few years, the UKERC research programme has included several research projects that are relevant to hydrogen, CCS and related technologies. In many cases the roles of hydrogen and CCS are explored as part of broader energy systems research that focuses on the technical, economic, environmental and policy implications of the transition to a low carbon energy system. Further details of these projects are provided in the project information template. Current and recent projects include:

- Security of UK energy futures, including futures where CCS is unavailable (2015-18);
- Assessing potential, feasibility and impacts of bioenergy with CCS (2017-19);
- Bioenergy with carbon capture and storage, and direct air carbon capture and storage: Examining the evidence on deployment potential and costs in the UK (2018-19);
- Heat, incumbency and transformations – including the potential implications of hydrogen futures (2016-18);
- Integrated analysis of flexible low-carbon heat pathways (2017-19); and
- Decarbonising domestic heat: national and local systems (2015-19).

UKERC's planned projects that include a substantial focus on these topics are summarised in section 5, and in the project information template.

4. International collaboration

The objective of UKERC's international activities is to strengthen UK's presence as a major global player in energy research, and to provide a focal point for international collaboration. Collaborations within Europe are prioritised to their importance for the UK energy research community, and due to UKERC's official role within the European Energy Research Alliance (see below). Collaborative activities outside the EU are prioritised using specific criteria. These include whether this a priority country for UK energy policies; whether there is an engagement gap UKERC is well placed to fill; the extent to which there is a shared energy research agenda, including a critical mass of research capacity on both sides.

UKERC's international collaborations include frequent bilateral discussions with international researchers, governments and companies; and more substantive partnerships (a recent example helped develop collaborations between the UK and Mexico). UKERC also has plans to implement a new exchange programme for UK and international energy researchers.

UKERC is involved in two major international initiatives. First, UKERC represents the UK energy research community in the European Energy Research Alliance (EERA). EERA includes 17 joint programmes, most of which focus on specific clean energy technology areas. UKERC has facilitated UK participation in 13 of these joint programmes. In addition to facilitating research collaborations within the European Union, EERA also involves researchers from non-EU members such as Norway and Switzerland. A key priority is ensuring continued UK participation in EERA after Brexit.

Second, UKERC is a founder member of the Low Carbon Societies Research Network (LCS-RNet). LCS-RNet was established in 2008 with funding from the Japanese government. It originated in a UK-Japan intergovernmental workshop series to explore pathways to low carbon societies. The core members of LCS-RNet include CIRED (France), ENEA (Italy), IGES and NIES (Japan), UKERC (UK) and the Wuppertal Institute (Germany). The network's activities include an annual conference, events at UNFCCC conferences and collaborative research. UKERC's priority for collaborative research within LCS-RNet is low carbon strategies in industrial regions. This also involves IGES and the Wuppertal Institute.

5. Future perspectives

UKERC's research programme for the next five years will focus on the seven themes set out in section 2. The overall aim is to explore the challenges and opportunities for implementing the energy transition, with a particular focus on achieving a 'net zero' energy system and economy by 2050. Projects that include analysis of hydrogen and/or CCS include:

Investigating regulatory frameworks for local energy systems (theme 2, 2020-21)

Regional economic and industrial transitions (theme 2, 2020-24)

Modelling synergies and tensions between local, regional and national energy transitions (theme 2, 2019-21)

Public attitudes to heat pathways (theme 4, 2019-21)

Decarbonisation of heat in the UK (theme 6, 2019-24)

Heat systems as a source of flexibility (theme 6, 2021-23)

Heat supply in local and regional energy systems (theme 6, 2020-23)

A bottom-up, technology rich, whole systems model of industry (theme 7, 2019-22)

Professor Jim Watson

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Before joining UCL, Jim was based at SPRU from 1993 – 2018, where he was Director of the Sussex Energy Group from Dec 2008 – Jan 2013.

Jim has a degree in engineering from Imperial College London and a PhD in science and technology policy from Sussex. He has 20 years' research experience on climate change, energy and innovation policy. Major outputs include co-edited books: *New Challenges in Energy Security: The UK in a Multipolar World* (Palgrave, 2013; with Catherine Mitchell) and *Global Energy: Issues, Potentials and Policy Implications* (Oxford University Press, 2015; with Paul Ekins and Mike Bradshaw).

Prof Watson frequently advises UK government departments and other organisations. He was an advisor to the Government Office for Science for a Foresight project on energy (2007-08), and has been a Specialist Adviser with three UK Parliamentary committees. He recently chaired the UK net zero advisory group to the Committee on Climate Change.

He also has extensive international experience, including over ten years working on energy scenarios and energy innovation policies in China and India. In 2008, he was a Visiting Scholar at the Kennedy School of Government, Harvard University.

He is a judge for the Queens Awards (on sustainable development), a member of the Global Challenges Research Fund strategic advisory group and a member of the UK government's fossil fuel price projections panel.

