UK Energy 2050: the Transition to a Secure Low Carbon Energy System for the UK

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International Research Network for Low Carbon Societies
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About the UK Energy Research Centre (UKERC)

- Created in 2004. Now in *Phase 2* (2009-2014)
- Funded by the UK Government's Research Councils' *Energy Programme*
- A distributed centre, HQ at Imperial College, London
- Acts as a hub for UK energy research, to improve the cohesion of the overall UK energy research effort
- Provides a gateway between the UK and the international energy research community.
- Informs UK energy policy development and research strategy, working with policy-makers, business and other stakeholders
- Carries out a diverse programme of interdisciplinary research, with partners from over 30 UK universities and other research institutions

RESEARCH COUNCILS' energy PROGRAMME

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UKERC Organisation

John Loughhead, Executive Director

Professor Jim Skea, Research Director

Supervisory Board

Advisory Board

Research Committee

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Research Co-ordination

Research

- **Energy Demand**
- **Energy Supply**
- **Energy & Environment**
- **Energy Systems**
- **Technology & Policy Assessment**

Capacity Building

- Studentships
- International Summer School

Networking

- Research Atlas
- Meeting Place
- International Engagement
- National Energy Research Network
- Sparks
- Knowledge Transfer Network Energy Generation & Supply

Communications

- Website
- Internal/external communications

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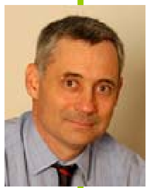
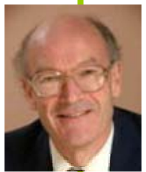
Research Themes

- **Demand**: Dr Nick Eyre, Environmental Change Institute, University of Oxford



- **Supply**: Professor Nick Jenkins, Institute of Energy, Cardiff University



- **Systems**: Professor Paul Ekins, University College London

- **Energy & Environment**: Professor Carol Turley, Plymouth Marine Laboratory

- **Technology & Policy Assessment**: Dr Robert Gross, Imperial College, London

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UKERC Research Fund

40% of UKERC's research budget is allocated through competitively-bid Research Fund. Recently funded projects include:

- Spatial aspects of bio-energy development in the UK
- Local and community governance of energy
- Carbon capture and storage: realising the potential
- Industrial Energy Demand Modelling
- Energy System Change: Public Values and Attitudes

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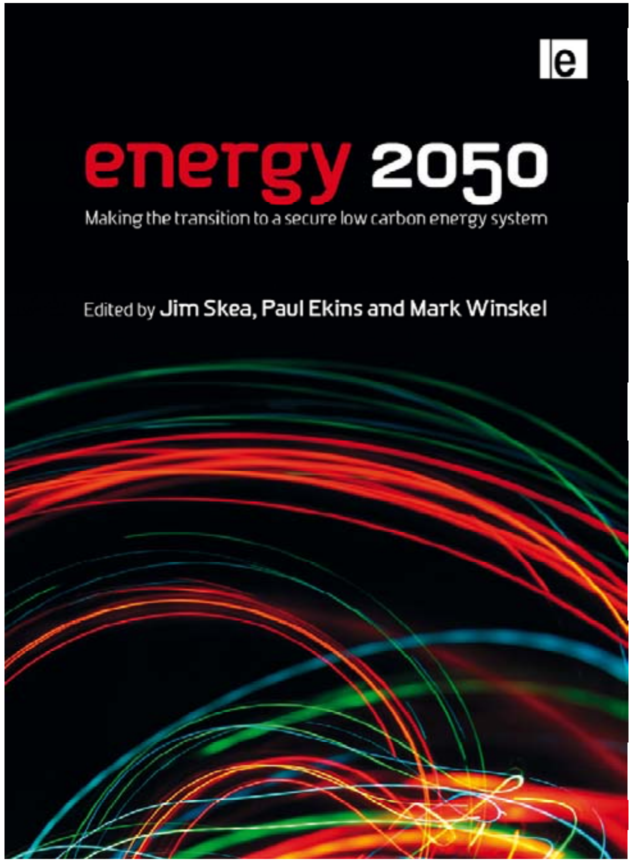
UKERC's *Energy 2050* Project (2007–09)

Showed how the UK could move towards a low-carbon energy system over the next forty years

Focused on the two primary goals of UK energy policy

- achieving an 80% reduction in carbon emissions by 2050, while…
- … ensuring that energy is delivered reliably



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The broad approach

- Not an attempt to accurately forecast the future
- Explored the choices & trade-offs associated with CO_2 reduction and energy resilience
- Combined underpinning scientific insights with integrating, modelling tools and approaches
- Made use of a range of system-level, network and sectoral modelling tools
- Different UKERC research skills collaborated within working groups

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Modelling Tools used in Energy 2050

System level models

- MARKAL Elastic Demand (MED): a technology rich linear optimisation model of the integrated UK energy system, including a wide range of supply and demand side responses

Network Industry Models

- WASP: Wien Autonomous System Planning Model -electricity generation planning (mixed integer programming)
- CGEN: Combined gas and electricity network -non-linear

Energy Demand Sectoral Models

- UKDCM: Domestic buildings carbon model
- UKNDCM: Non-Domestic buildings carbon model
- UKTCM:Transport and carbon model

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Four 'Core' Scenarios

Resilience →

Low Carbon ↓

REF Reference	R Resilient
LC Low carbon	LCR Low carbon resilient

- *Reference*: UK energy policies, as of 2007
- *Low Carbon*: follows a decarbonisation trajectory consistent with UK policy target for 80% CO_2 reduction by 2050
- *Resilient*: 'capacity of an energy system to tolerate shocks while delivering affordable energy services to consumers'
  - Defined by demand, supply diversity, adequate capacity margins and reinforcing infrastructure
- *Low Carbon Resilient*: combines together decarbonisation and system resilience criteria

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Seven sets of ‘Variant’ scenarios

- pathways to a low carbon energy system
- technology acceleration
- energy security and resilience
- lifestyle and consumption
- socio-environmental sensitivities
- global energy markets
- de-centralised energy systems

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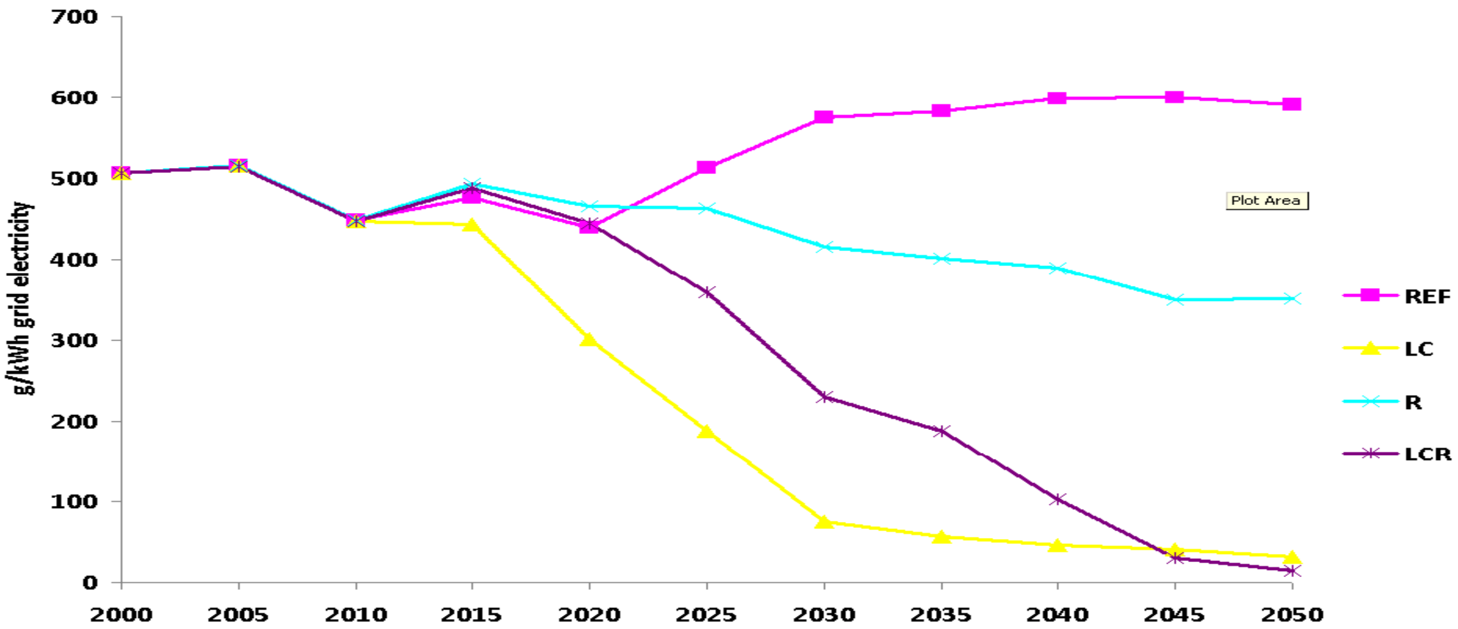
Overall messages

- Achieving a resilient low-carbon energy system in the UK is technically and economically feasible at an affordable cost.
- There are multiple possible pathways to a low-carbon economy. A key trade-off is the speed of reduction in energy demand versus the decarbonisation of energy supply.
- Reducing energy demand plays brings multiple benefits. It insures against:
  - The possible failure of key technologies to deliver
  - Public resistance to the use of certain supply side technologies
  - Price shocks and import dependence
- Aggressive promotion of energy efficiency and conservation is the least cost means of driving down energy demand, and is key to rapid initial progress

Resilience and Decarbonisation

- The goals of energy security and decarbonisation are linked but are not identical. A focus on CO_2 reduction alone could result in higher energy demand than would a resilience-driven policy
- Reducing energy demand is a key enabler of system resilience – reduces vulnerability and need for investment in supply and infrastructure
- Further investment in gas infrastructure (storage, LNG) is needed to maintain reliable supplies, as major disruptions to UK gas supply could have major impacts



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Decarbonisation Pathways

- From 2010-30, the electricity sector is heavily de-carbonised in most scenarios. After 2030, electricity decarbonisation unlocks decarbonisation in transport and buildings, using electric vehicles, plug-in hybrids, heat pumps.
- In most scenarios, electricity demand is much higher in 2050 than it is now. Exceptions to this where energy demand is heavily reduced by lifestyle changes, energy security concerns, or environmental concerns about supply options.
- Nuclear power, offshore wind and carbon capture and storage (CCS) can all play a big role in the UK electricity generation mix, though renewables deployment in many scenarios is slower than envisaged in the EU Renewables Directive
- Oil virtually disappears from the UK energy mix by 2050 in almost any 80% CO_2 reduction scenario

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Technological Innovation

- In accelerated technology development scenarios, currently emerging supply technologies play a significant role in UK energy mix after 2030
  - offshore wind, 3rd gen PV, marine, 2nd gen bioenergy, fuel cells, 3rd gen nuclear fission
- More diverse low-carbon supply portfolios, and less long-term pressure on demand reduction
- The overall cost of decarbonisation is significantly reduced, especially after 2030, up to £36bn welfare savings compared to non-accelerated scenario
  - Or, a way to decarbonise more deeply for the same overall cost to society
- Technology acceleration requires a substantially increased long-term commitment to RD&D
  - the balance between early and late RD&D, between deployment and development, respective roles of the private and public sectors and national / international efforts need careful assessment and monitoring

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Lifestyle Change Scenario

- Considers a 'lifestyle' scenario, where personal actions are aligned with socio-political goals to transform energy use in the residential and transport sectors

- mainly affects the use of oil and gas, the fuels most vulnerable to price rises and interruption

  - reduce energy demand in homes and transport by more than 50% below baseline levels by 2050

  - reduce national energy use and carbon emissions by ~30% below baseline

- increases the share of electricity in final demand, but reduces the need for massive electrification to meet tough carbon targets

- Lifestyle changes could reduce the overall cost of delivering a low carbon energy system by up to £70 billion

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Environmental and Social Concerns

- Reducing CO_2 emissions leads, for the most part, to reductions in other pressures on the environment
- The exceptions – including radioactive releases, use of water and land, some aspects of air quality – are not a rationale for inaction on a low-carbon economy, but signal areas requiring regulatory attention
- Bio-energy raises several environmental issues relating to air emissions, water availability and land use
- Public concerns about large scale supply technology expansion could significantly restrict their deployment, with increased costs of meeting CO_2 targets
  - more action may be needed on demand reduction and bringing forwards other low carbon supply technologies, including microgeneration
  - Public engagement and acceptance are a key aspect of transition

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International Context

- Many uncertainties at the international level affect UK energy system change. Most are outside the control of UK policy e.g. fossil fuel prices, biomass imports and the cost of international CO_2 emission credits
- under high fossil fuel prices, coal-fired generation using CCS has a significantly diminished role in UK decarbonisation pathways, especially when combined with system resilience
- emission credits may offer a useful source of flexibility, expected to be cheaper than domestic action in longer term
- UK decarbonisation pathways are highly sensitive to international forces, with possible doubling of welfare costs by 2050
  - need to mitigate international vulnerabilities, where possible

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Some Weaknesses and Next Steps

- Limited treatment of uncertainty
  - A series of deterministic inputs and outputs, i.e. not probabilistic
- Simplifying assumptions
  - Optimises for social welfare (sum of producer + consumer surplus) under perfect foresight, i.e. not stochastic
- Incomplete coverage
  - e.g. of enabling / radical technologies … new materials, storage technologies, smart grids, decentralisation etc.
- Weaknesses now being addressed in UKERC Phase II scenarios
  - More thorough treatment of uncertainty: stochastic and probabilistic systems modelling
  - Better representation of international aspects of UK system change
    - global TIAM energy system modelling, with UK as a defined region, allowing endogenous learning, trading permits

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Conclusions

- Energy systems are seamless webs of connected technical and social components. Changing any part of the system is likely to have consequences elsewhere
  - energy systems research tools must reflect these interdependencies, or it is likely to mislead
- Decarbonisation implies a fundamental remaking of the system, but system complexity and heterogeneity mean that no single optimal pathway can be confidently defined to respond to the challenge
  - Multiple possible responses, and scenarios illustrate a range of possible pathways and key trade-offs, under explicit and distinctive assumptions
- Policy is ultimately a matter of priority-setting though processes of deliberation and decisionmaking
  - energy systems research can support and inform this process by providing best available evidence
- Basic message is optimistic: multiple possible pathways for an affordable transition
- Realising this potential faces practical challenges not easily represented in scenarios
  - Strong, sustained and adaptive policies

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Thank You

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