Dr Jonathan Radcliffe, Senior Research Fellow, and CLCF Programme Director

FAPESP, 12 May, 2014

THE UK'S FUTURE ENERGY SYSTEM

UNIVERSITY OF BIRMINGHAM

Context - energy

"The current 'energy problem' is of serious concern to most countries in the world. The most important aspects of the problem are

a) rapidly rising oil prices
b) conflicting views about the desirability of expanding the nuclear programme
c) uncertainty about future availability of fossil fuels and
d) effects of the rising cost of energy on the standard of living

Many countries are thus in the process of making crucial decisions about energy policy. However, the nature of the energy policy choices available is not fully understood… "

The Birmingham Energy Model

Economics of Planning, 1979, Volume 15, Issue 1, pp 18-50

M. Carey, S. C. Littlechild, P. G. Soldatos, K. Vaidya, D. Basu

Department of Industrial Economics and Business Studies

University of Birmingham

UNIVERSITY OF BIRMINGHAM

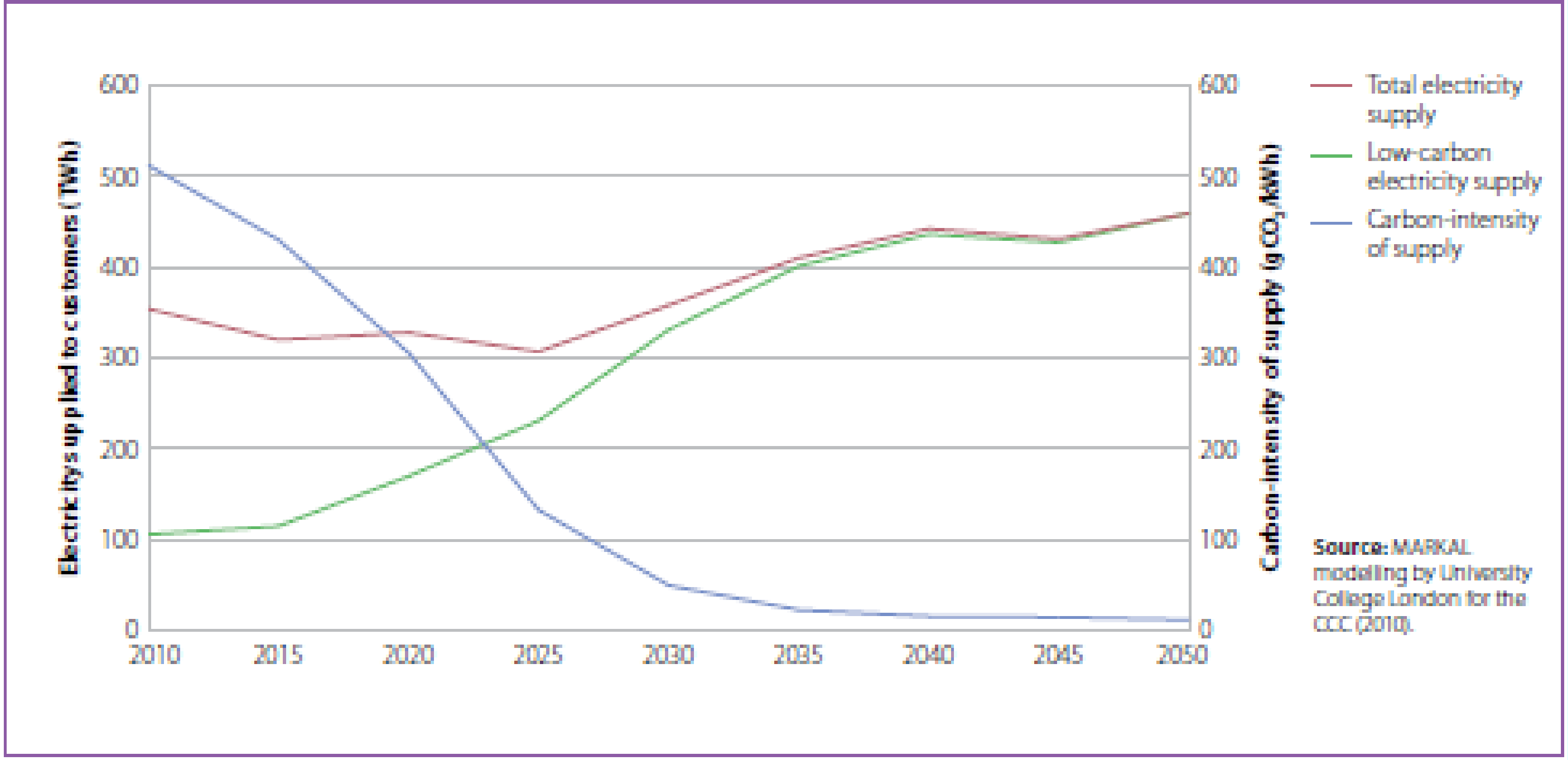
Context – climate change

- 1992 – Rio Earth Summit: United Nations Framework Convention on Climate Change (UNFCCC) treaty to "stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system".
- 1997 – Kyoto Protocol with emissions reduction targets
- 2000 – UK Royal Commission recommends 60% CO_2 reduction by 2050
- 2006 – Stern Review on the economics of climate change Policy to reduce emissions should be based on three essential elements: carbon pricing, technology policy, and removal of barriers to behavioural change.
- 2009 – UK Government accepts Committee on Climate Change recommendation of 80% CO_2 reduction target – legally binding

UNIVERSITY OF BIRMINGHAM

Committee on Climate Change

Figure 3.9: MARKAL trajectory for power sector (2010-2050)



,

scenario, enacted under the Climate Change Act – legally commits the UK to keeping emissions below the defined level.

UNIVERSITY OF BIRMINGHAM

Scenarios and models

- Scenarios: Provide insights not forecasts

‘Scenario thinking is the use of the imagination to consider possible alternative future situations, as they may evolve from the present, with a view to improving immediate and near-term decision making.’ (Hughes)

- Enable companies to plan for the future

Shell scenarios since 1970s to allow leaders ‘make better business decisions’

- Help Governments develop policy

Rigorous, evidence-based analysis and modelling is needed to underpin planning for a [low carbon] economy

Can bring communities together behind an approach, give sense of long-term direction

UNIVERSITY OF BIRMINGHAM

UKERC Scenarios

UK Energy Research Centre (UKERC), MARKAL-MED model results find:

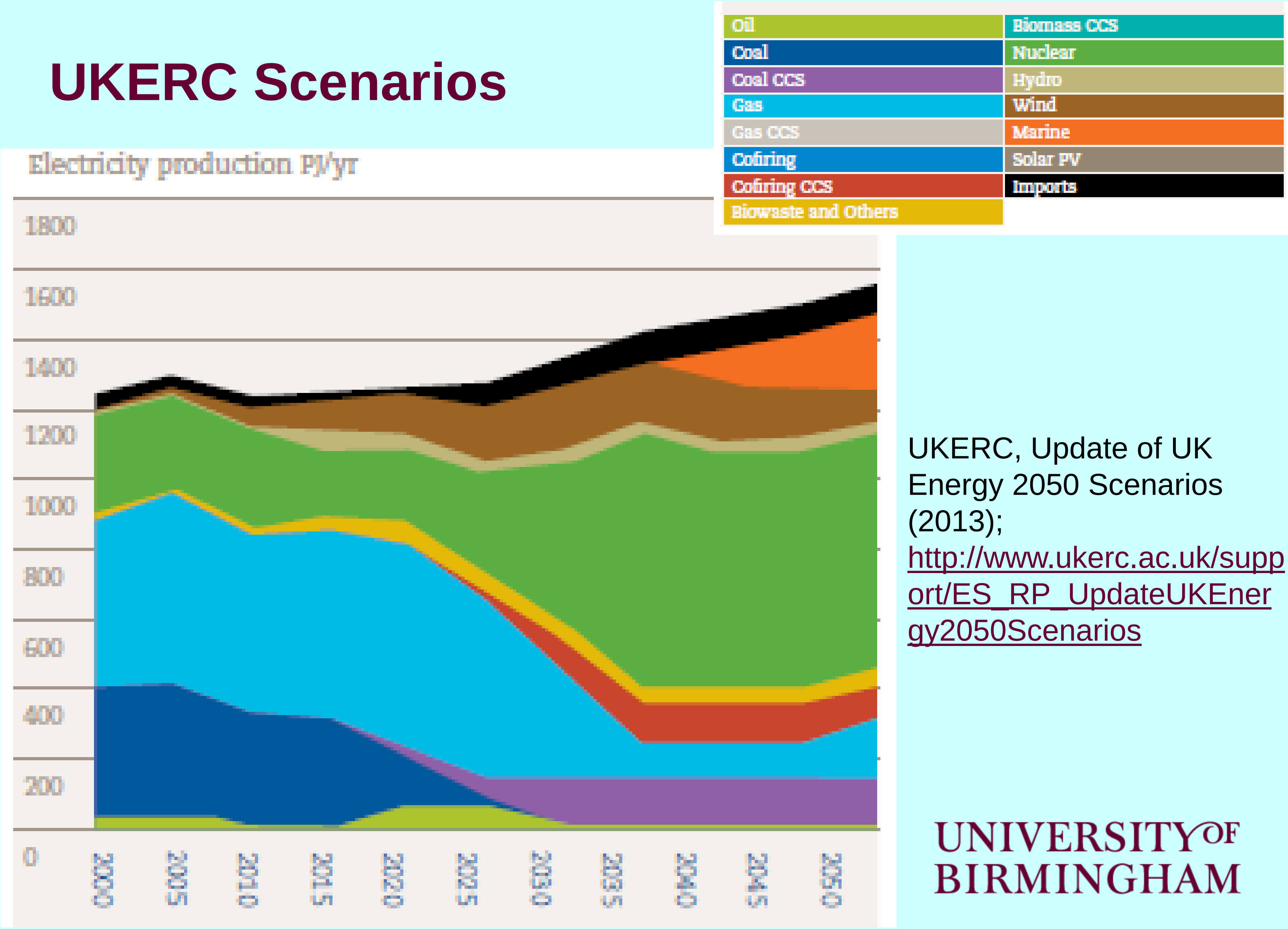
- If the UK is to meet its GHG emission reduction target for 2050 cost effectively, the UK electricity system needs to be decarbonised by 2030 by at least 80%
- Continuing uncertainty about the optimal low carbon electricity supply: nuclear, renewables, fossil with CCS
- Electrification of heat, power and transport
- Uncertain future of gas grid
- Available sustainable bioenergy not clear

Meeting the carbon emission reduction target therefore requires a wholesale transformation of the energy system

UKERC, Update of UK Energy 2050 Scenarios (2013);
http://www.ukerc.ac.uk/support/ES_RP_UpdateUKEnergy2050Scenarios

UNIVERSITY OF BIRMINGHAM

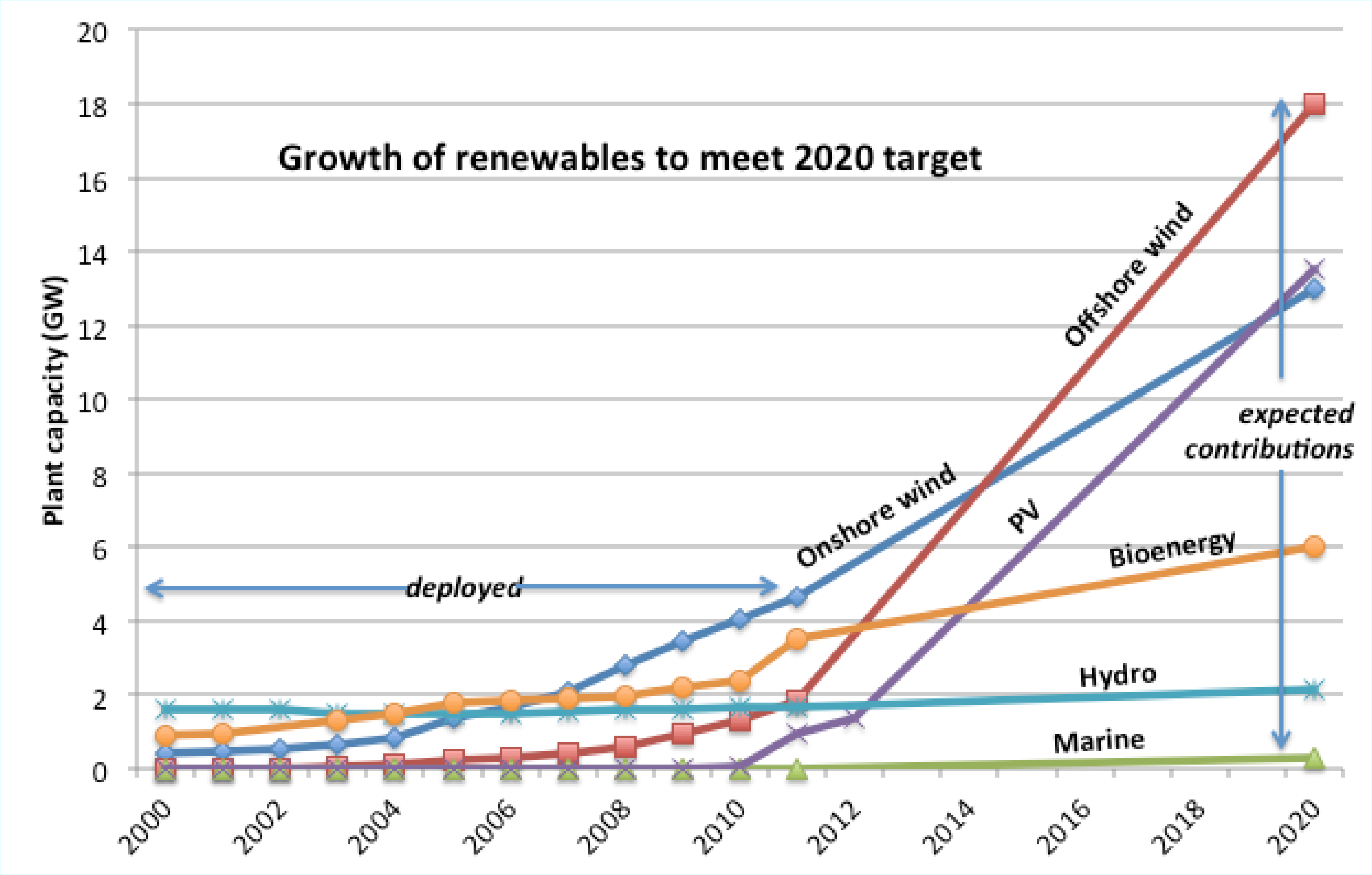
UKERC Scenarios



UKERC, Update of UK Energy 2050 Scenarios (2013); http://www.ukerc.ac.uk/support/ES_RP_UpdateUKEnergy2050Scenarios

UNIVERSITY OF BIRMINGHAM

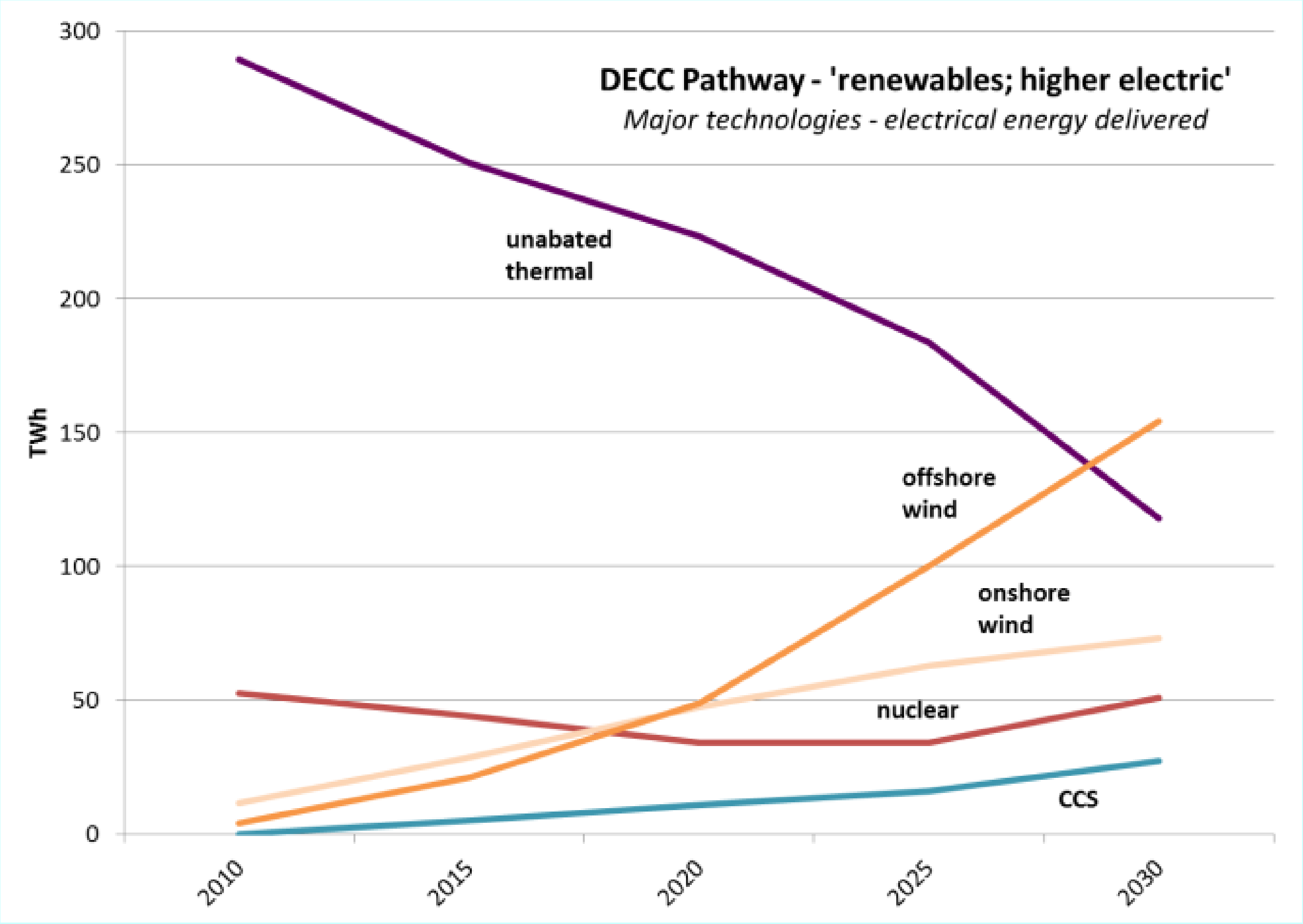
Renewables key driver to UK energy system transformation



Sources: DUKES (DECC, 2012), UK Renewable Energy Roadmap (DECC, 2009) and 2012 update, UK National Renewable Energy Action Plan (2009)

UNIVERSITY OF BIRMINGHAM

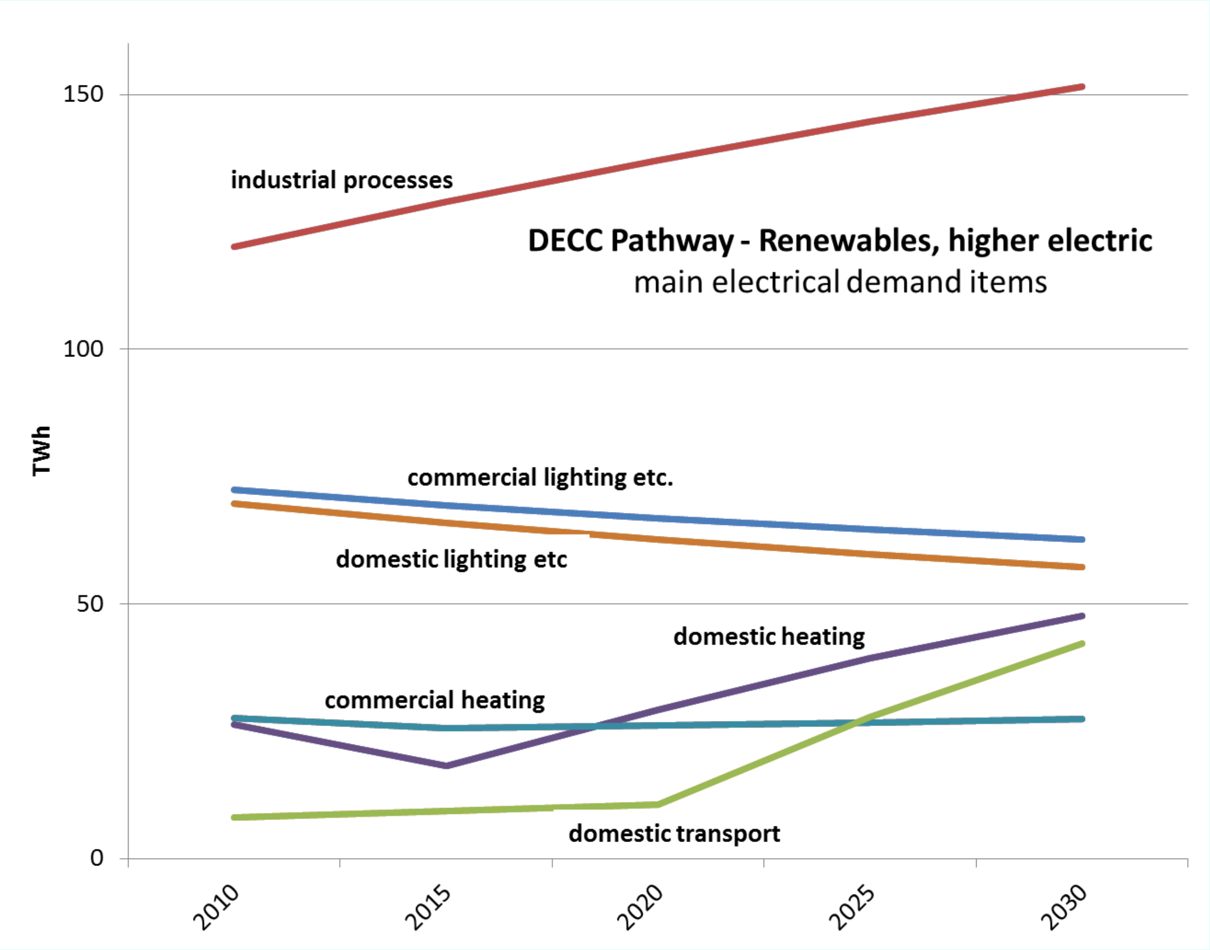
Example pathway - supply



UNIVERSITY OF BIRMINGHAM

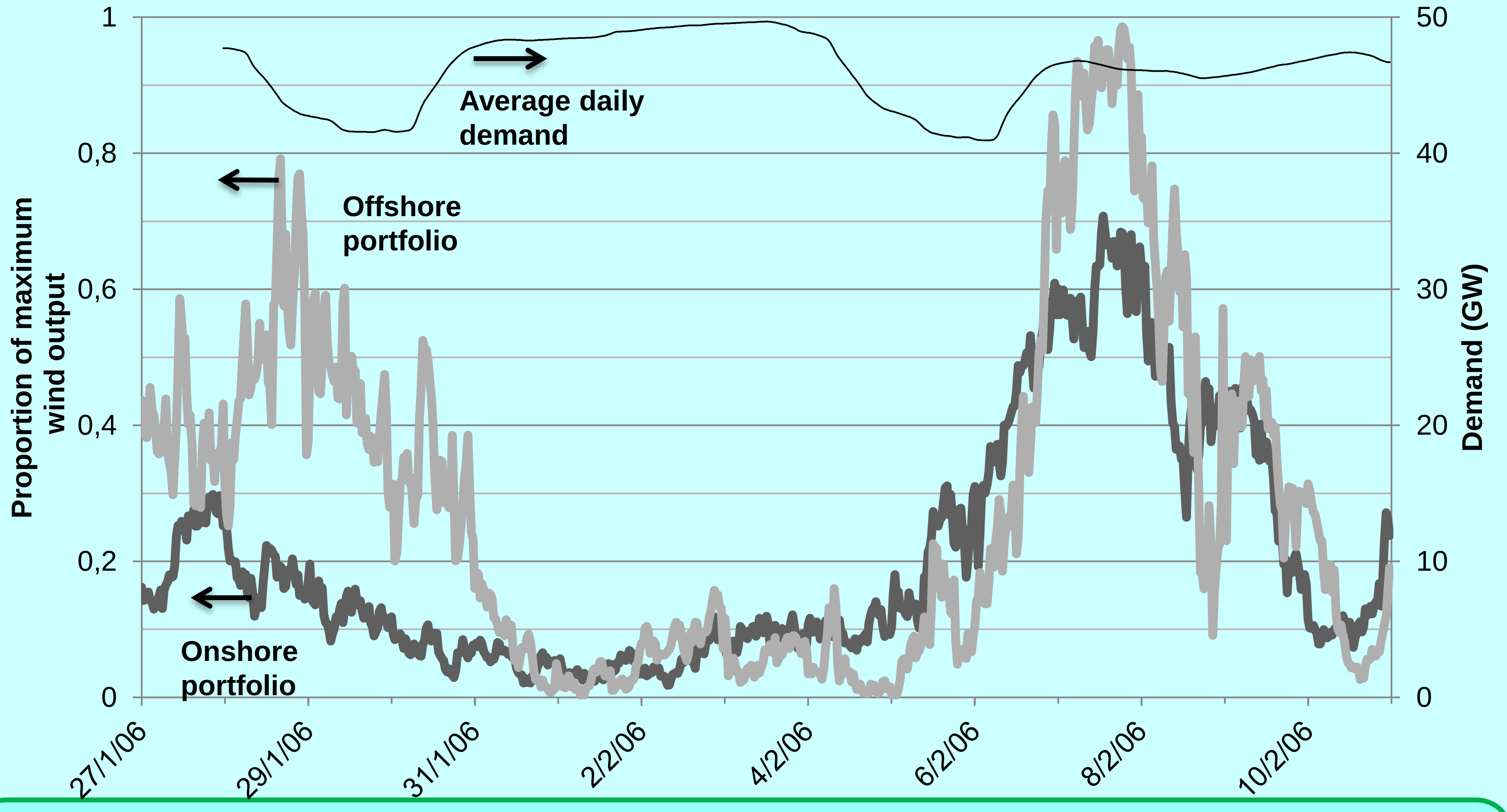
http://www.decc.gov.uk/2050

Example pathway - demand



UNIVERSITY OF BIRMINGHAM

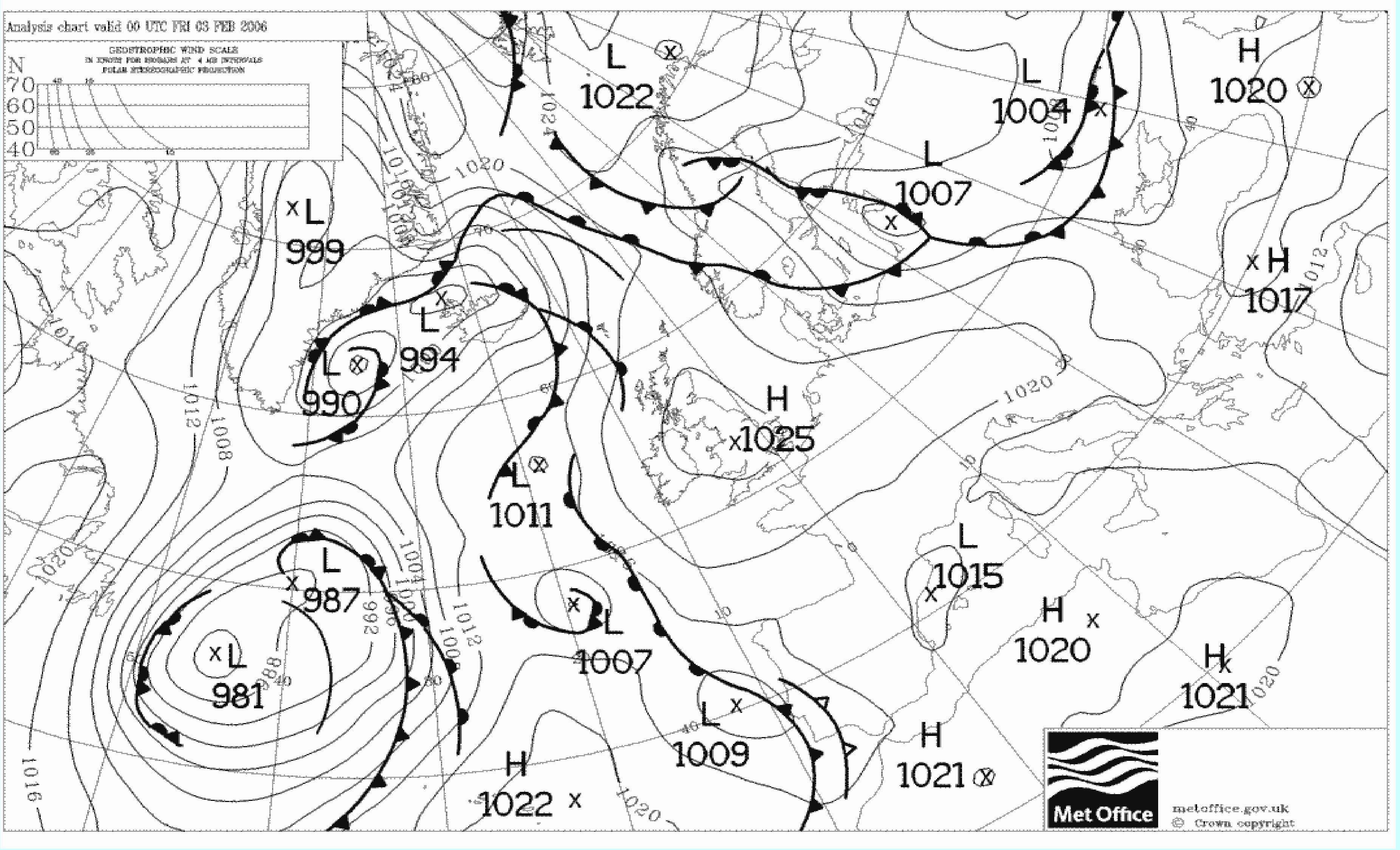
Increase in intermittent generation



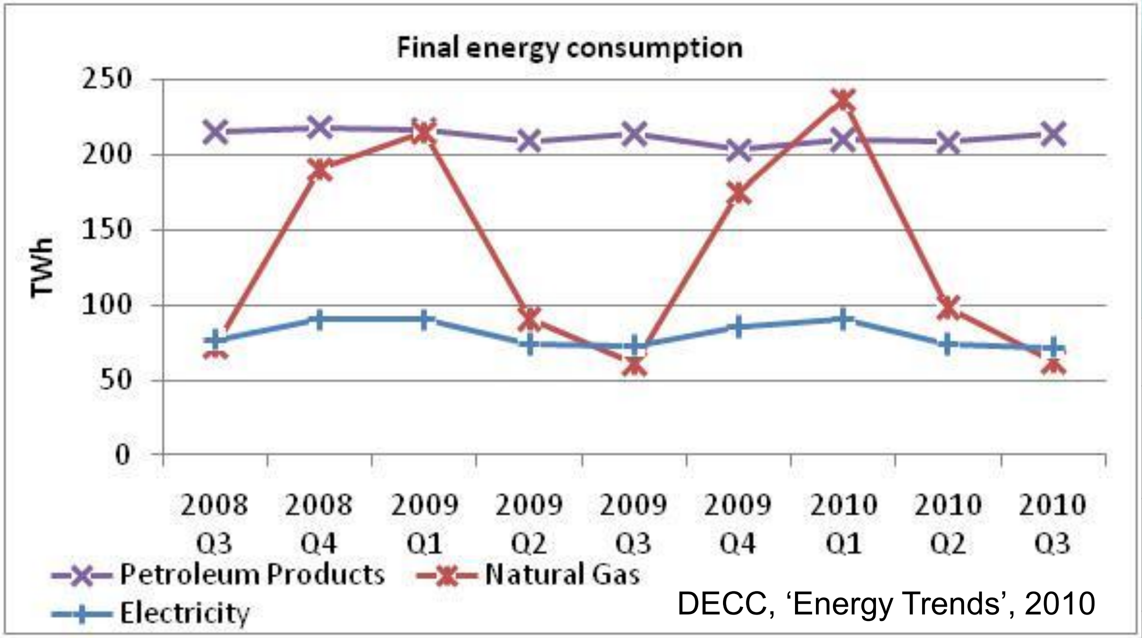
Peak demand can occur at an extended time of low wind output. Winter 2006 wind data has wind generation 6% of capacity over 5 days when demand totalled 5.7 TWh. Drop from 35% load factor is equivalent to 1TWh 'gap'. Data from E.ON.

Also short timescale variability and rapid ramping up/down.

6 February 2006…



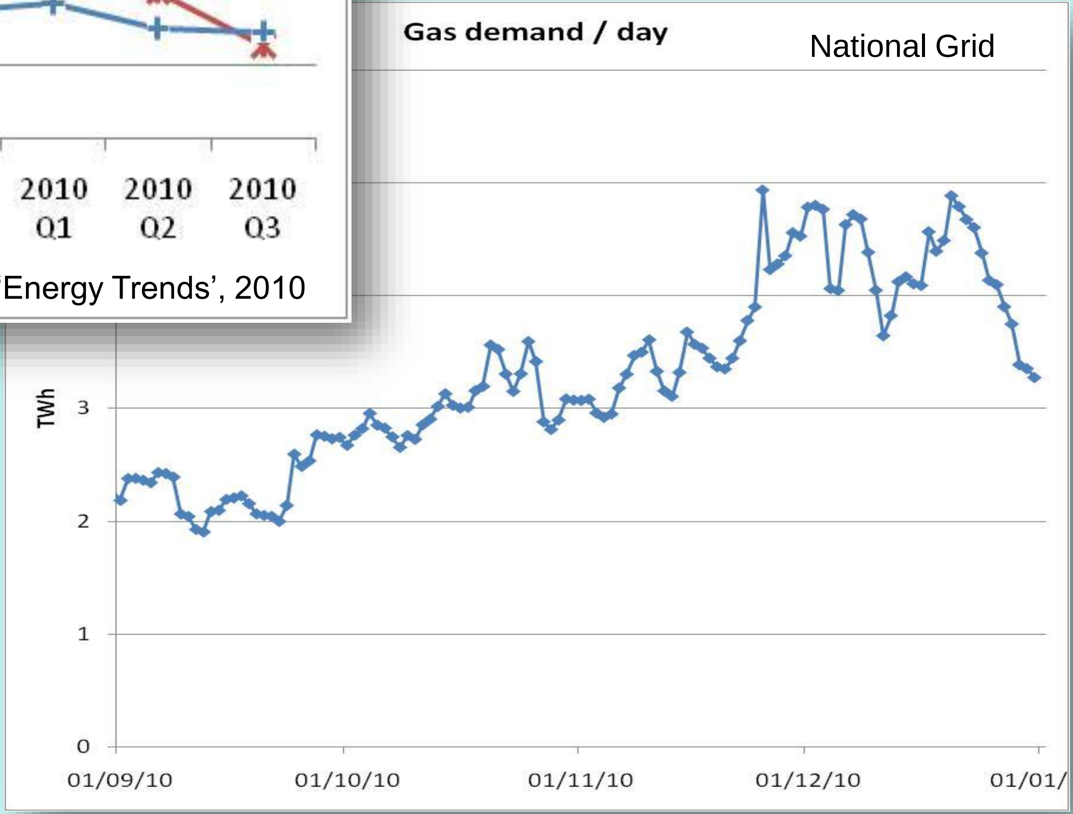
Electrification of space heating



DECC, 'Energy Trends', 2010

Current space heat demand:

- Predominantly gas (half of gas use is for domestic space heat)
- Strong seasonal profile
- Weather related variation over days
- Daily peaks

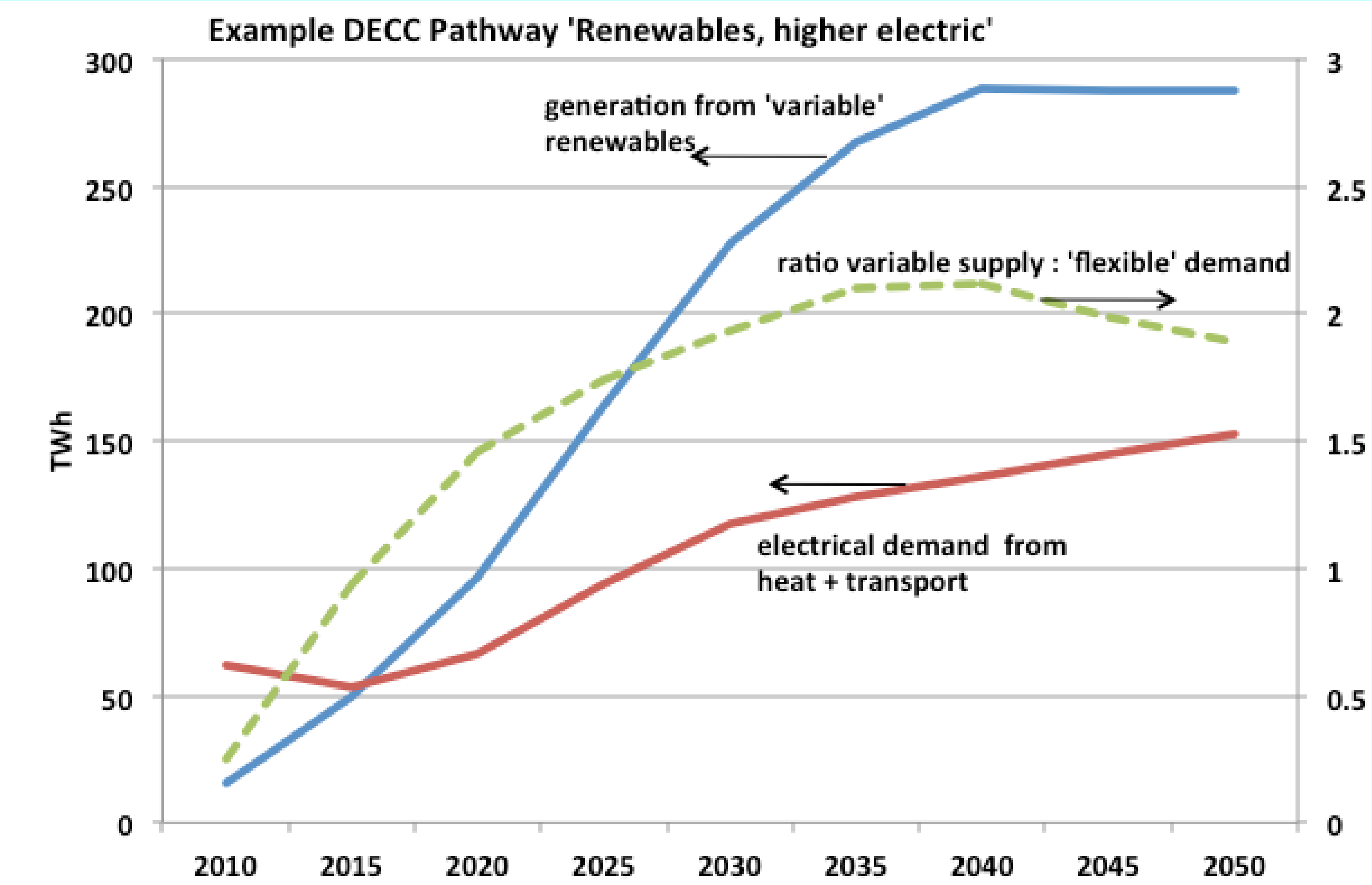


National Grid

Generation capacity to meet all electrical space heat demand in 2030 (if a smooth distribution) would be ~10GW.

Meeting spikes from weather and evening peak demand could double this.

Example pathway dynamics



- Dynamics of energy system transition could be critical to deployment of enabling technologies
- Likely that intermittent generation will expand before demand response from EV and HPs

UK Energy system need for flexibility

Main elements of UK energy system scenarios to meet 2050 GHG targets:

- Decarbonise power sector
- Increase energy efficiency
- Electrification of demand

Challenges will become more acute in pathways to 2050:

- Large proportion of intermittent generation by early 2020s
- Increase in demand for electricity for heating and transport in late 2020s

Many scenarios which have guided policy not able to treat power system balancing effectively, nor the dynamic evolution of technology deployment.

Timescale	Challenge
Seconds	Renewable generation introduces harmonics and affects power supply quality.
Minutes	Rapid ramping to respond to changing supply from wind generation.
Hours	Daily peak for electricity is greater to meet demand for heat.
Hours - days	Variability of wind generation needs back-up supply or demand response.
Months	Increased use of electricity for heat leads to strong seasonal demand profile.

UNIVERSITY OF BIRMINGHAM

Global drivers for energy system transformation

Drivers

- Increasing renewables
- Improving reliability
- Lowering costs
- Increasing access
- Greater urbanisation
- Energy security

UNIVERSITY OF BIRMINGHAM

Thoughts on future energy systems

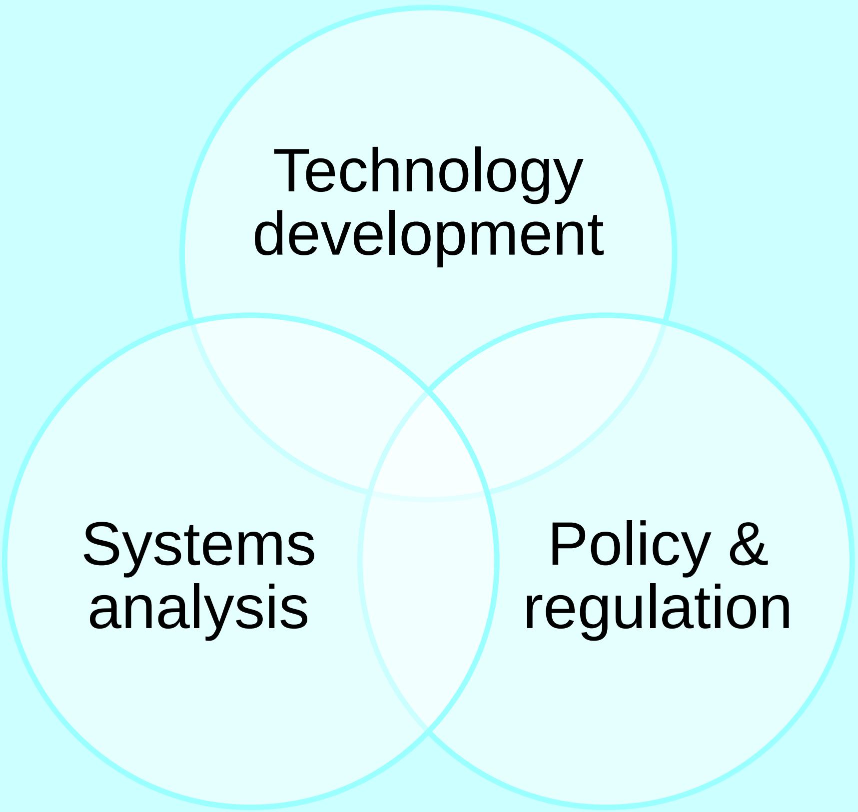
- There is now an opportunity with global energy system transformation and technological progress with increasingly sophisticated analytical tools.
- We need to deliver energy systems for 2020s+ that is fit for the longer term. The deployment rates of generation and demand side technologies in the transition (to low carbon) will be critical in determining the asset base beyond 2030.
- Analysis of the transition will allow investment in infrastructure and innovation to be well directed, and for the policy environment/market framework to be designed such that the system is delivered efficiently

To achieve the objectives we need an integrated approach…

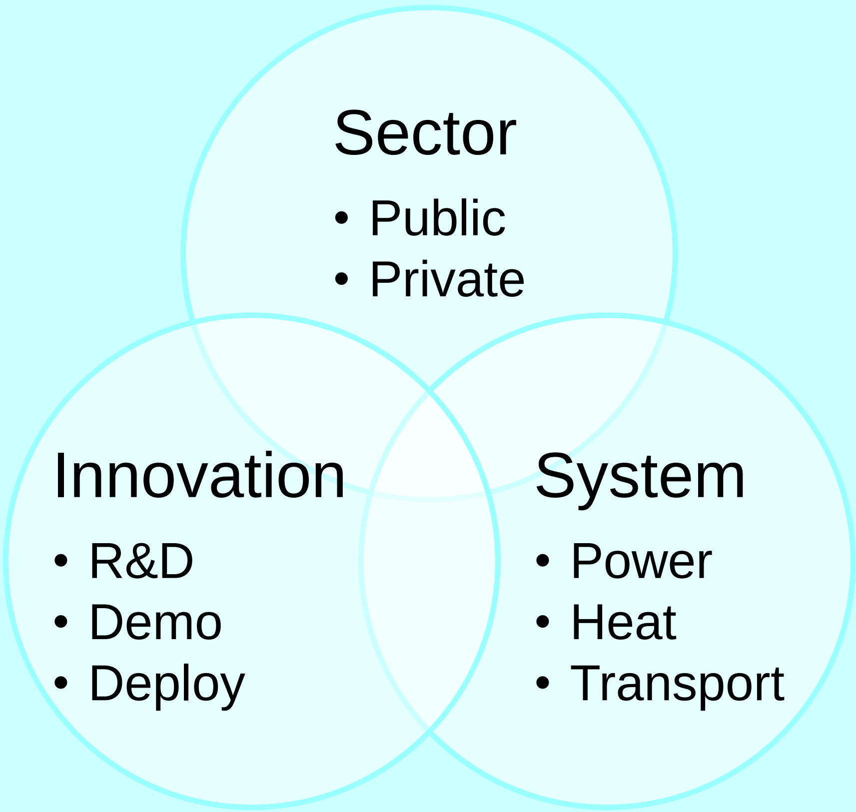
What does that mean, and what are we doing in the UK and University of Birmingham?

UNIVERSITY OF BIRMINGHAM

Integrated approaches



What we need to do



Where we need to do it

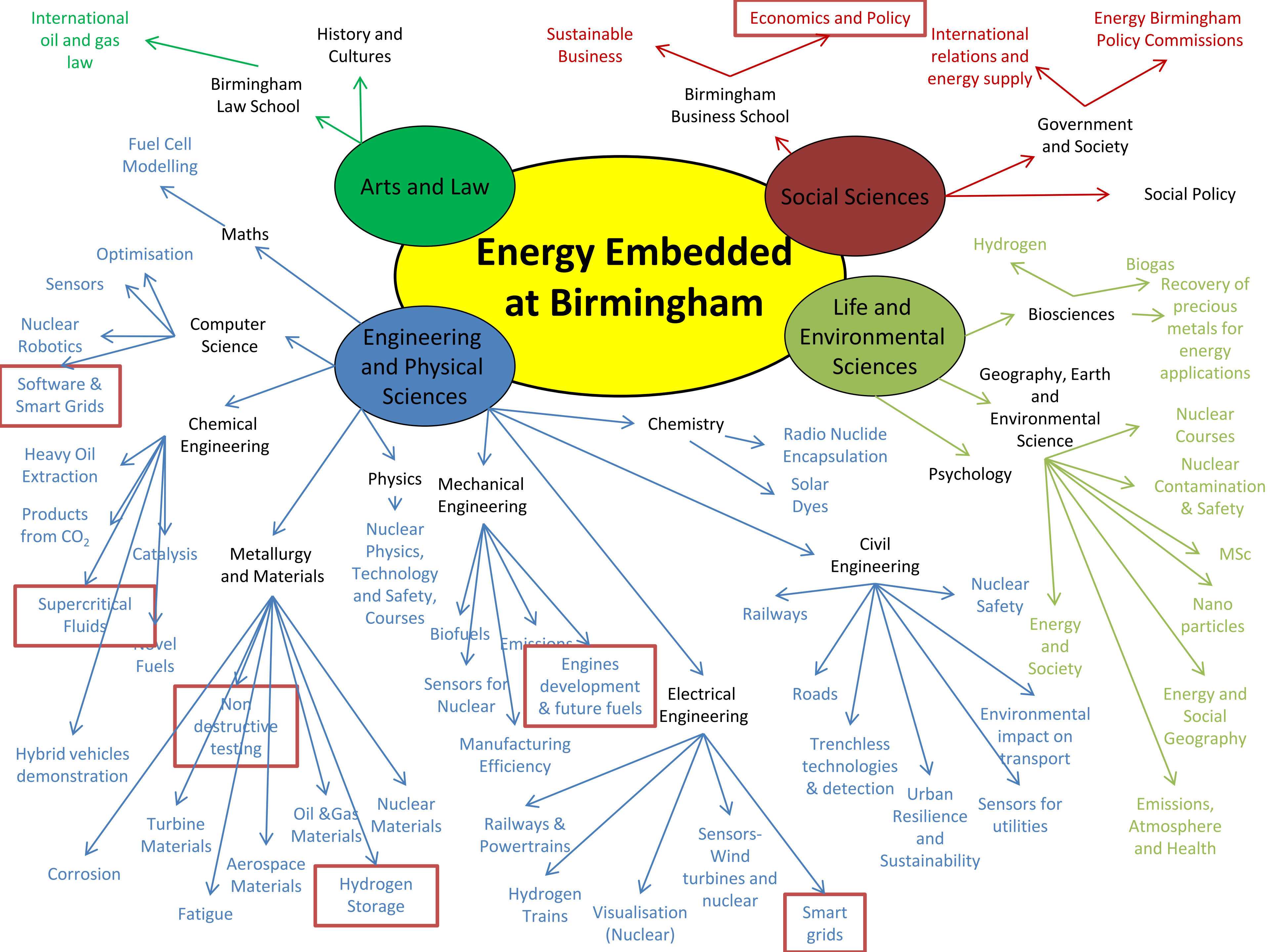
UNIVERSITY OF BIRMINGHAM

Energy at Birmingham

UoB is tackling the challenges though: (a selection of examples!)

- Research: hydrogen, energy storage, smart grid…
- Education: Doctoral Training Centres, Midlands Energy Graduate School
- Collaboration:
  - Midlands Energy Consortium (Birmingham, Loughborough, Nottingham)
  - Centre for Low Carbon Futures (Birmingham, Hull, Leeds, Sheffield, York)
  - Industry
  - Government
  - International

UNIVERSITY OF BIRMINGHAM



Energy Embedded at Birmingham
Arts and Law
Birmingham Law School
International oil and gas law
History and Cultures
Social Sciences
Birmingham Business School
Sustainable Business
Economics and Policy
Government and Society
International relations and energy supply
Energy Birmingham Policy Commissions
Social Policy
Life and Environmental Sciences
Biosciences
Hydrogen
Biogas
Recovery of precious metals for energy applications
Geography, Earth and Environmental Science
Nuclear Courses
Nuclear Contamination & Safety
MSc
Nano particles
Energy and Society
Energy and Social Geography
Emissions, Atmosphere and Health
Psychology
Engineering and Physical Sciences
Maths
Fuel Cell Modelling
Computer Science
Optimisation
Sensors
Nuclear Robotics
Software & Smart Grids
Chemical Engineering
Heavy Oil Extraction
Products from CO_2
Catalysis
Supercritical Fluids
Novel Fuels
Hybrid vehicles demonstration
Metallurgy and Materials
Non destructive testing
Corrosion
Turbine Materials
Fatigue
Aerospace Materials
Oil &Gas Materials
Hydrogen Storage
Nuclear Materials
Physics
Nuclear Physics, Technology and Safety, Courses
Mechanical Engineering
Biofuels
Emissions
Sensors for Nuclear
Engines development & future fuels
Manufacturing Efficiency
Chemistry
Radio Nuclide Encapsulation
Solar Dyes
Electrical Engineering
Railways & Powertrains
Hydrogen Trains
Visualisation (Nuclear)
Sensors- Wind turbines and nuclear
Smart grids
Civil Engineering
Railways
Nuclear Safety
Roads
Trenchless technologies & detection
Urban Resilience and Sustainability
Sensors for utilities
Environmental impact on transport

Research focus on energy storage

Flexibility becomes a critical component of the energy system.

Energy storage is a potential solution which:

- can capture off-peak or excess generation and deliver at peak times, does not compromise national security of supply, does not require behavioural change from consumers…
- …but has its own challenges as an emerging disruptive technology: cost/performance; acceptance by the wider energy sector; and
- is <u>one of UK Government's "Eight Great Technologies</u>"

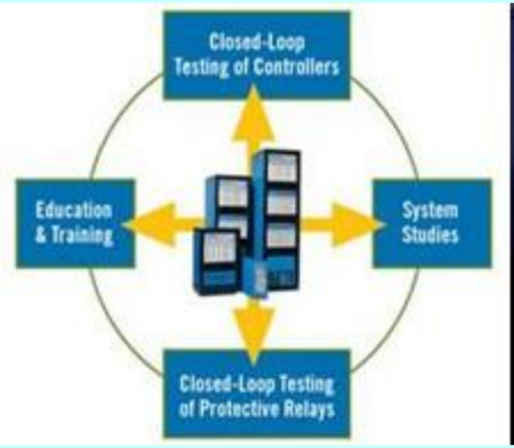
Centre for Low Carbon Futures 2050

UNIVERSITY OF BIRMINGHAM

Smart Grid

Research facilities on Smart Grid

- A smart power grid and real-time simulator that proivides the capability to realistically simulate smart power grids with the integration of distributed power generation including wind, wave and fuel cell genreation systems.
- Monitoring and control capability as well as real-time information integration, monitoring, protection and closed-loop control functions



UNIVERSITY OF BIRMINGHAM

Hydrogen Energy: Key Science Areas

Hydrogen Storage

Fuel cell testing

Hydrogen from biomass

Hydrogen hybrids

UNIVERSITY OF BIRMINGHAM

Education

Through Midlands Energy Graduate School (MEGS):

- Doctoral Training Centre in hydrogen, fuel cells and applications
  - Broad coverage of technologies
  - Socio-economic topics
  - Interdisciplinary
  - Specific research topics, but as part of wider context

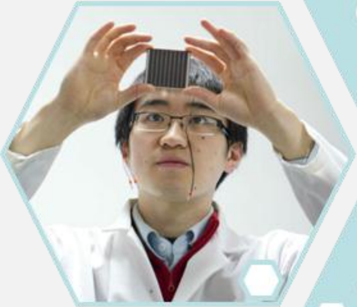
  Equipping students for careers.
- Engineering Doctorate Centre in Efficient Fossil Energy Technologies
- MSc/PG Diploma in Electrical Transportation Systems and Infrastructure

and

- Nuclear EngD fully-funded by industry

UNIVERSITY OF BIRMINGHAM

Who we are



unique collaboration

training tomorrow's energy leaders

PhD & MSc students, academics & industry

3 leading UK energy universities

Domestic partnerships

In academia:

- Midlands Energy Consortium (MEC): Universities of Birmingham, Loughborough and Nottingham; a multi-disciplinary collaboration in energy research and training
- Centre for Low Carbon Futures (CLCF): Universities of Bimingham, Hull, Sheffield, Leeds and York; collaborative membership organisation that focuses on sustainability for competitive advantage

And multiple project-level collaborations.

In policy:

- Birmingham City Council: Green Commission, Carbon Roadmap, ‘mini-Stern’
- Nuclear Policy Commission, 2012

UNIVERSITY OF BIRMINGHAM

Industrial collaborations

- Manufacturing Technology Centre (MTC)
  £40M Government investment with Loughborough, Nottingham & TWI ; industrial partners include Rolls Royce & BAE Systems
- Strategic Partnership with Rolls-Royce
  ~£30m (with Cambridge and Swansea)
- SAMULET
  - £96m (with Industrial partners and HEIs)
- Nuclear industry funds MSc

and many more…

UNIVERSITY OF BIRMINGHAM

CLCF Energy Storage Centre

Centre for Low Carbon Futures 2050

- Multi-university research partnership, drawing on expertise from Universities of Birmingham, Hull, Leeds, Sheffield, York
- Integrated innovation, covering
  - Technology, policy and business
  - Research, development, demonstration, deployment
  - International collaboration
- Energy storage programme since March 2013
  - Published Energy Storage/Liquid Air reports
  - Enabling collaborative research
  - Informing policy makers
- Other activities on cities (mini-Stern reviews), CCS (PACT: Pilot-scale Advanced Capture Technology), nuclear (small modular reactors)
- UoH MoU with USP; UoY working with Raizen on biofuels

Concluding remarks

- Enabling the transition to a low-carbon society is a key element for the University of Birmingham.
- We are building research capability, and using existing expertise from a wide range of disciplines.
- Education and training
- High level of ambition which we will achieve in partnership with others.

Though energy systems are different, the responses to the challenges we will face over coming years can be similar.

Welcome the opportunity to develop links: identifying areas of research and training in which we can work together.

UNIVERSITY OF BIRMINGHAM

THANK YOU

j.radcliffe@bham.ac.uk

UNIVERSITY OF BIRMINGHAM