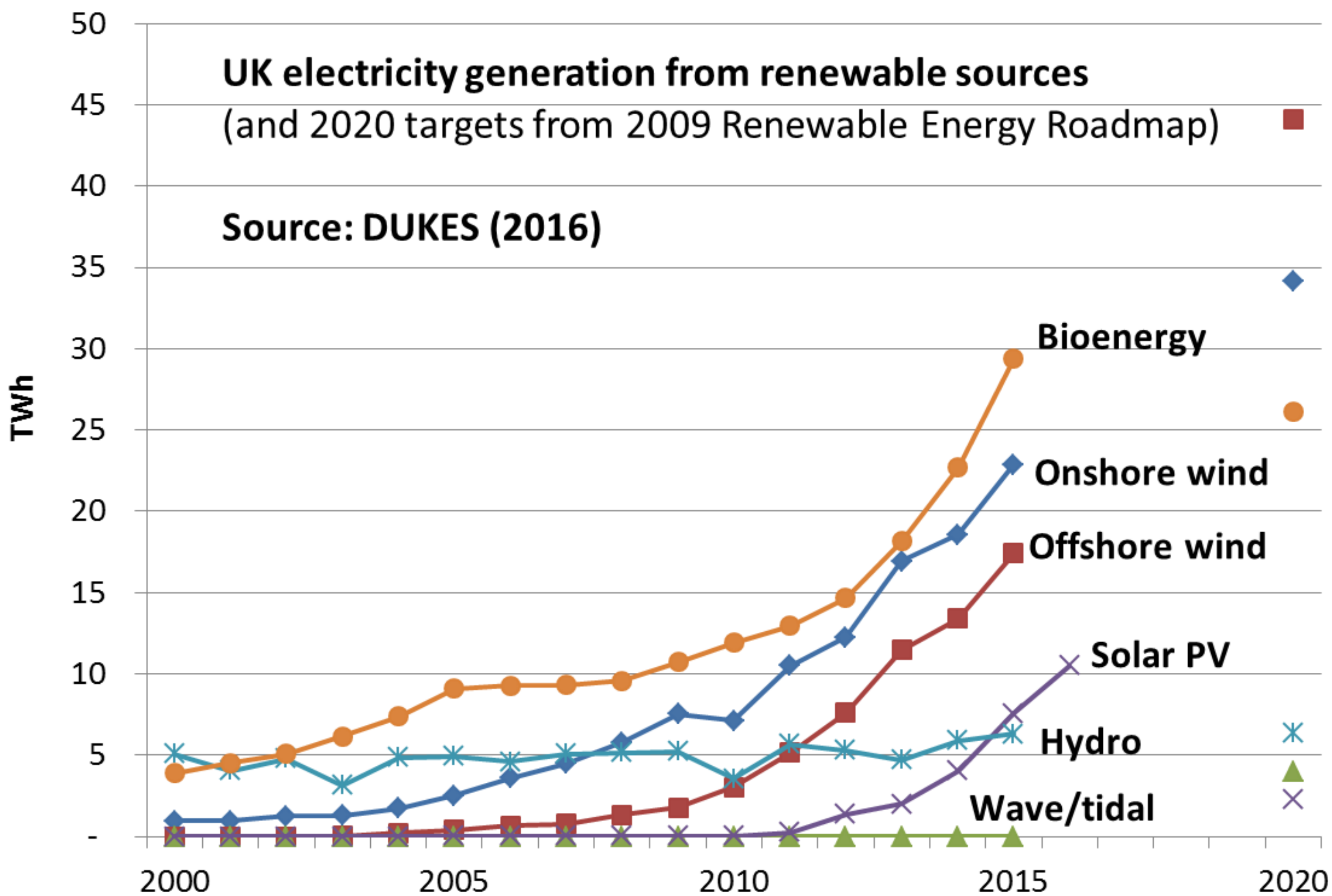
UNIVERSITY OF BIRMINGHAM | COLLEGE OF ENGINEERING AND PHYSICAL SCIENCES

Energy innovation and policy

Jonathan Radcliffe, Senior Research Fellow

IEA EGRD meeting, Birmingham 15 June 2017

Recent decarbonisation of electricity in the UK

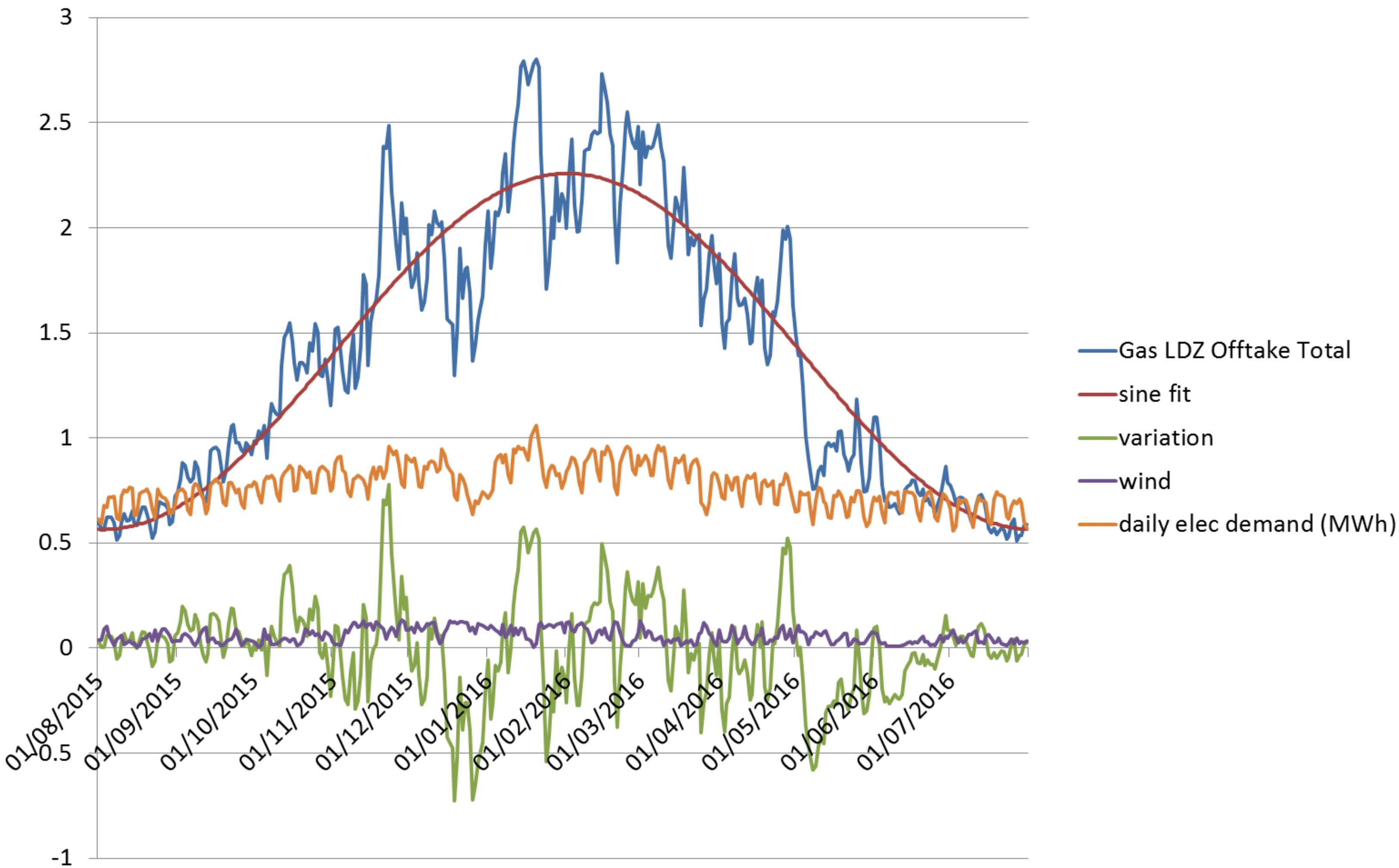


Latest projections for 35% of electricity from renewables by 2020

But missing targets for heat and transport…

Sources: Digest of UK Energy Statistics (DECC, 2016)

Electricity and gas in the UK



Source: National Grid

UK Energy system need for flexibility

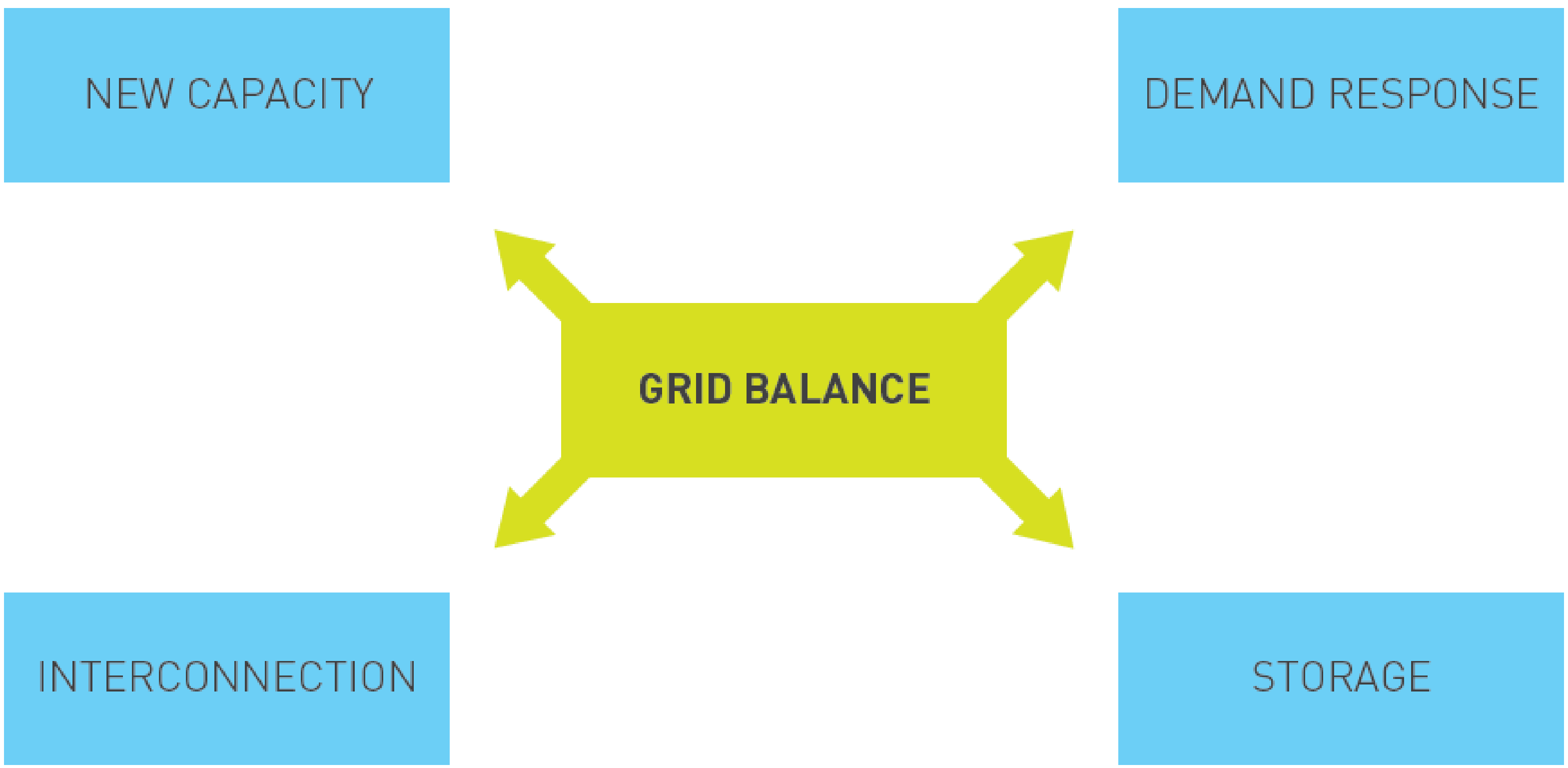
Challenges will become more acute in pathways to 2050 and will emerge at different times:

- 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.

Options for providing flexibility



Source: Taylor, P.G., Bolton, R., Stone, D., Zhang X-P., Martin C., Upham, P. (2012). Pathways for Energy Storage in the UK. Centre for Low Carbon Futures.

Existing energy storage in the UK

Coal: 1Mt coal = 3,000 GWh_e
(about two months output at 2GW)

Current gas storage ~50,000 GWh

Pumped hydro storage:
total UK = 28GWh_e

Hot water cylinder:
one tank = 6kWh_{th};
14m tanks = 84GWh_{th}

Applications and technologies

Application description	*Scale of storage*	*Technology options (red indicates future potl)*
Domestic scale energy storage for domestic peak shaving	2-5 kW 4-10 kWh 2-8 hours	• Li-ion/lead-acid batteries • Thermal ES
District scale energy storage for peak shaving, deferring distribution n/w reinforcement	50-500 kW 200 kWh –2 MWh 2 – 8 hour	• Li-ion/Pb-acid/NaS batteries, H2, flow batteries • TES with heat network • Cryogenic ES (CES), Superconducting Magnet ES (SMES)
District scale energy storage for balancing microgrids and renewables integration	200 kW – 1 MW 1-10 MWh 6 – 12 hours	• NaS/Pb-acid batteries, Hydrogen, flow batteries • TES with heat network • CES, SMES
District scale seasonal energy storage	200 kW – 1 MW 100's MWh months	• Thermal energy storage - underground hot water/rock storage • PCMs, hydrogen
Large scale storage for renewables integration	10 – 200 MW 100 MWh–2 GWh 12 – 48 hours	• PHS, CAES, Hydrogen, flow batteries • Punped Thermal ES (PTES), CES, A-CAES
Energy storage for spinning reserve	5-500 MW 10 MWh – 1GWh 24 hours – weeks	• PHS, CAES, flow batteries • PTES, CES
Centralised large scale grid storage for wind integration	1-10 GW several GWh days - weeks	• PHS • PTES, CES, H2

Smart power?

<u>‘Smart Power’, National Infrastructure Commission (2016)</u>

“The Commission’s central finding is that smart power – principally built around three innovations, interconnection, storage, and demand flexibility – could save consumers up to £8 billion a year by 2030, help the UK meet its 2050 carbon targets, and secure the UK’s energy supply for generations.”

“Crucially, storage technology will not need subsidies to be attractive to investors – businesses are already queuing up to invest.

Regulation, on the other hand, does require attention. When our electricity markets were designed these technologies did not exist.”

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A New Approach to Energy Storage

Isentropic Ltd develops and commercialises class-leading energy storage systems that allow utilities to profitably manage the evolving power generation landscape.

Isentropic Ltd was established to develop Pumped Heat Elect… energy storage system based on a novel, high efficiency recipr… thermal stores. The development of the thermal stores has le… opportunity for energy storage integrated into gas power pla… Storage.

The influx of renewables and the imminent retirement of bot… less stable grid requiring both energy storage and additional flexible power generation.

Gas Power generation is the solution to this issue, providing it is supported by *Isentropic* technology. Our technology allows a gas plant to remain available at all times to the grid, give a

Isentropic Ltd is in administration. Mark Robert Fry and Kirstie Jane Provan were appointed as joint administrators of Isentropic Ltd on 22nd January 2016.

Plus ça change…

"Government must stimulate research into solving the problems that large-scale intermittency and embedded generation would pose to the electricity supply system as a matter of urgency."

"We recommend that the Government promote research and development into new technologies for large-scale energy storage, possibly on a collaborative basis in Europe."

'Energy — The Changing Climate', Royal Commission on Environmental Pollution (2000)

Regenesys – 100MWh flow battery, development cancelled by RWE in 2003

Overcoming barriers to deployment of energy storage

- Technology cost and performance: other technologies are currently cheaper
- Uncertainty of value: the future value is dependent on the energy system mix
- Business: capturing multiple revenue streams is difficult to establish, both for a potential business and the market in which it will operate
- Markets: the true value of energy is not reflected in the price; more fundamentally, the future long-term value of storage cannot be recognized in today’s market
- Regulatory/policy framework: restrictions on ownership; paying levies twice
- Societal: wider community acceptance has not yet been considered

Energy storage innovation

Innovation frameworks

- Technology Innovation Systems
  - Structure and function
- Multi-level perspective
  - Strategic niche management
- Co-evolutionary perspective

Literature suggests:

- Analysis of innovation needs to go beyond considering the technology itself
- Both the structure and function of innovation systems are important
- Path dependency and lock-in can be significant barriers
- Innovation systems take time to form – especially for radical disruptive technologies

From Taylor and Radcliffe, paper presented at the 2016 BIEE Research Conference "Innovation and Disruption: the energy sector in transition"

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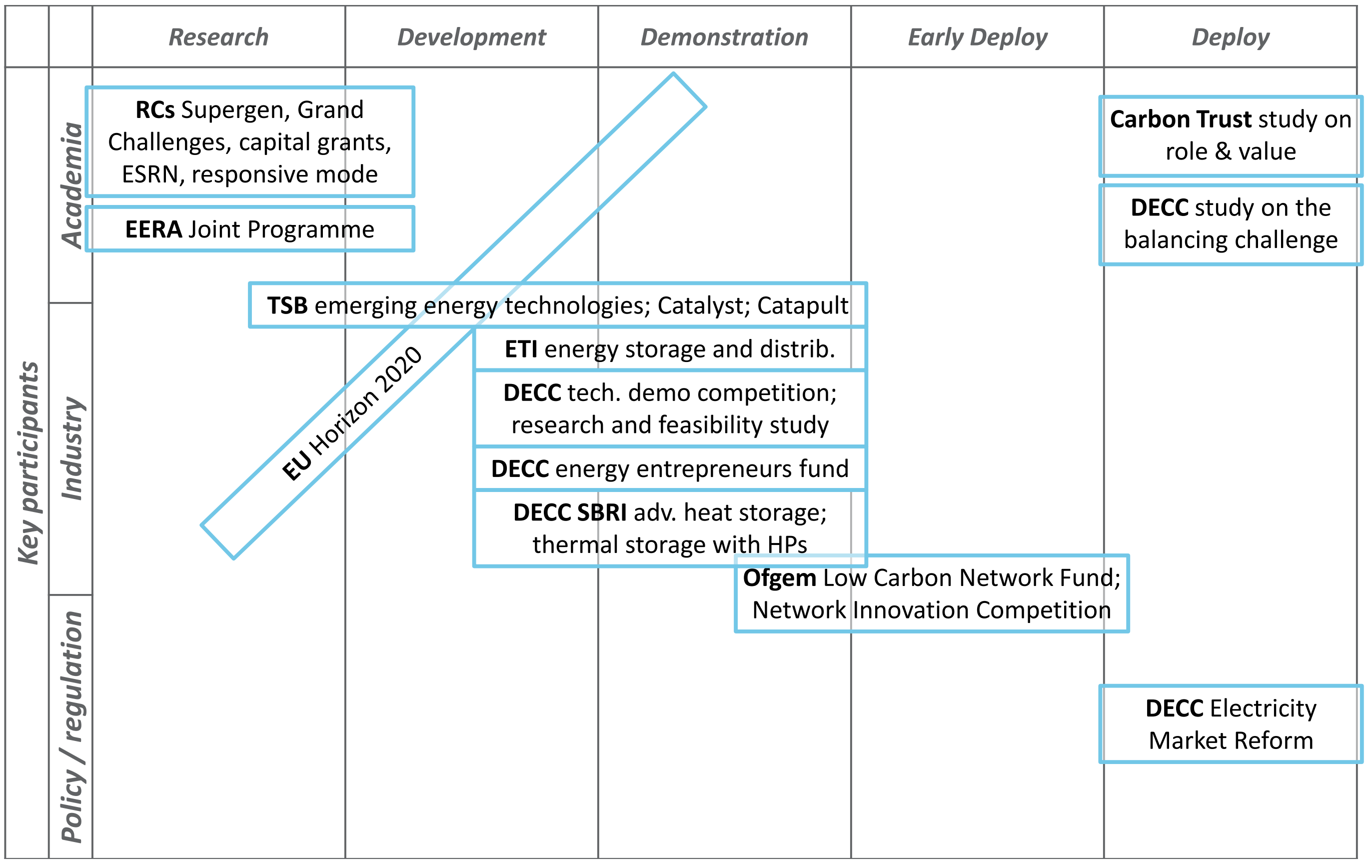
UK energy storage innovation landscape



Source: Radcliffe, J; Taylor, P; Davies, L; Blyth W; Barbour, E (2014) Energy storage in the UK and Korea: Innovation, investment and co-operation. Centre for Low Carbon Futures

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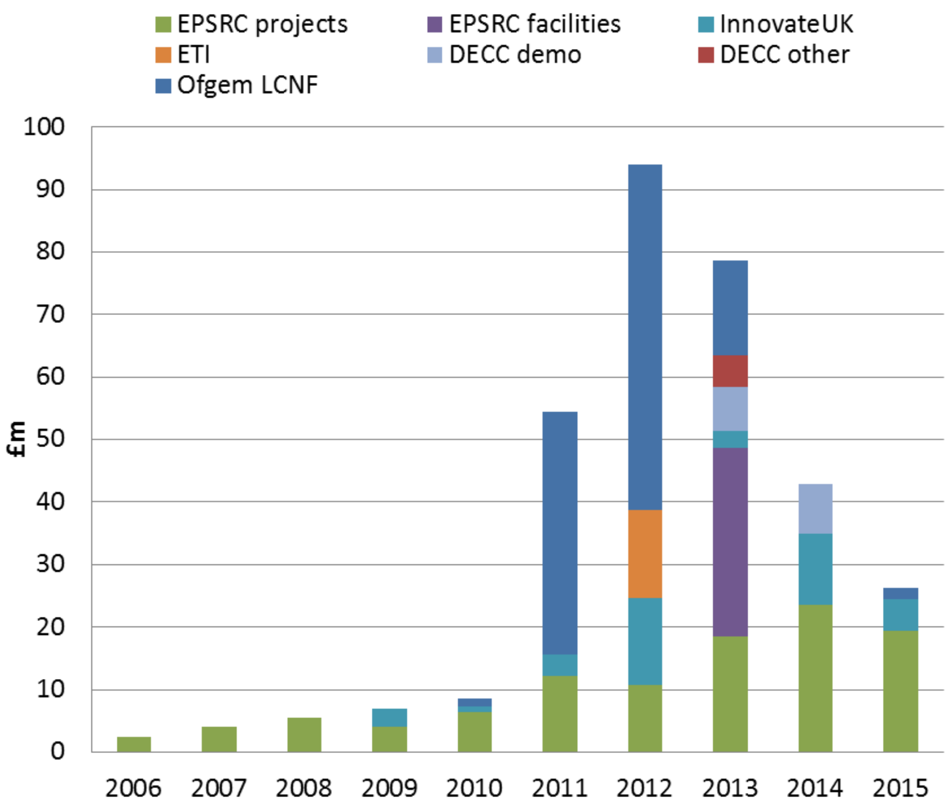
UK public sector funding for energy storage technologies



Source: UKERC Research Register

IEA energy category	Funding 2000 – 2009 (£k)
Energy storage	7,551
Wind energy	25,816
Solar energy	37,721
Ocean energy	39,511

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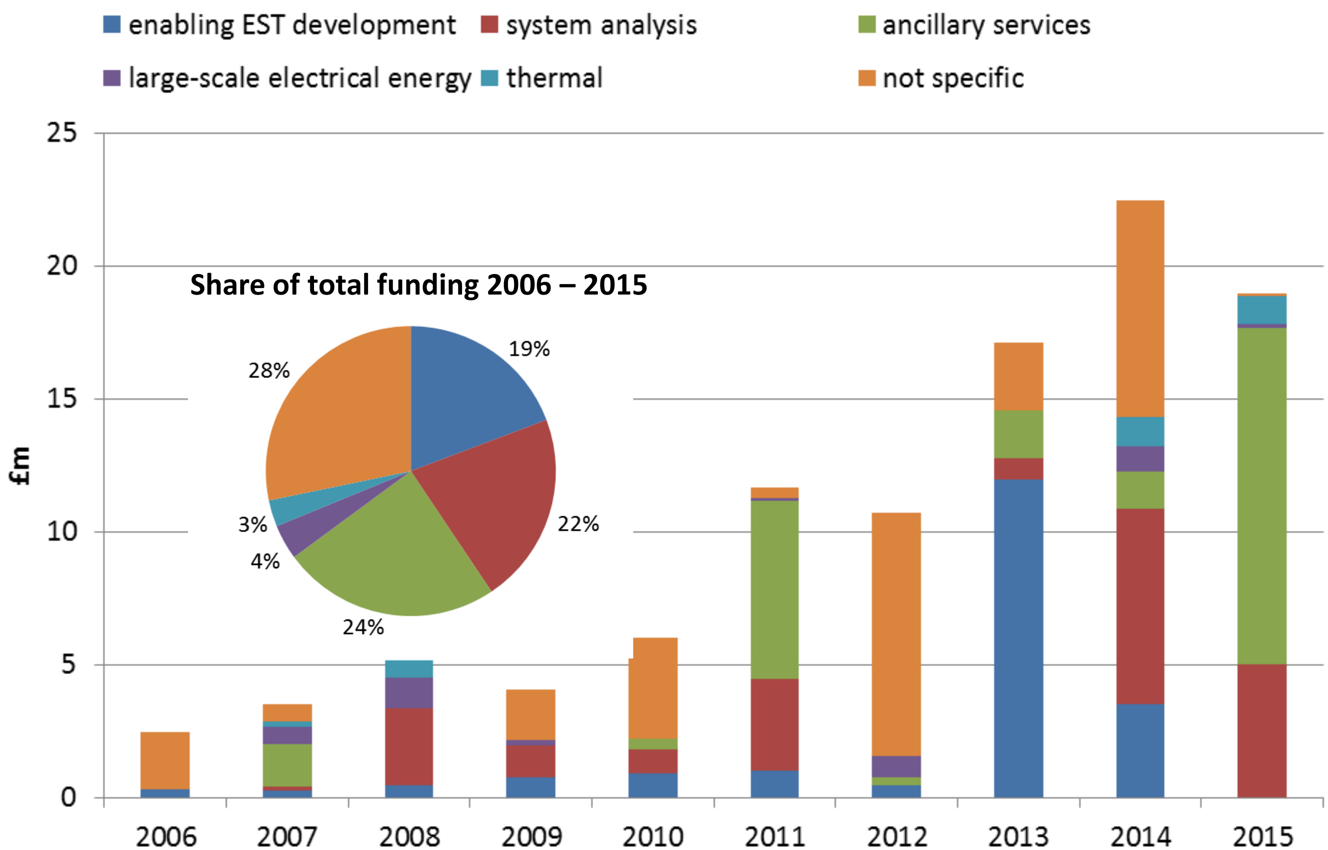
EPSRC funding for energy storage by main technology service



Source: EPSRC Gateway to Research

i.e relatively small amounts for thermal and large-scale energy storage

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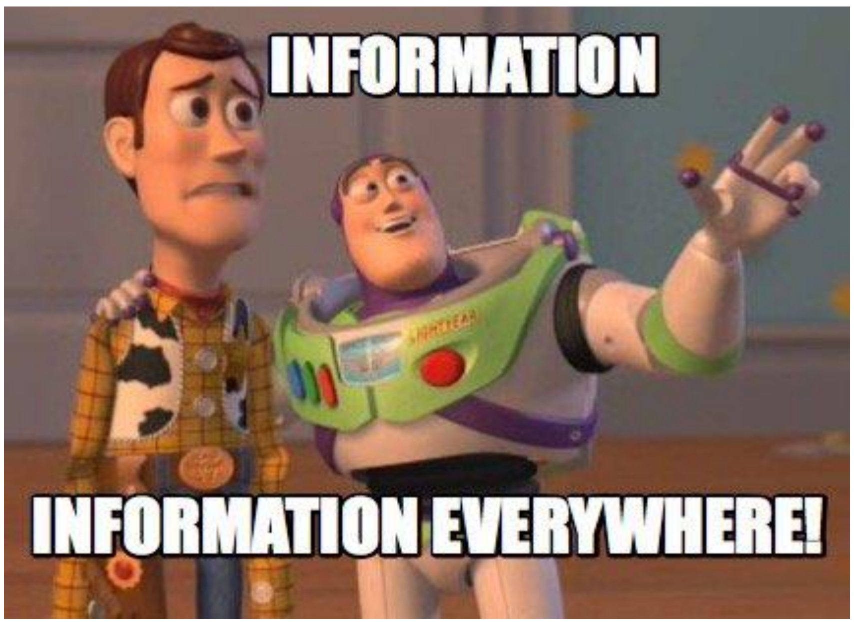
Summary of findings for energy storage innovation

- Energy storage provides an interesting case study for technology innovation systems.
- Near-term storage services likely to be over timescales of seconds – minutes, but high penetrations of “inflexible” generation means increasing need for large stores of energy over hours – days.
- There has been a lag in support, and lack of vision across the innovation landscape, which is needed to enable the appropriate technologies to be developed.
- Overall level of funding for energy storage, while increasing, is low compared to other technologies and not sufficiently joined-up. It is not sufficiently supported by policy to provide confidence to private sector investors.

Decision making in energy policy: Evidence-informed policy making

Using evidence to inform decisions is a central tenet of the policy making process in the UK.



But, **in practice**, many other factors shape the outcomes, f.e.

- political expediency;
- restricted time frames and budgets;
- perceptions, ideas and competency of the actors involved…

From literature review by Timea Nochta (UoB) for
Across Scales in Energy Decision Making (ASCEND) study
http://gtr.rcuk.ac.uk/projects?ref=EP%2FR002231%2F1

Decision making in energy policy : Evidence-informed policy making

Conclusion

Both **the evidence** itself, and **how it is used**, are important to consider.

Previous studies found that

- evidence can reduce **uncertainty** in some aspects of the policy problem, but also create space for uncertainty in other aspects;
- Decision-making takes place in **networks** (a set of public or private sector actors involved in the policy-making process) of actors due to fragmentation.

Decision making in energy policy : Evidence use in energy policy making

Research into the use of evidence in the **energy policy-making** process:

- The assessment of model use;
- How models act to allow different groups to work together;
- The governance processes and energy/climate change policies.

Main findings:

- A relatively small proportion of available models are being used;
- ‘Usable’ models need to be credible and legitimate sources of information and they must hold political (and scientific) salience.

Decision making in energy policy : Evidence use in energy policy making

There are **gaps** in our understanding of

- the **actors** from different sectors (public, private, research) involved in energy policy making operating at each scale;
- the ways in which they **interact** with each other;
- the **nature** and **quality** of such interactions;
- their **impact on outcomes** in relation to energy policies and strategies.

Of particular interest: the **role, identity and resources** of organisations which (can) act as **intermediaries** within the networks of energy policy making.

Decision making in energy policy : Proposed directions for research

We can develop a better understanding of how energy policy-making could be supported through:

- identifying the relevant **actor networks** (structure, operation and impact) with the aim of exploring how models can best support energy policy-making across scales and sectors;

and

- improving the **quality of evidence** through models which have better representation of the energy system processes across scales in order to enhance their **salience**, **credibility** and **legitimacy**.

Conclusions/discussion

- Analysis can show a future benefit
  - The analysis and how it is used are important to decision makers
- The potential offered by energy storage will only be realised if the innovation system functions as a whole
- Need combination of technological and policy support to drive innovation
  - R&D is cheap
  - Deployment support is expensive, subsidies not popular, but what is a subsidy
- Complexities associated when taking whole-systems perspective with multiple objectives: Innovation support must consider how the different parts of the 'whole energy system' will co-evolve, including heat and transport, and across temporal and spatial scales
- Time horizons for support mechanisms are critical
  - Need coordinated and long-term view: not currently in place

Consider also: H_2, CCS, SMRs?

Broader consideration of support for energy technologies at:

'Remaking the UK's energy technology innovation system: From the margins to the mainstream' Winskel et al, Energy Policy (2014

http://dx.doi.org/10.1016/j.enpol.2014.01.009

Thank You

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http://www.birmingham.ac.uk/energy