Key issues for energy storage research and innovation

LCEDN conference
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Energy Systems and Policy Analysis group
https://www.birmingham.ac.uk/espag

The Institute for Global Innovation

Tackles global challenges based around SDGs, with multi-disciplinary approach. Director: Prof. Hisham Mehanna

Priority Themes: Resilient Cities, Water Challenges, Gender Inequality, 21st Century Crime

The **Resilient Cities** theme aims to re-assess the concept of resilience and its measurement, as it is applied to cities and linked rural regions that are undergoing transitions at different levels of analysis (individual, community, city, national), across multiple sub-systems and timescales.

https://www.birmingham.ac.uk/research/global-goals/igi/resilient-cities.aspx

A strategic roadmap for UK energy storage research

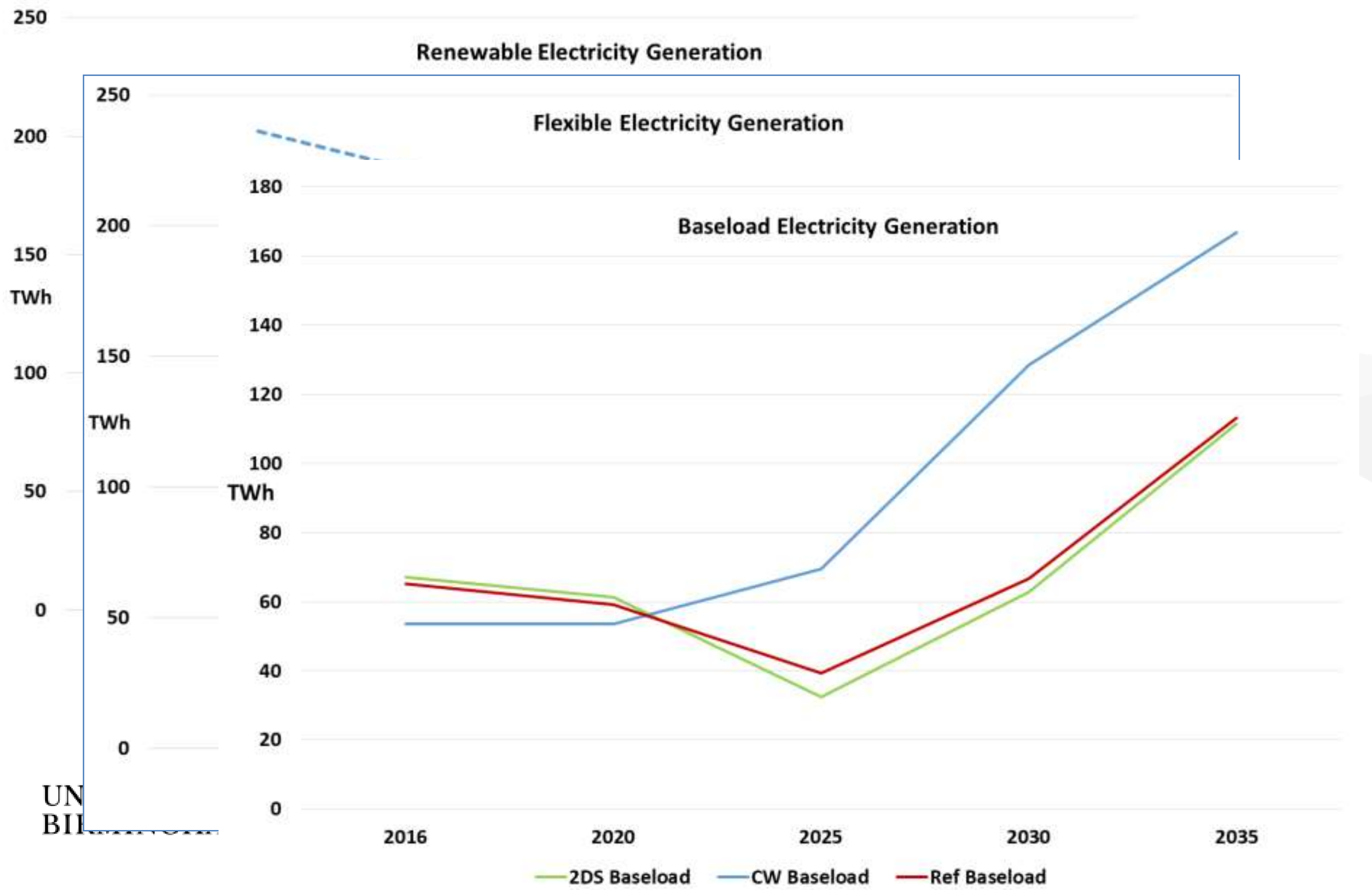
Aim to develop an integrated national roadmap for energy storage research for the Energy Storage Supergen Hub.

- Energy systems analysis: understand the needs
- Science & technology trajectories: assess future potential

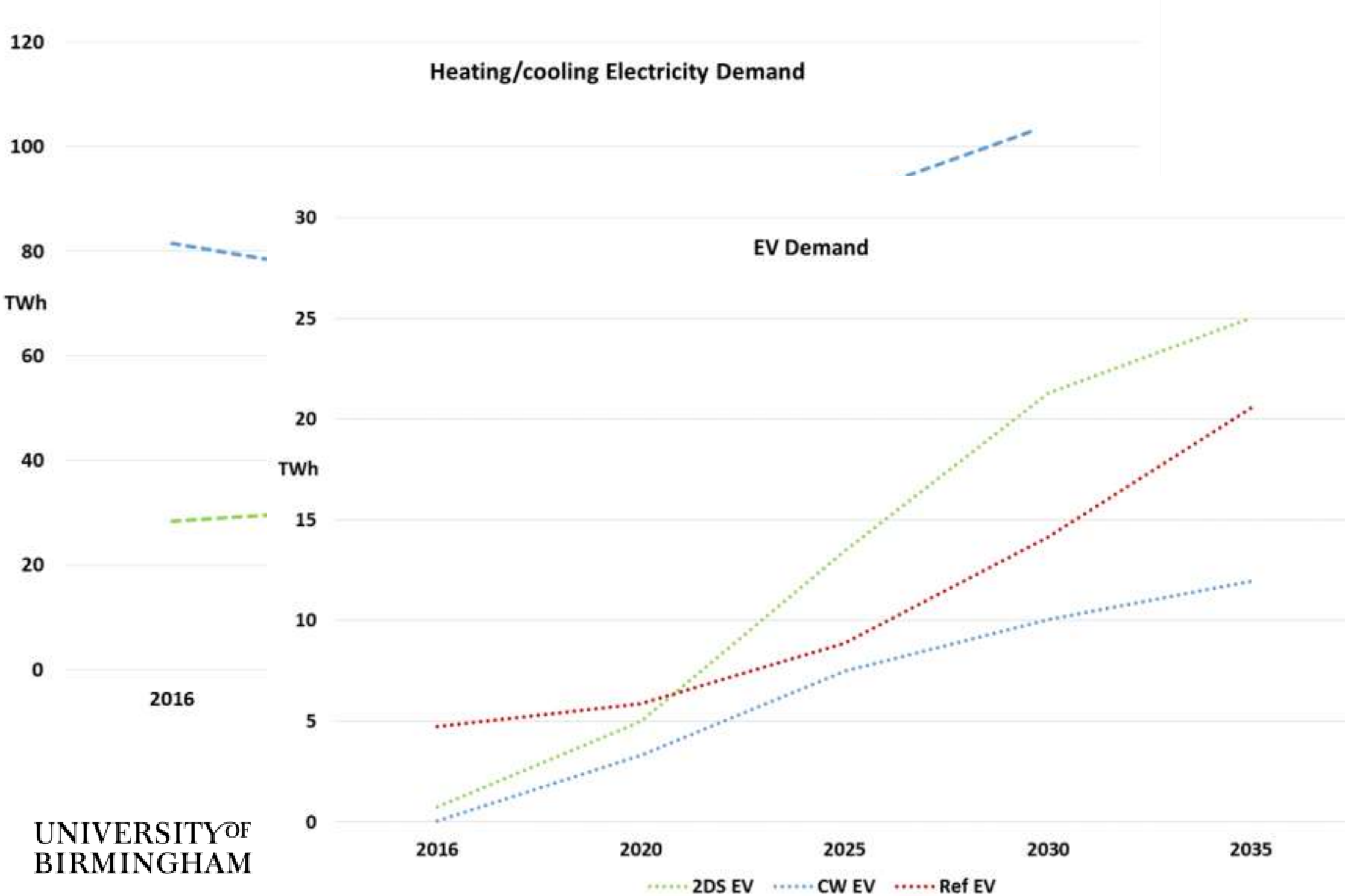
Described from:

- Evidence review
  - Academic publications
  - Scenarios: National Grid FES; ETI; BEIS UEP
  - 'Grey' literature
- Expert input
- Our analysis

Energy System Scenarios – Generation



Energy System Scenarios – Electric demand



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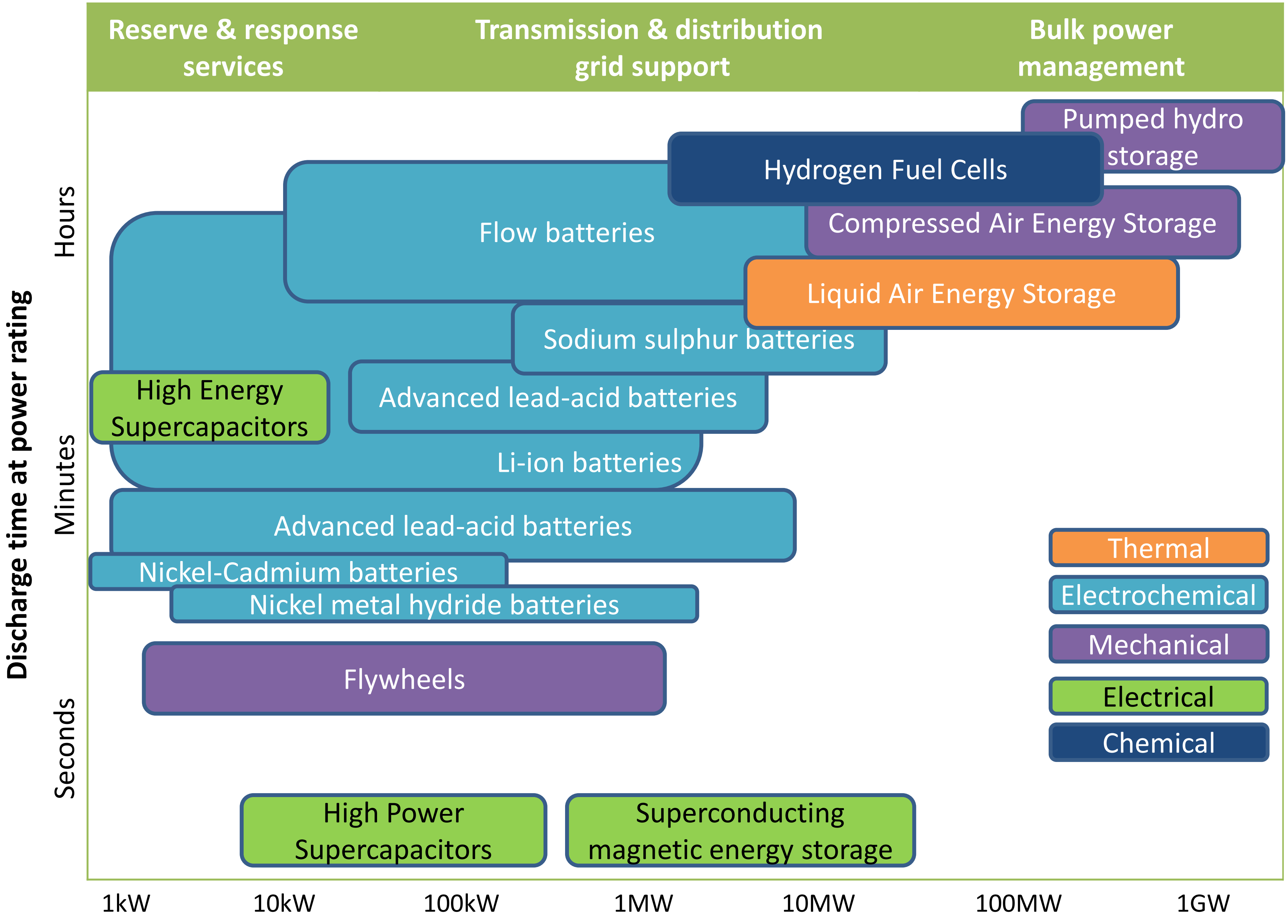
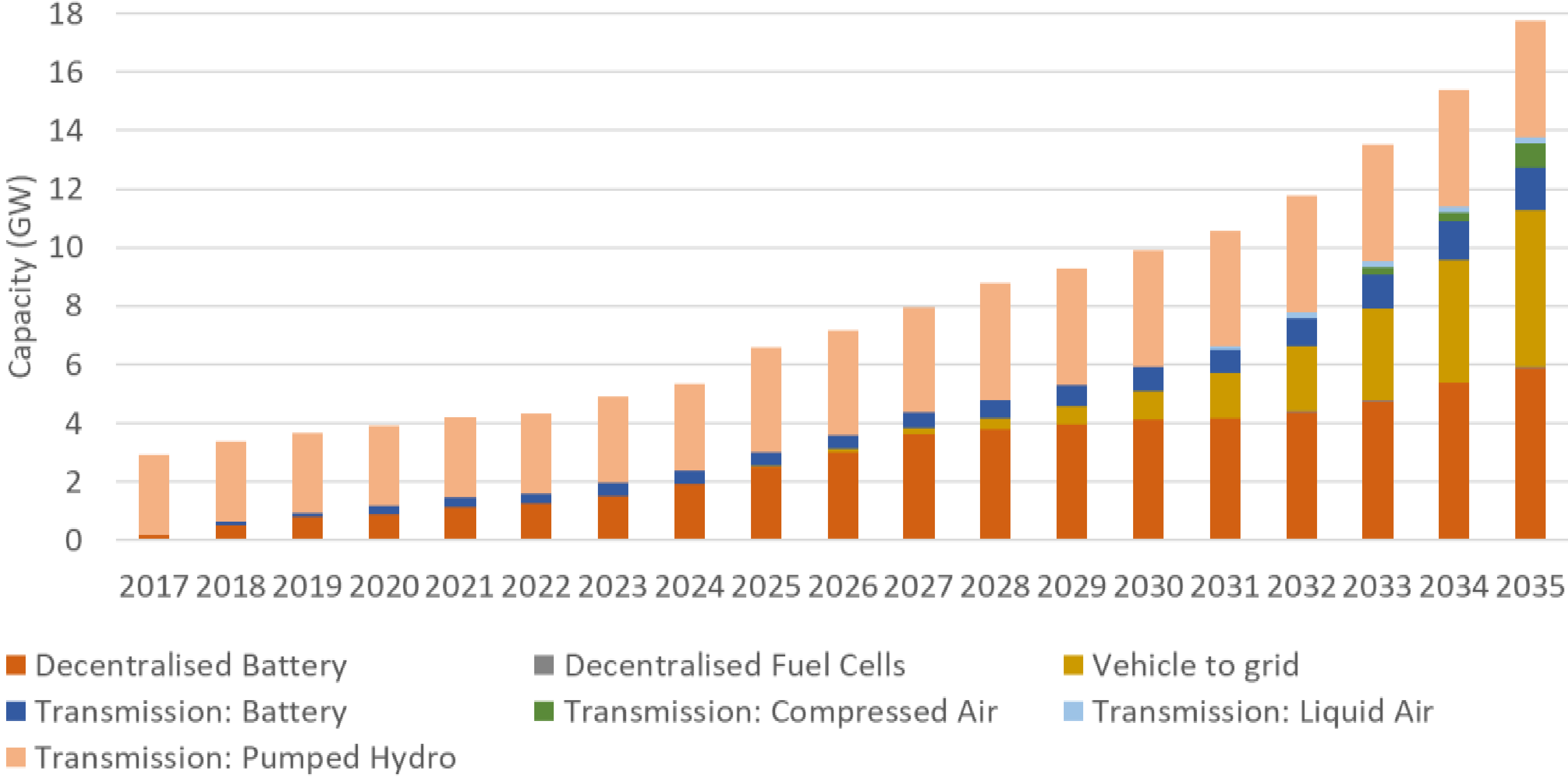
General energy system needs for flexibility

Timescale	Challenge
Seconds	Renewable generation introduces harmonics and affects power supply quality. Reduced inertia from less rotating machinery.
Minutes	Rapid ramping to respond to changing supply from wind/PV generation.
Hours	Daily peak for electricity demand.
Hours - days	Variability of wind/solar generation.
Months	Seasonal supply and demand profile.

Electricity Storage Technology options



Insights from scenarios



UK deployment (National Grid FES 2018 – 2DS)

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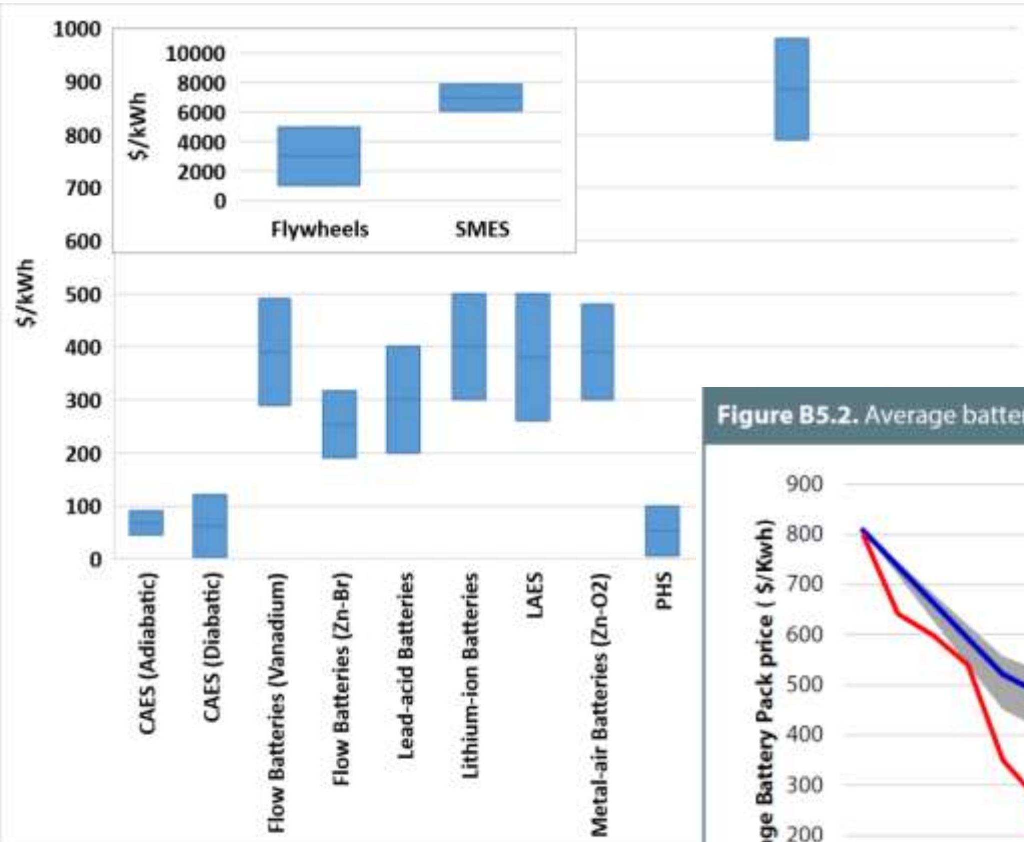
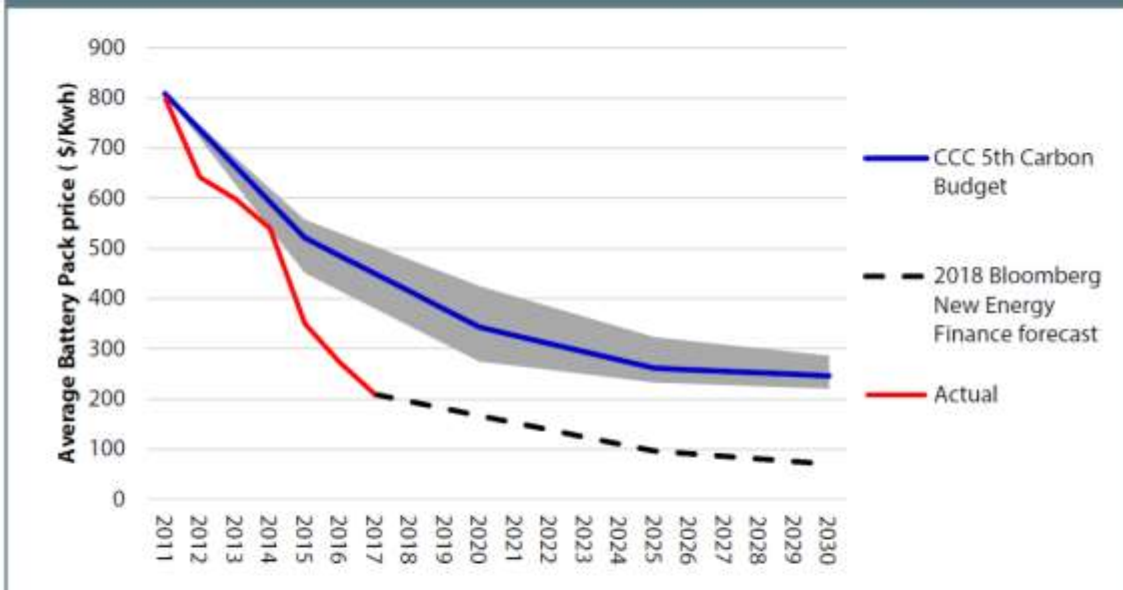
Costs



Net Zero: The UK's contribution to stopping global warming, Technical Report
Committee on Climate Change
May 2019

Figure B5.2. Average battery cost for electric vehicles - Actual and forecast to 2030



Source: BNEF (2018) *Electric cars to reach price parity by 2022; CCC (2015) Sectoral scenarios for the Fifth Carbon Budget.*

Recommendations

Energy system in the near-term:

Energy system

- Growth in variable RES → increasing need for ancillary services

Energy storage potential

- Need for quick response/reserve
- Batteries commercial in some auto sector niches and grid markets

Continue

- Strengthen electrochemical battery RD&D base [Faraday]
- Assess degradation effects

Early 2020s:

Energy system

- High proportion of RES, uncertain FF capacity and nuclear baseload
- Increasing local generation
- Growing take-up of EVs

Energy storage potential

- Inter/intra-day peak shifting/load levelling to maximise utilisation of networks & capacity
- EV batteries, and second-life/recycling

Prepare now

- RD&D across potential larger energy scale ESTs
- Investment in EV manufacturing skills/plant
- Technical and policy/regulatory integration of auto/electricity systems
    - Systems analysis for EV charging configurations; V2G
    - Potential for novel business models
    - Analysis of local scale/distributed contributions
- Environmental/resource impacts of ESTs

Mid - late 2020s

Energy system

- Decarbonisation of heat, but no clear technological pathway:
    - heat pumps/district heat/low carbon gas
- Possible flexibility from CCS
- Wider transport decarbonisation

Energy storage potential

- Seasonal peak shifting
- HGVs

Prepare now

- Develop/test/demo technologies with potential seasonal timescales
    - Thermal energy storage: buildings, districts
    - Hydrogen
- Systems analysis including heat

Prepare soon

- Technical & policy/regulatory integration of auto/heat/elec systems
- Establish institutional competencies across scales

Multi-Scale Analysis of Facilities for Energy Storage (MANIFEST)

EPSRC
Engineering and Physical Sciences Research Council

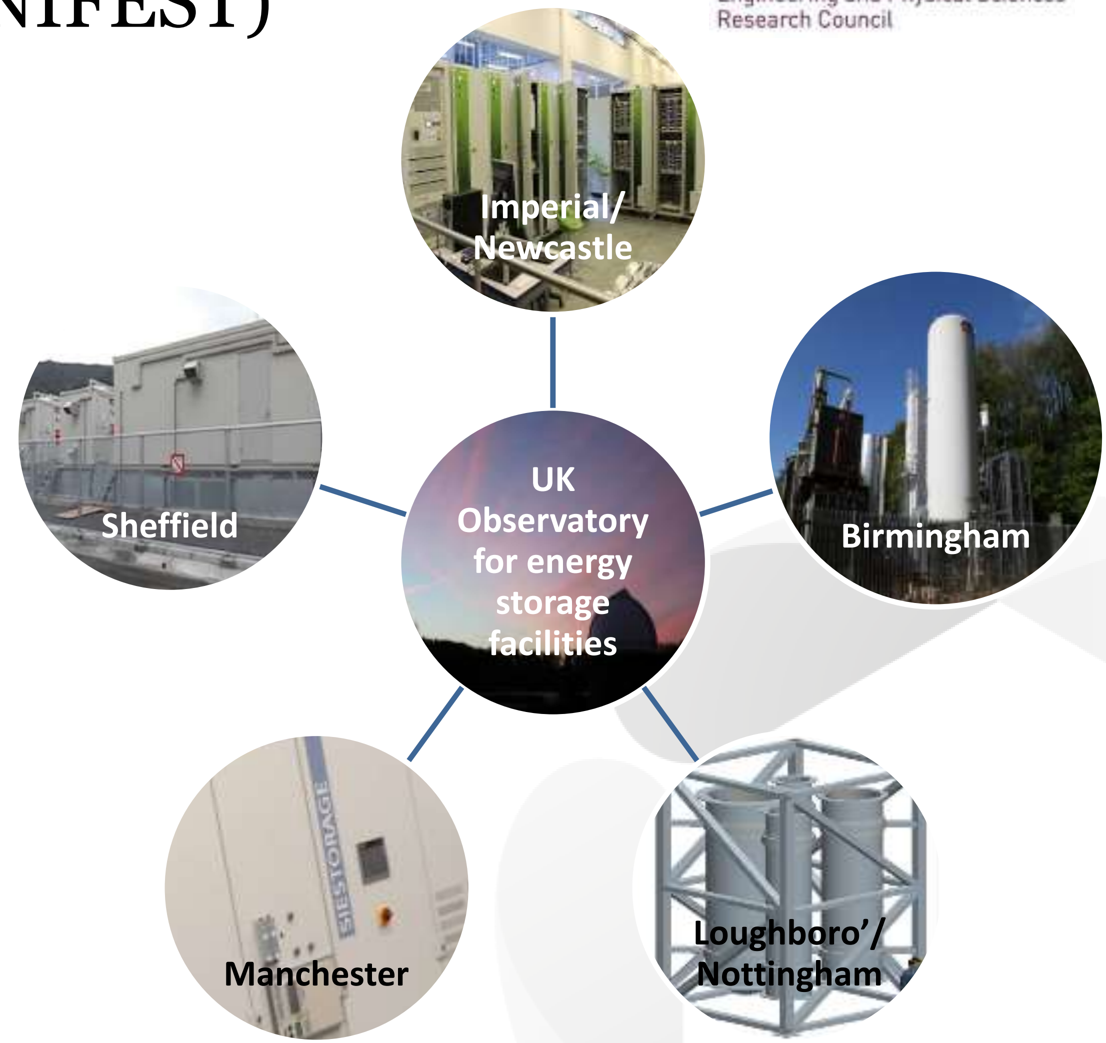
£5m/4 years EPSRC-funded project

Collaboration of universities that shared £30m capital investment for ‘Eight Great Technologies’ in 2013.

Work packages:

1. Materials characterization and diagnostics
2. Multi-scale modelling
3. Operation and optimization
4. UK Energy Storage Observatory: www.birmingham.ac.uk/UKESTO

http://gtr.rcuk.ac.uk/projects?ref=EP/N032888/1



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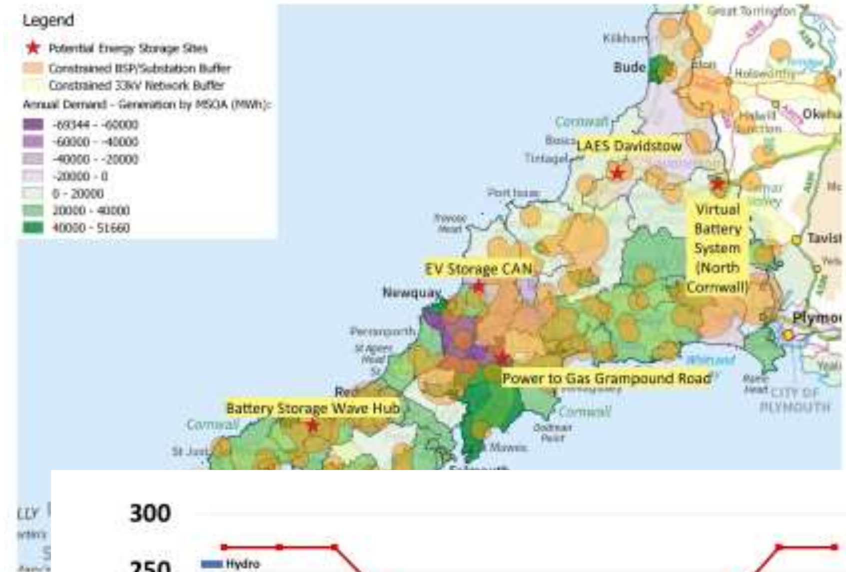
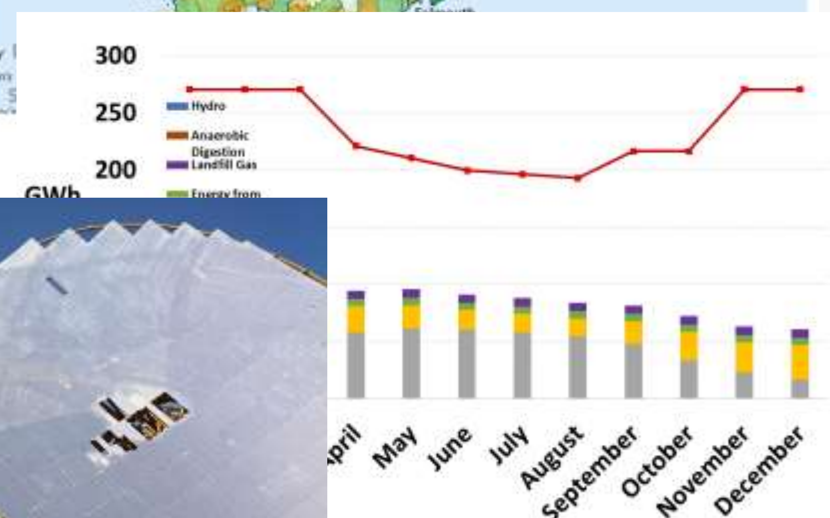
PI and Director: Jonathan Radcliffe (Birmingham)
Co-Directors: Nigel Brandon (Imperial), Yulong Ding (Birmingham), Phil Eames (Loughborough), Andrew Forsyth (Manchester), Dave Stone (Sheffield)

Possible solutions are context-dependent





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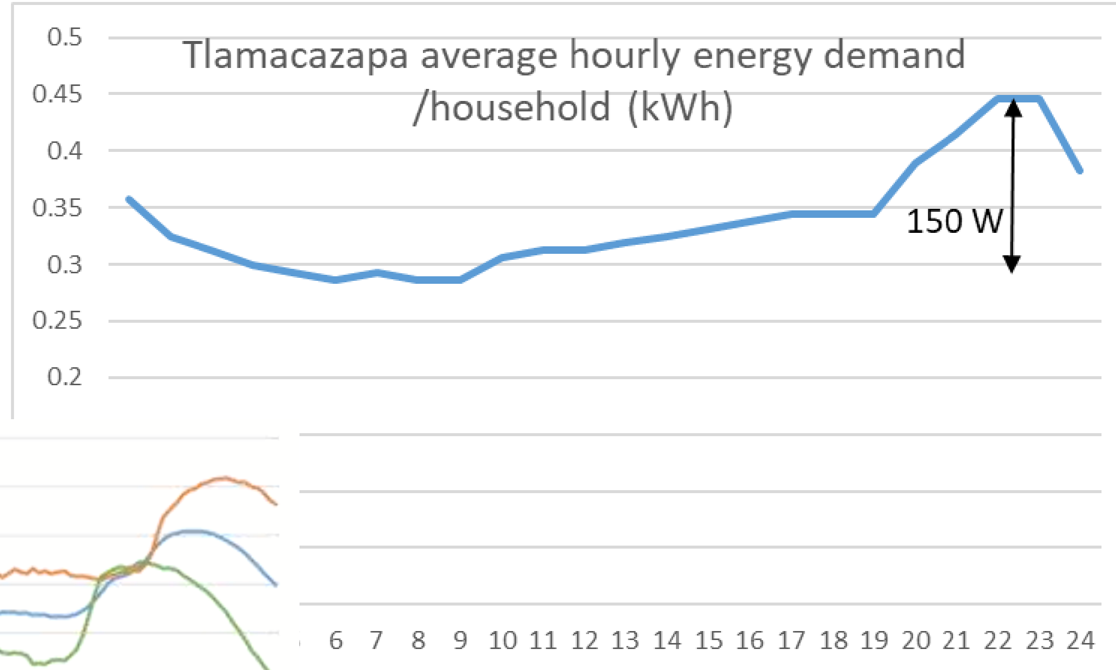
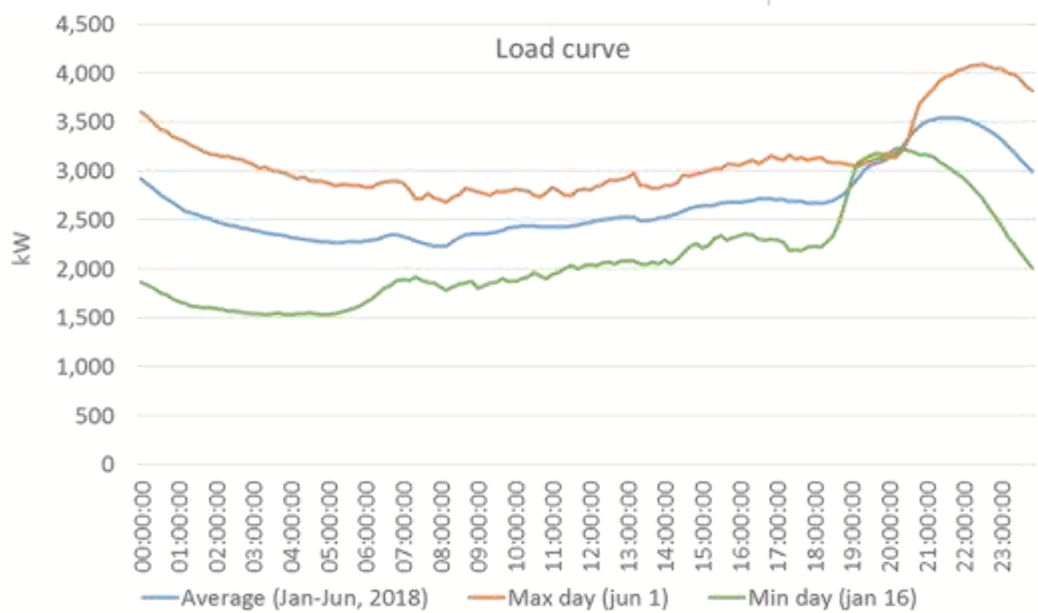
Understanding demand



Regional distribution network load around Taxco, Mexico



Assumes average 1.8kWh/person/day

Assess what energy services are needed, and the technologies that could meet these needs.

Trade-offs when selecting technologies

- Cost
- Performance (duration, cycle life, efficiency)

→ Techno-economic analysis for each in different application cases:

- Water services
- Energy services

lowering cost and increasing supply.

Potential battery technologies for Tlamacazapa

	Lead-acid	Lithium-ion	Vanadium flow
Energy density (Wh/L)	50-90	400-550	16-35
Power density (W/L)	10-400	1,500-10,000	2
Cycle life (cycles)	500-2,000	1,500-4,500	>10,000
Energy cost ($/kWh)	200-400	173-279	290-490
Efficiency	70-90%	85-95%	65-85%
Discharge duration	Up to 10hrs	Up to 8hrs	24hrs+

Multi-criteria decision analysis (MCDA) approach

With alternative technologies, to be evaluated against a number of criteria, MCDA provides systematic framework to analyse technologies, with involvement of stakeholders.

An MCDA model consists of four elements:

(1) the options to be appraised,

(2) the criteria (or attributes) against which the options are appraised,

(3) scores that reflect the value of an option's expected performance on the criteria, and

(4) criteria weights that equate the relative values on one criterion as compared to another

Can see the 'options' as being specific energy storage technologies (or services) which help meet the criteria under different scenarios.

2018 Murrant & Radcliffe, Assessing energy storage technology options using a multi-criteria decision analysis-based framework, Applied Energy v231, pp788-802

What else should be considered?

Wider negative and positive impacts of interventions, e.g.:

- Environmental – effects on water system by increasing extraction; waste management; air quality
- Equitable across socio-economic groups, gender, age etc
- Resilience

Sustainability: maintenance (skills, spare parts), future costs; provide training

Regulatory: relationship to grid/network

Practicalities: safely installing PV panels, batteries, lights

THE FARADAY INSTITUTION ReLiB

REUSE & RECYCLING OF LITHIUM ION BATTERIES

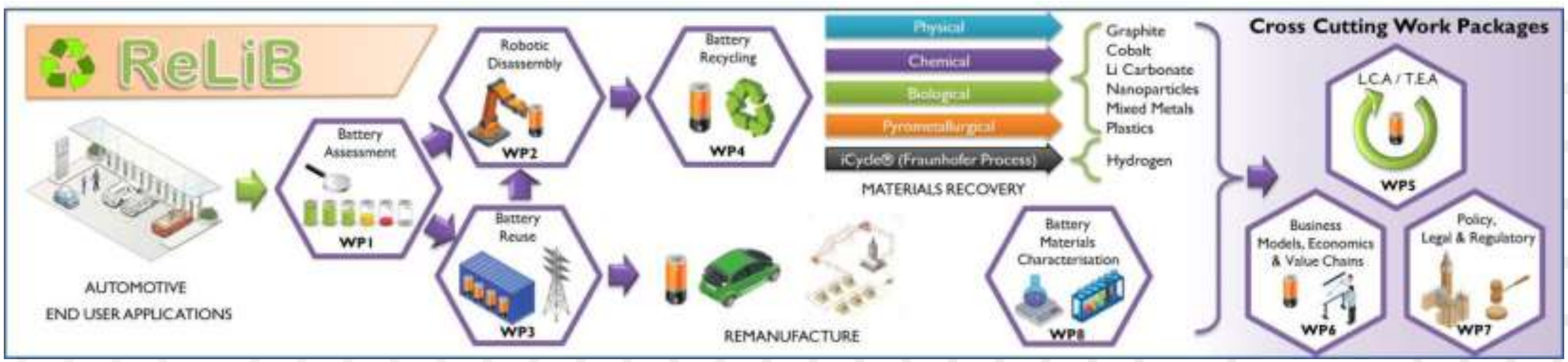
RE-USE & RECYCLING OF LITHIUM ION BATTERIES

To facilitate a circular economy in lithium-ion batteries, tackling the most demanding technical and socio-economic challenges in sensing, gateway testing, sorting, re-use and recycling 100% of a battery pack.

Partner universities:

Birmingham, Cardiff, Edinburgh, Leicester, Liverpool Newcastle, Oxford Brookes, Diamond Light Source

+ 14 industry partners



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Summary

- Consider the (context-specific) needs of
  - Users
  - Systems

- Longer term
  - Environmental impacts: re-use(d), recycle
  - Maintenance: local skills

- Policy/regulation
  - Institutional framework to enable deployment
  - Across scales

Thank you

and to colleagues in Energy Systems and Policy Analysis group: Carlo Luiu, Oluyemi Jegede, Dan Murrant, Xinfang Wang, Chunping Xie

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