Integrated Market-fit and Affordable Grid-scale Energy Storage

Energy Storage Grand Challenge, EPSRC(EP/K002228/1)

EPSRC Pioneering research and skills | THE UNIVERSITY OF WARWICK | Loughborough University | IMAGES | The University of Nottingham | British Geological Survey NATURAL ENVIRONMENT RESEARCH COUNCIL | Energy

Major Challenges

•Hidden values and benefits unclear
•Cost of ES technologies
•Market position

Our Methods

- Whole system techno-economic modelling study
- Power network operation scenarios
- Integrated energy storage

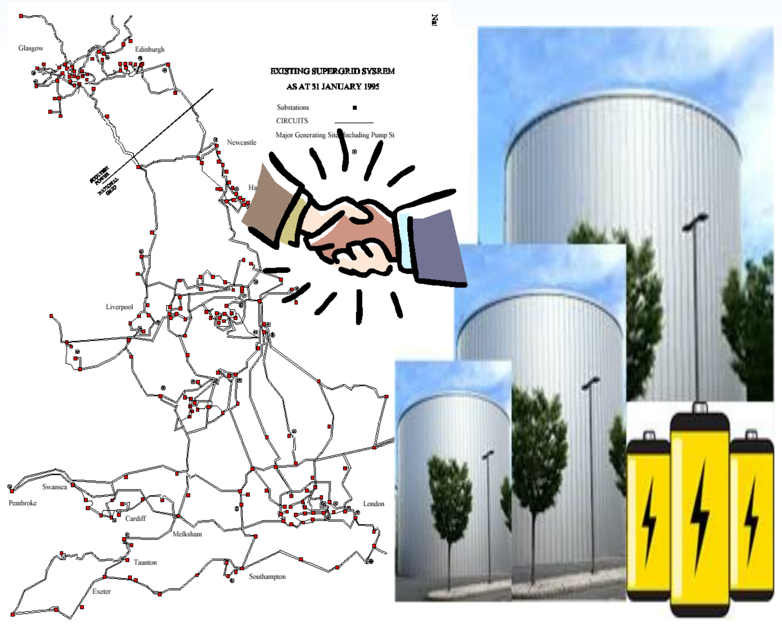
Why we need Research Council Funding support?

- Future low carbon energy systems, sustainable development
- Suitable market platform and economic policy
- Cost reduction for affordability

Whole System Techno-Economic Modelling Study to Address the Challenge in Economic Viability

Background and Scenarios

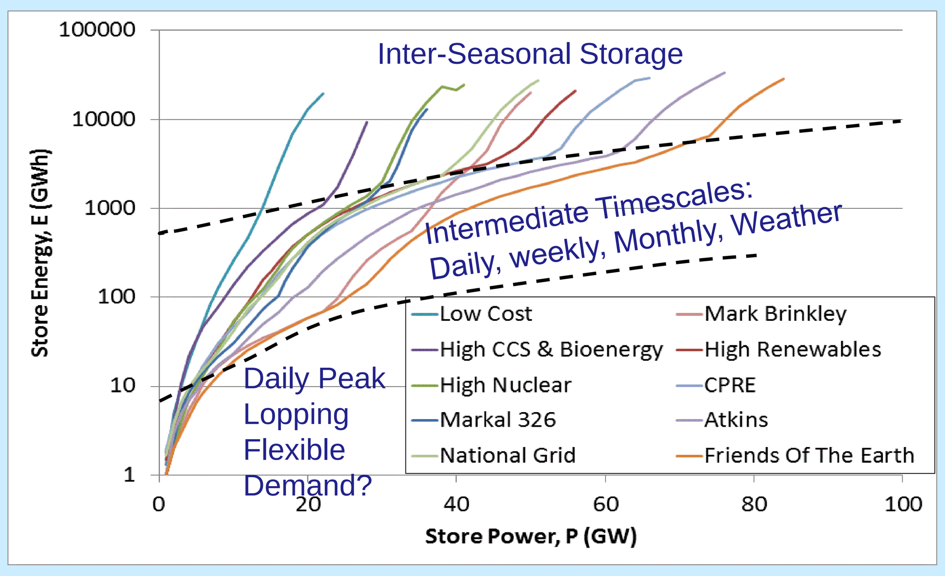
- Electricity use in the UK
- Hourly time steps for 1 year
- DECC 2050 Calculator scenarios with low carbon energy supply in 2050
- Storage performs peak lopping, arbitrage and curtailment avoidance
- Required energy capacity increases exponentially with power rating



Main Results

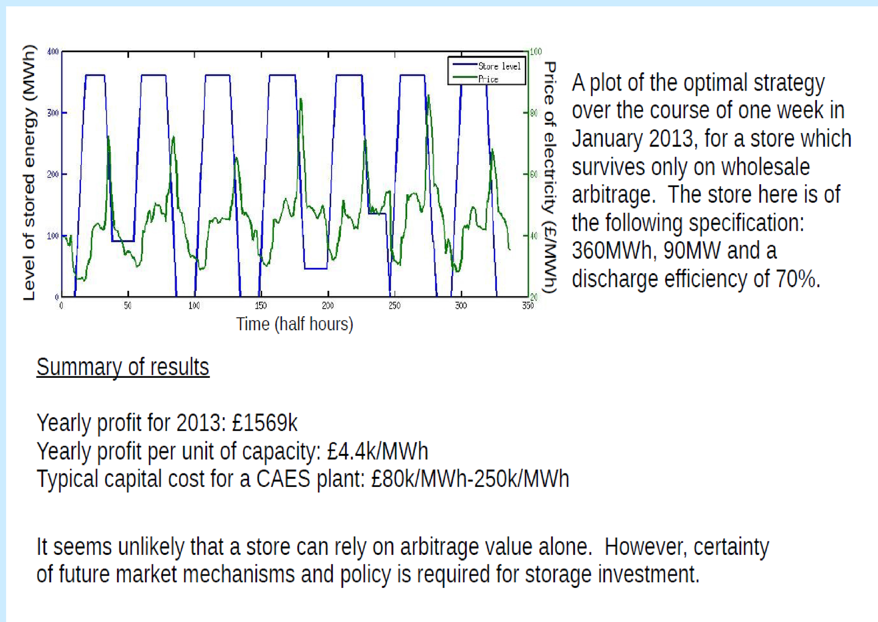
- Batteries and fuel cells/hydrogen are not enough (in terms of cost and scale)
- Batteries have too high a cost per kWh of storage capacity and limited cycle numbers
- Hydrogen has very low cost per kWh but is too expensive per kW, because no one has yet built an electrolyser cheap enough!
- Heat storage and CAES have moderate costs per kW and kWh, between those of batteries and hydrogen
- Heat storage and CAES therefore win out at timescales between minutes and weeks
- These are the main timescales of weather-related variation of wind power, solar power and demand.

Size of store needed to meet annual peak demand



From Future Energy Scenario Analyses (FESA)

But can storage make money for its operators?



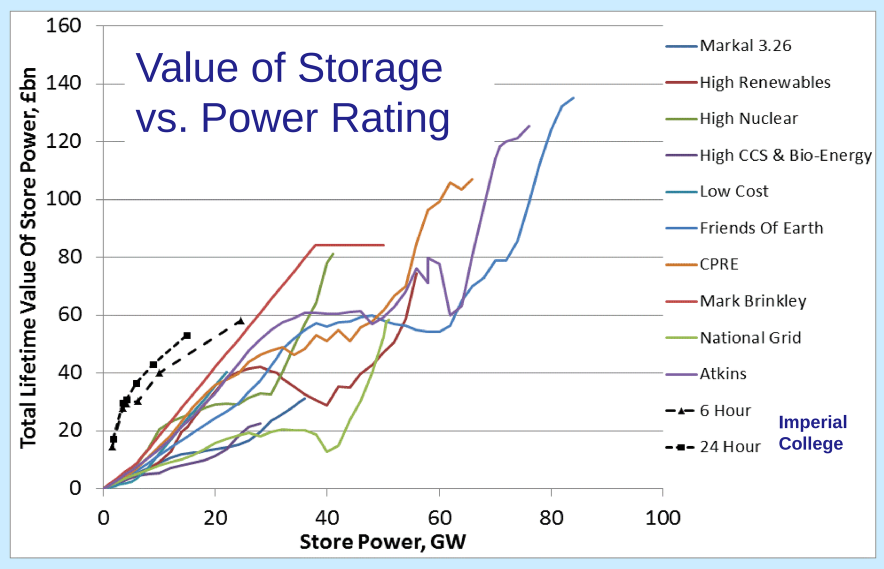
Compare FESA with Pujianto, Aunedi, Djapic & Strbac, 'Whole-Systems Assessment of the Value of Energy Storage in Low-Carbon Electricity Systems'

FESA

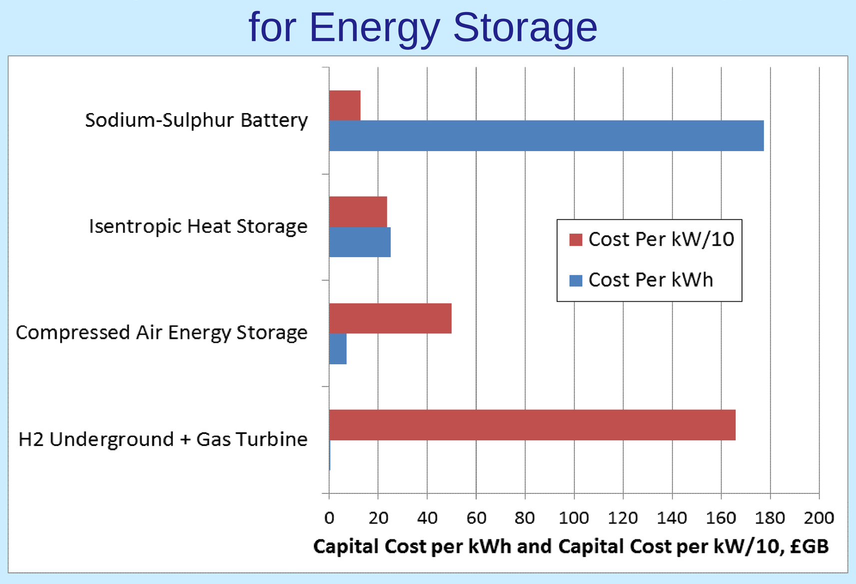
- Time step model of 1 year
- UK
- Carbon saved
- Fuel saved
- Backup generation saved
- All DECC low-carbon scenarios in 2050
- Storage durations from 1 to 1000 Hours

Imperial College

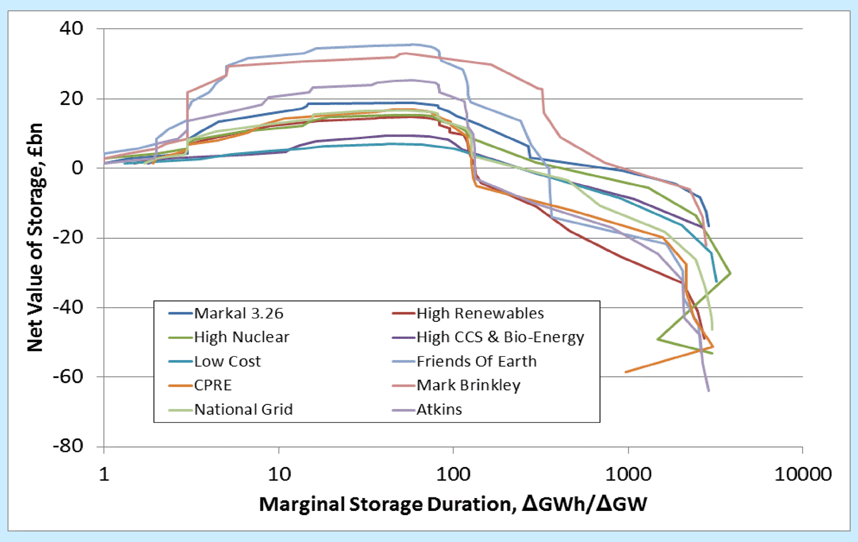
- Time step model of 1 year
- Great Britain
- Carbon saved
- Fuel saved
- Backup generation saved
- Only DECC High Renewables scenario in 2030
- Storage durations of 6 hours and 24 hours only
- Transmission system savings
- Reserve (standby)
- Frequency response,



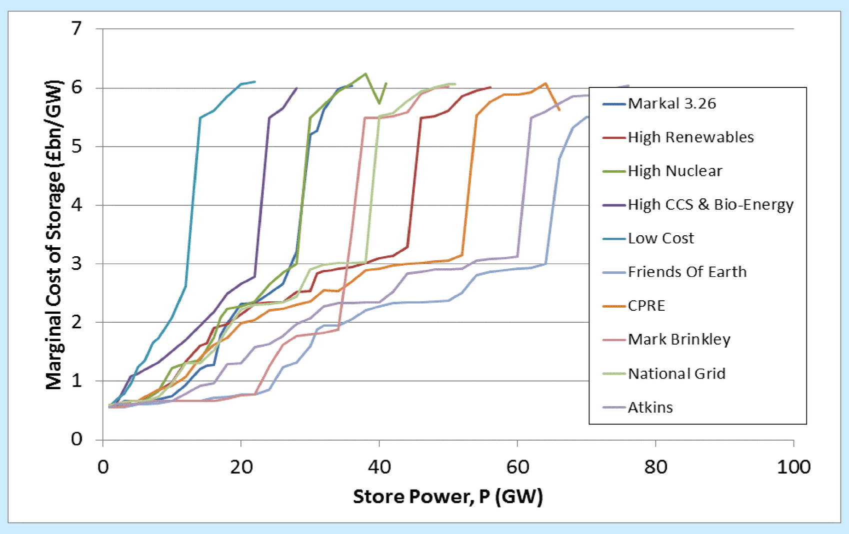
Capital Costs Per Power and Energy for Energy Storage



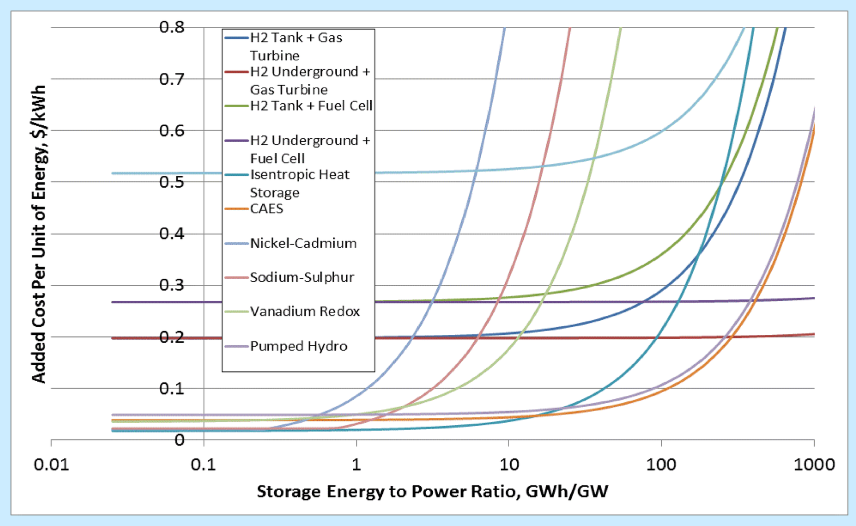
Net Total Lifetime Value of Storage



How Much Storage is it Worth Building?

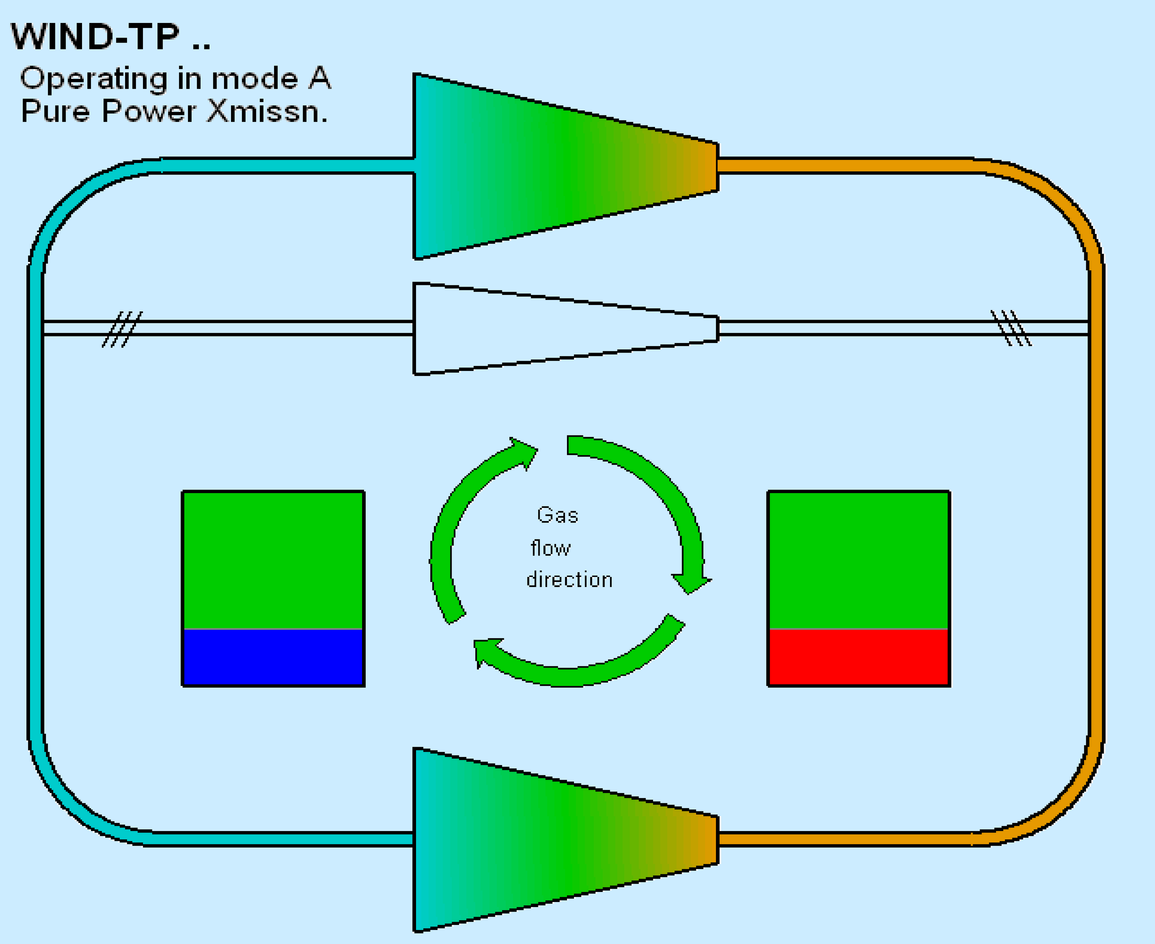


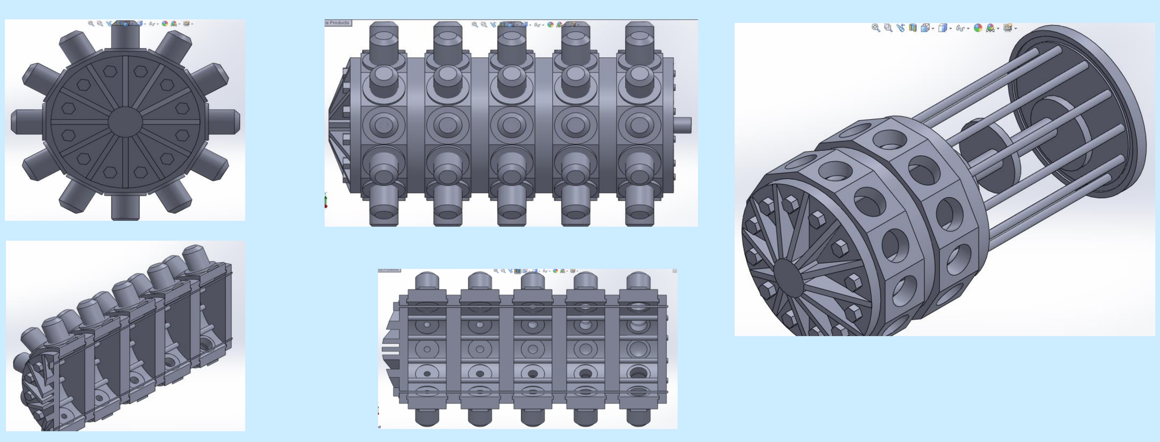
Cost of Storage with Increasing Timescales



Integrated Energy Storage: Integration of Technologies, Integration with generation and Applications

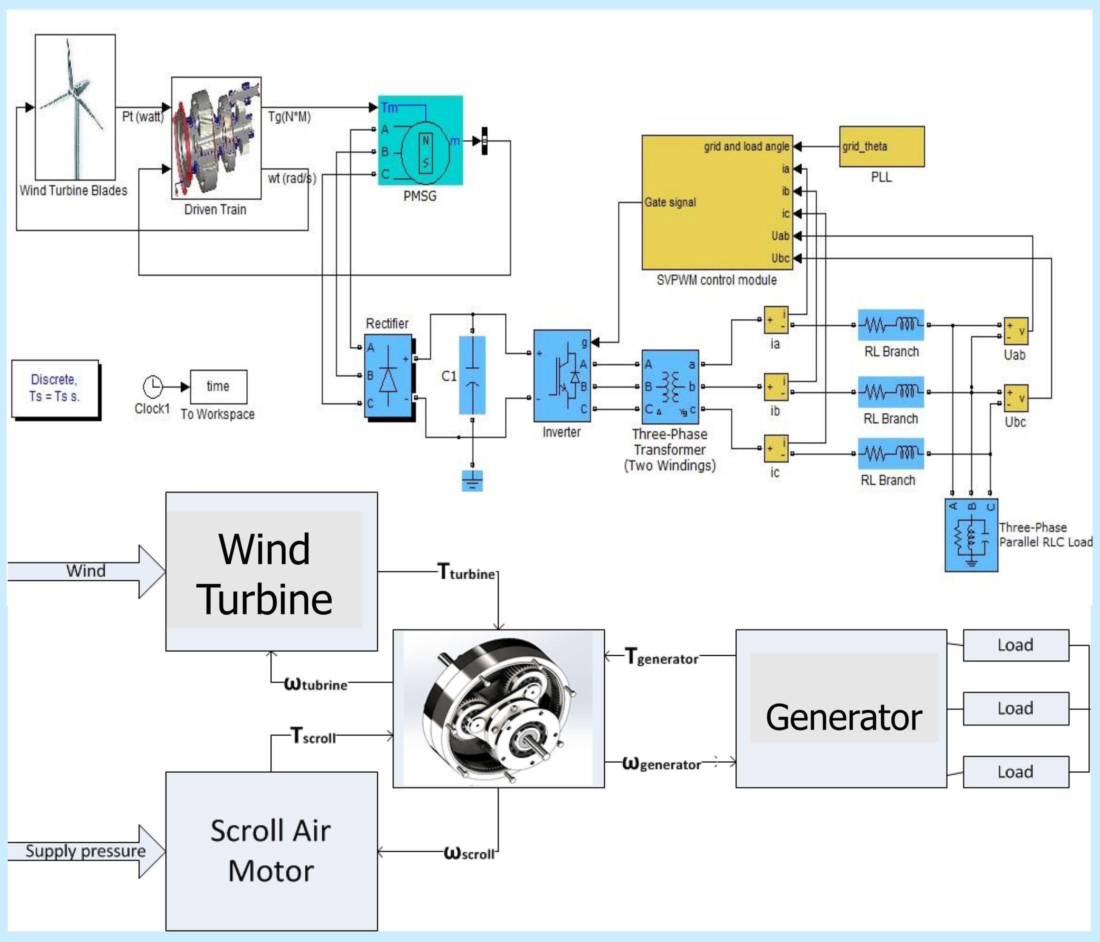
ES Integrated with *Wind: Thermal Pumping*

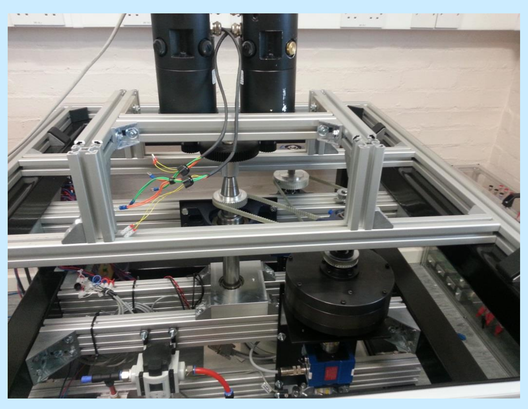




•Illustration of *WIND-TP* available at https://www.youtube.com/watch?v=7TKRZDkVVmk

CAES Integrated with *Wind*





CAES Integrated with Cooling *(Flowbattery)*

Air expansion producing cool air for data centre.

Rolls-Royce | INEOS Enterprises | flowbattery | e.on UK | nationalgrid | COSTAIN | GE Energy | Highview Power Storage | Gateway | Gaelectric

Project information can be found at:
www.warwick.ac.uk/energystorage
and
www. integratedenergystorage.org