Medium-Duration Energy Storage in the Net-Zero UK

Role and Value of Energy Storage in Future UK Low Carbon Energy System

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Role and Value of Energy Storage: Research Questions

• What are the system implications of energy storage?
  – Facilitating cost effective decarbonisation
  – Providing flexibility in system operation in different timeframes

• How to quantify the whole-system benefits of energy storage?

• How to identify the optimal portfolio of energy storage technologies and the potential market volume?

• What are the key drivers for energy storage?

• What is the role and value of medium/longer duration energy storage?

• How energy storage competes with other technologies?
Modelling approach

Spatial resolution: Local & National level

IWES – Integrated, Whole-Energy System model

Temporal resolution

- Energy system capacity planning: Years before delivery
- Long-term supply and storage scheduling: Months to days before delivery
- Day-ahead supply, storage, and demand scheduling: One day to one hour before delivery
- System balancing: Actual delivery: physical supply and consumption (second timescale)
Flexibility – key driver for cost effective evolution to low carbon energy system

Flexibility – Storage & DSR
Storage increases the ability of the system to integrate RES

WSC_{RES} = LCOE_{RES} \pm \text{System Integration Cost}

Whole-System costs and competitiveness of RES driven by system flexibility
Volume of the market for Storage & DSR post 2030 > £8bn/y
Carbon benefits of flexibility

UK scenario

Storage + DSR = 10 GW less nuclear

Storage + DSR = 15 GW less offshore wind

Installed capacity (GW)

2020 2025 2030 2035 2040 2045 2050

No flexibility

Installed capacity (GW)

2020 2025 2030 2035 2040 2045 2050
Value of storage with different durations (impact on operation costs and CO2 emissions)

Size of the storage tank has a significant impact for large volumes of deployed storage capacity
Value of energy storage flexibility services: an illustrative case

Providing multiple services increases the value of energy storage. The value implies that storage can reduce the investment and operation cost of the system.
Competition between energy storage and other flexible solutions

High storage cost: £1,160/kW
Low storage cost: £360/kW

- 8 GW (High cost)
- 19 GW (Low cost)
- 11 GW (Low cost)
- 2 GW (High cost)

Annual GB system cost savings (£m/yr)

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OPEX, D CAPEX, I CAPEX, T CAPEX, S CAPEX, G CAPEX

Total
How important is the integration of heat, gas electricity, sectors?

Increased investment in heating infrastructure delivers larger cost savings in the electricity system.

Flexibility - significant opportunity from integrating heat / cooling, gas, electricity, transport, water infrastructure.
Optimal portfolio of power generation and storage capacity in different pathways

A stricter carbon target tends to require more firm low carbon generation
Energy storage can reduce cost of operation of and investment in energy infrastructure. The value is system specific; higher with stricter carbon target.

Hydrogen storage in different pathways

12.5 – 19.5 TWh of H2 storage (both underground and medium pressure overground) needed in the H2 pathway. Driver: H2 is produced across the year to be used in winter. It can increase the capacity factor of H2 infrastructure and reduce its capacity demand.

Low H2 storage capacity indicating low-seasonal storage requirement in Electrification and Hybrid pathways
Firm Low Carbon Generation: Renewables + Medium/Long term storage

Note:
- In 0 Mt, CCGT and OCGT will run on biogas (carbon-neutral)
Value of smart TES

• Scenario
  – 2050 energy system
  – Electrification of heat and transport (light vehicles)
  – Carbon target
  – Very large energy storage capacity

• Counterfactual
  – No Active Building (low flexibility)

• Analysis
  – Flexibility provided by smart PCM-based TES (10,20 GW)
    • Convert electricity to heat
  – Gross system value
    • £103-£113/kW per year

Significant value of TES
Changes in the optimal electricity generation production due to PCM-based TES

TES reduces the need for firm low carbon generation (nuclear)
Thermal storage or electricity storage?

- Number of households: 34.3 M
- Thermal storage: 1.7 kWth/household

Multi-energy coupling also creates competition for flexibility resources across energy sectors.
Heat is stored (particularly in Summer) to be discharged in Winter.

*Scenario with 20 GW TES*
Additional H2 storage to deal with a prolong low wind period

Notes:
- Scenario: heat decarbonisation via electrification with 0Mt carbon target
- The range of results reflects the variability of wind that was expected to be available
- The “missing wind” is filled by storing the excess wind via electrolysers in the form of hydrogen which is used by H2 CCGTs
- Gas / H2/ electricity Interconnection
Findings

• Energy storage – critical for supporting cost effective energy system decarbonisation

• Providing multiple services increases the value of energy storage
  – Firm capacity (for security)
  – Arbitrage (short to long term)
  – Balancing services
  – Network reinforcement
  – Low carbon agenda (managing RES)

• Medium/Long duration energy storage could displace firm-low carbon generation

• The value is system specific
  – Whole-system (multi-energy vectors) approach evaluation
  – Synergy and competition with different energy storage technologies and other flexibility technologies
  – Dealing with extreme weather conditions