



# The Benefits of Long Duration Energy Storage in the GB market

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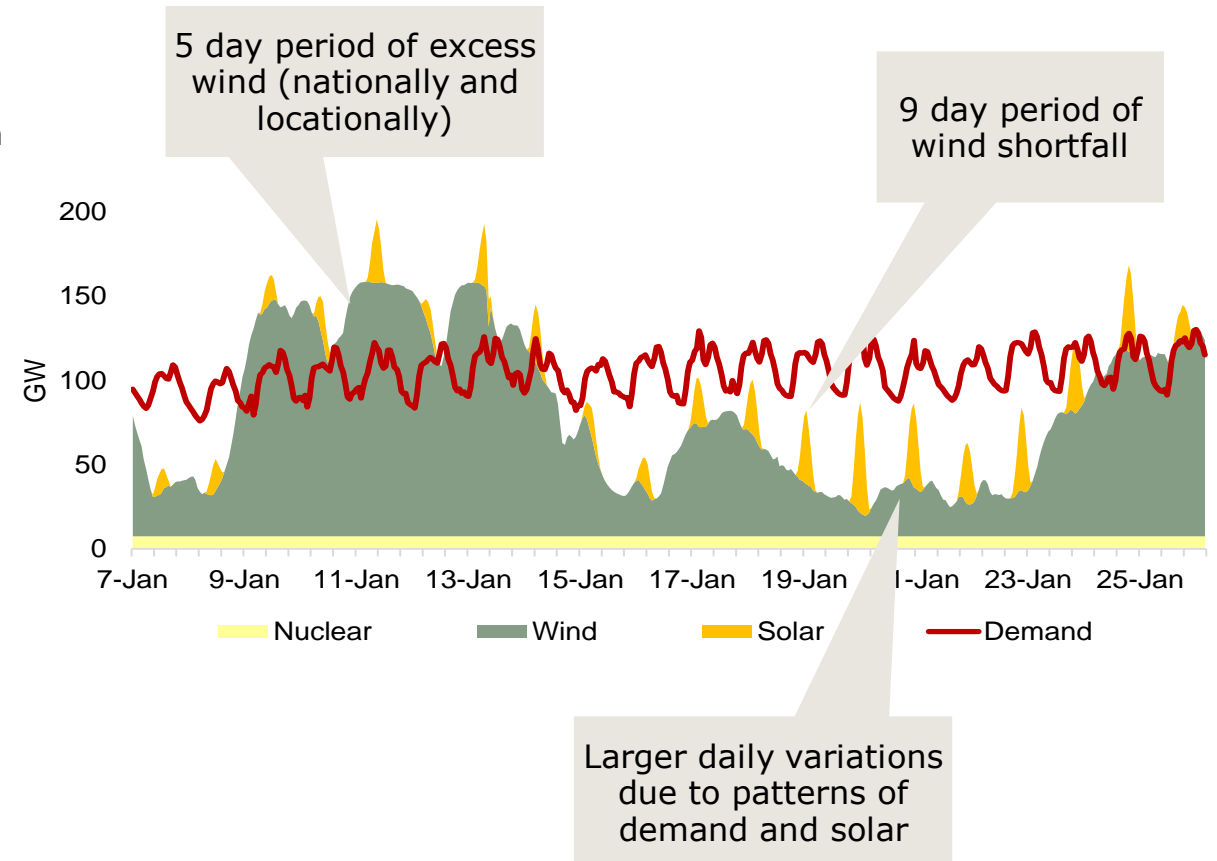
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## The 2050 net zero target creates the conditions where more storage is beneficial to the system

- The UK 2050 net zero targets imply a huge expansion of intermittent renewables.
- This transition from a fossil fuel-driven to a weather-driven generation mix means the requirements of the electricity system will alter:
  - The increased variability in supply of power will increase the need for flexibility solutions across multiple timeframes.
  - A reduction in synchronous thermal generation will lead to a greater need for system services
  - New generation located far from demand centers will exacerbate network congestion issues
- Progress towards net zero means that there will be greater demand for multiple types of flexibility. Storage technologies are well placed to meet these flexibility requirements.
- Whilst there is a very strong pipeline of short duration li-ion batteries at present, the outlook for long duration storage is more uncertain.

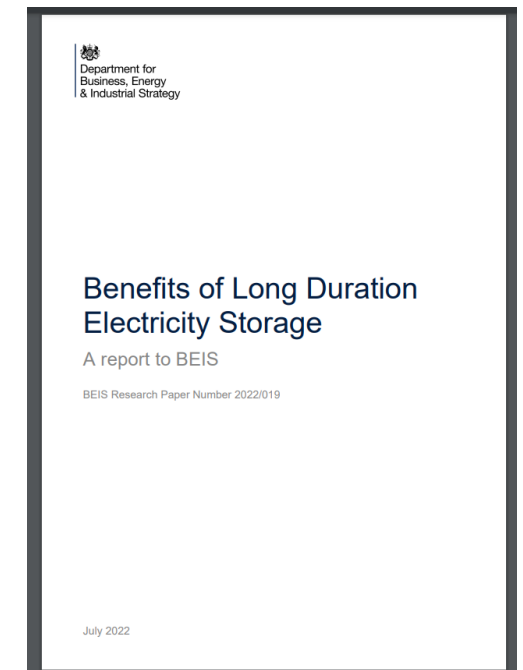
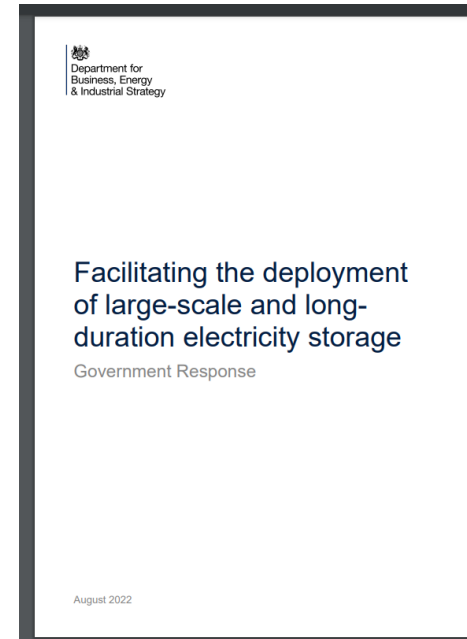
### EXAMPLE JANUARY 2050 GENERATION PATTERNS



Note: Generation patterns based on weather of January 2017

# The Department of Business, Energy and Industrial Strategy commissioned AFRY to quantify the benefits of long duration energy storage ("LDES")

- A large range of different long duration storage technologies exist, each with different flexibility characteristics. These include:
  - Pumped storage
  - Liquid Air Energy storage (LAES)
  - Compressed Air Energy Storage (CAES)
  - Flow batteries, and other innovative chemical storage options
  - Hydrogen storage (either in pressurized tanks or salt caverns)
- In 2021, BEIS issued a call for evidence on the "Facilitating the deployment of large-scale and long duration electricity storage". This highlighted that these storage technologies typically:
  - Are capital intensive;
  - Have long project development lead times; and
  - Have few contracted revenue streams available to them.
- As such, it highlighted the barriers these technologies face and BEIS commissioned AFRY to investigate the role of storage in the future GB system.



## BEIS asked AFRY quantify the impact of LDES on system costs and answer a series of research questions on the future needs of storage for net zero

- AFRY replicated BEIS' own net zero scenarios within our own BID3 modelling framework. This has some key differences to the BEIS DDM model:



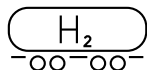
- Full 8760 hour resolution and multiple weather patterns instead of sample day modelling
- Co-optimisation and sector coupling of power and hydrogen sectors
- 11 zone approach to transmission constraints within the electricity network



- In order to quantify the benefits of storage, we modelled a range of scenarios, with 2 cases each time:
  - A “short duration storage only” reference case, where the only storage technologies available were short duration options
  - An “All durations case”, which also included both medium and long duration technologies in the model investment decisions



- The delta in modelled outcomes quantifies the benefits, based on the input assumptions made. There are key caveats:
  - Only a subset of the possible scenarios were considered and only a subset of possible storage technologies were modelled (with a focus rather on required services).
  - Future costs of storage are highly uncertain and AFRY only modelled a set consistent with BEIS' Central view on costs.
  - The model assumes sufficient prices signals for efficient delivery of investments and creates economically rational outcomes.
  - The core scenarios assumed no locational constraints would occur for the transport of hydrogen across the country.
  - The study was performed prior to the 2035 net zero power sector target, and 2035 emissions therefore reflected the 6<sup>th</sup> carbon budget level of 11mt.

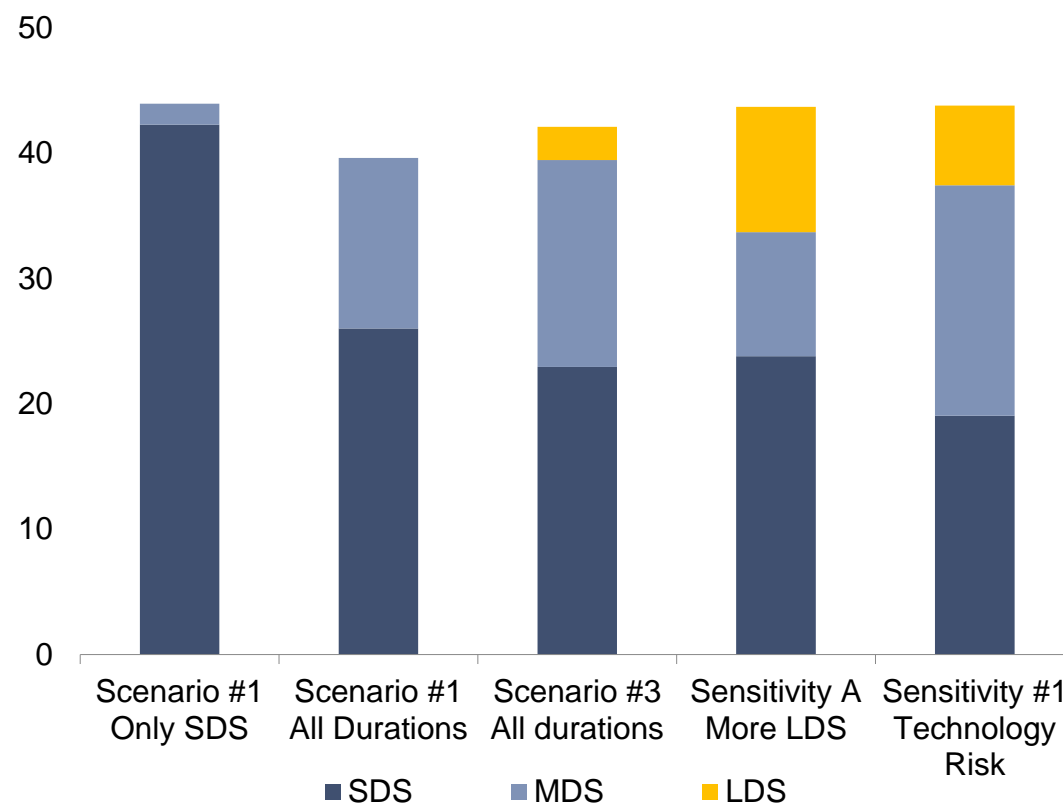


## SCENARIO RESULTS OVERVIEW

Up to 25GW of medium and long duration power storage, plus 15TWh hydrogen storage was found to reduce system costs by £13bn to £24bn

- AFRY introduced 4 categories of storage beyond BEIS' definition of short and long duration storage
  - Short duration (**SDS**): up to 4 hours
  - Medium duration (**MDS**): 6 to 12 hours for within day balancing
  - Long duration (**LDS**): Over 20 hours, for weekly or seasonal balancing
  - Hydrogen storage: apart from pressurised tanks, considered 7 to 30 day salt caverns
- Storage can provide this benefit by:
  - Providing low (or zero) carbon security of supply, during extended low wind periods
  - Faster reduction in unabated gas generation;
  - Avoided curtailment of renewables;
  - Avoiding/delaying the need for transmission network reinforcement;
  - Reducing reliance on shorter duration storage alternatives;
  - Reducing the need for immature and emerging technologies (such as gas with CCS)

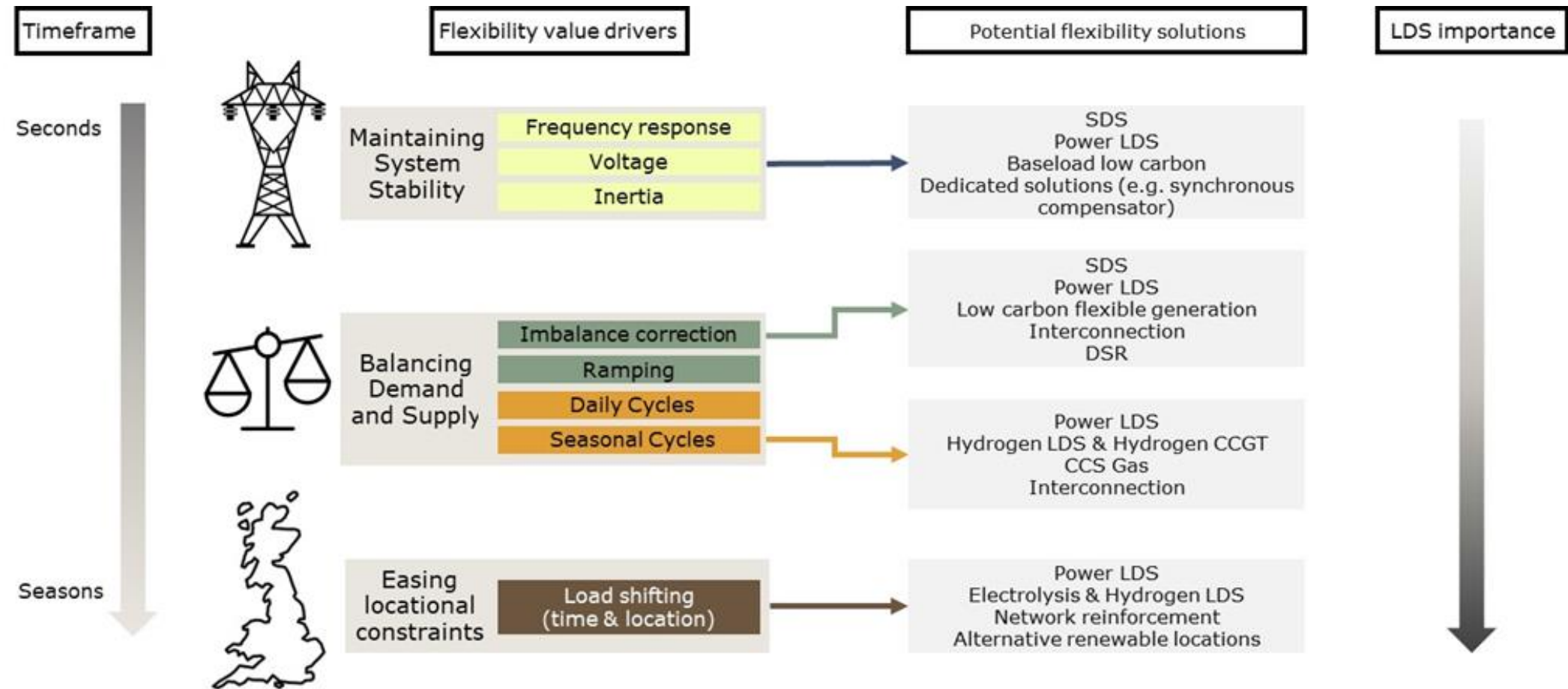
2050 POWER STORAGE CAPACITY ACROSS SCENARIOS (GW)



Notes: Cost reductions defined as the system resource costs, between 2030-2060, on an NPV basis. SDS only case includes existing PSH as MDS



The characteristics of the system needs lead to certain technology solutions.  
LDS may offer cost savings by offering bundles of multiple services.



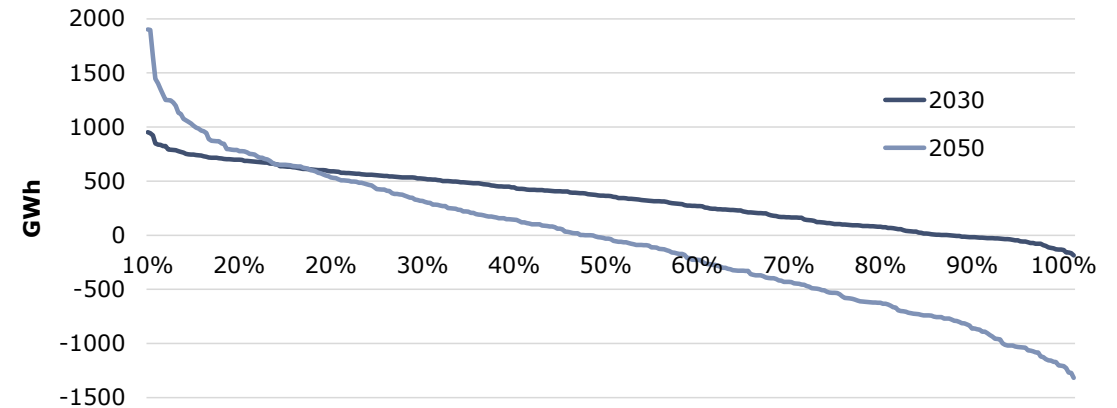


## KEY DRIVERS OF STORAGE REQUIREMENTS

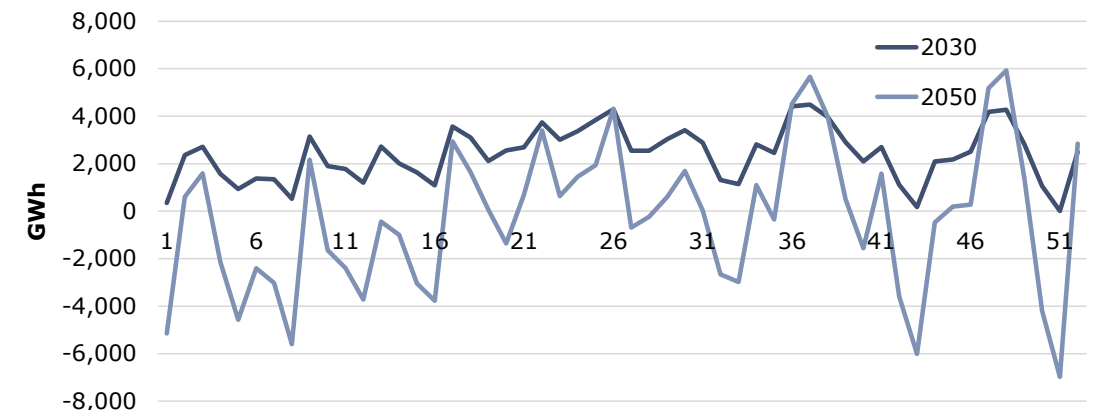
# Analysis of residual demand patterns for 2050 shows the system will require flexible capacity that can provide multi-day and weekly sustained response

- Meeting the economy-wide net-zero ambition will rely heavily on a rapid decarbonisation of our electricity system, underpinned by two key trends:
  - significant expansion in renewable generation capacity. 2030 target is for 50GW offshore wind. By 2050 renewable capacity may be in the order of 155 to 240GW according to prior modelling done by BEIS; and
  - growth in electricity demand reflecting the underlying expectation of increased electrification in the transport and heating sectors.
- These trends contribute to a volatility of residual demand, which in turn provides a signal for technologies that can respond to the swings in renewable generation.
  - This volatility appears at a range of different timescales
- A wind dominated system tends towards sustained periods of shortfall and excess
  - This need can be fulfilled by a range of technologies, including LDS, but also low carbon flexible thermal

**DAILY NET RESIDUAL DEMAND DURATION CURVE**



**WEEKLY NET RESIDUAL DEMAND PATTERNS**

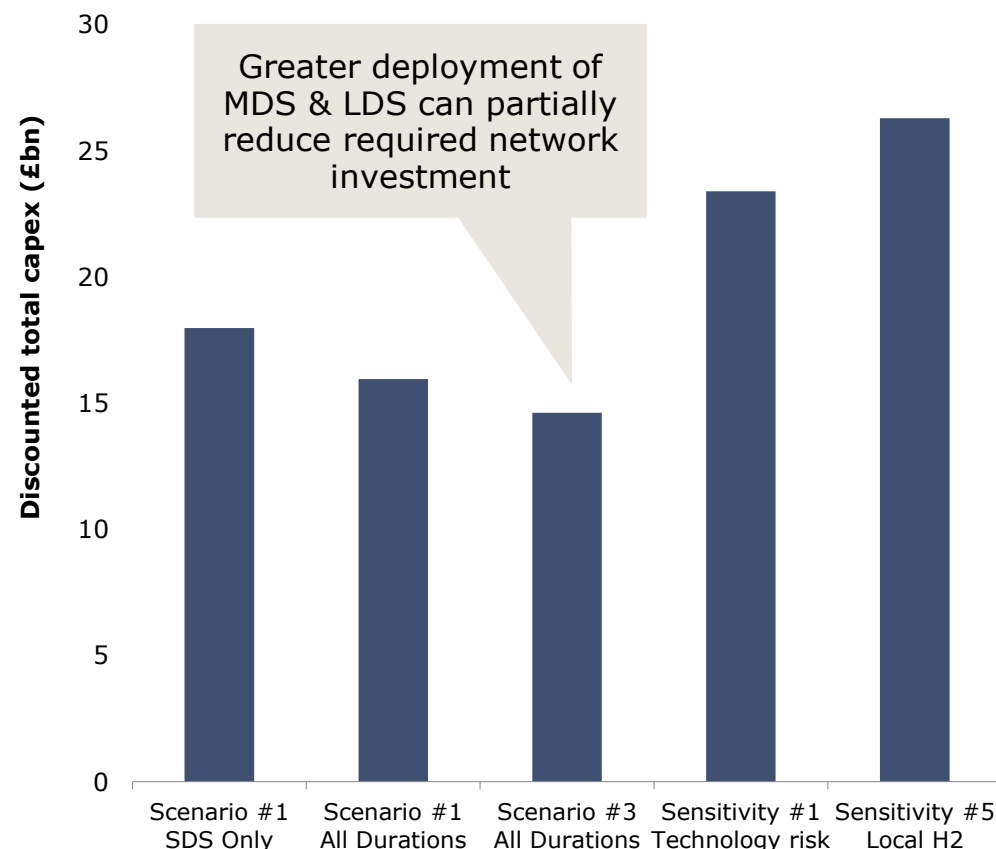


Residual demand is defined as power demand (excluding electrolysis) minus renewable generation. Positive values indicate a generation deficit and negative values a surplus of generation.

## All flexibility solutions are reliant on new transmission network capacity, but storage solutions can help reduce both total costs and deployment risks

- For some technology options, the infrastructure needs are complex.
  - For example, flexible thermal options such as Gas with CCUS requires today's gas infrastructure, a CO<sub>2</sub> network and sufficient storage.
- Electrolysis and hydrogen storage can reduce the needs for gas and carbon infrastructure, but to deliver the benefits identified in the scenarios, would also require a hydrogen transmission network.
  - However, it highlights that hydrogen storage is really a bundled set of technology solutions that require effective co-ordination.
  - Where hydrogen was more expensive or more difficult to deploy, investment in the power network was much higher
- Power storage solutions typically do not have the durations required to remove the need for new network capacity in total
  - Without investment, many storage options will become "sterilized" behind even longer duration constraints
  - But they can mitigate network deployment risks and minimize curtailment in addition to optimal reinforcement

**DISCOUNTED TOTAL TRANSMISSION NETWORK CAPEX (£BN)**

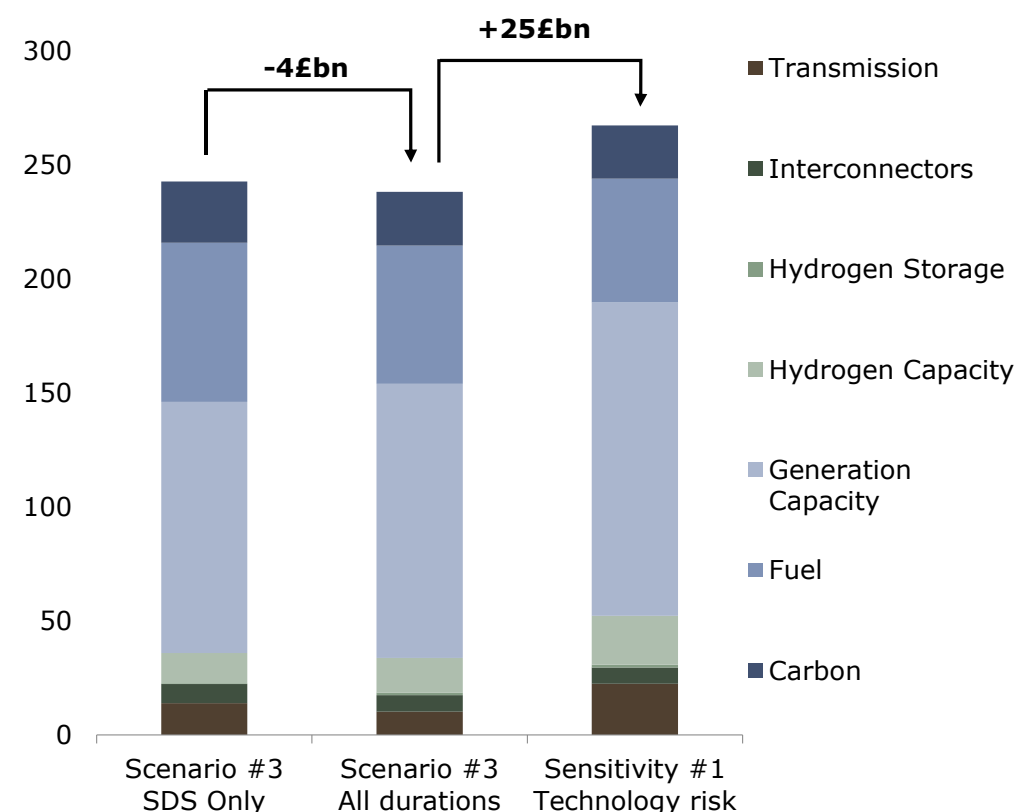


Notes: Values shown are the NPV of future total transmission network capex, between 2030-2050, on an NPV basis.. Assumes NOA6 reinforcements to 2030 included

# Supporting LDES is a low regrets decision, because it mitigates the risks around emerging hydrogen and CCUS options

- Ignoring risks around the delivery of new technologies, current cost estimates suggest that flexible thermal capacity is needed.
  - This could be Gas with CCUS. But the modelling showed that electrolysis + hydrogen LDS + hydrogen CCGTs reduced costs.
- However, if these solutions do not deliver, then the timeframe to 2035 means that there is a risk of much higher costs.
  - Without CCUS, hydrogen, and power LDS, the system would be stuck with SDS (batteries) and unabated gas on the system for longer. There is material value at risk (see system costs, right) and makes meeting the emissions reduction targets harder.
- Support for Power LDS now reduces the risks around other emerging technologies and the potential for additional costs.
  - Across the scenarios, around 3GW of power LDS (>20hr storage) emerged as a low regrets level of investment today (in addition to the beneficial MDS).
  - They can help provide the necessary flexibility services ahead of the emerging technologies scaling up.
  - They can mitigate any potential delays to the transmission network reinforcement required to integrate new renewables.

**NPV OF TOTAL SYSTEM COSTS TO 2030 TO 2040 (£BN)**



## Website links

- BEIS' response to the LLES call for evidence:
- <https://www.gov.uk/government/consultations/facilitating-the-deployment-of-large-scale-and-long-duration-electricity-storage-call-for-evidence>
- AFRY's report on the benefits of long duration storage:
- <https://www.gov.uk/government/publications/benefits-of-long-duration-electricity-storage>



## BEIS: Next steps

- In the British Energy Security Strategy, Government had identified the system need for long duration Electricity storage and committed to ensure the deployment of sufficient LLES to balance the overall system by developing appropriate policy to enable investment by 2024.
- From our 2021 Call for Evidence: most respondents identified that a mechanism is required to bring forward LLES investment.
- We intend to identify an appropriate business model to de-risk investment and to de-risk investment by 2024, by:
  - carrying out further analysis on the costs and benefits of intervention across a wider range of electricity system scenarios;
  - conducting a final assessment of potential suitable interventions,
  - working with Ofgem to develop an appropriate policy, consultation and delivery of policy.





## CONCLUDING REMARKS

# Contact us

– **Reach out** to us for more information:

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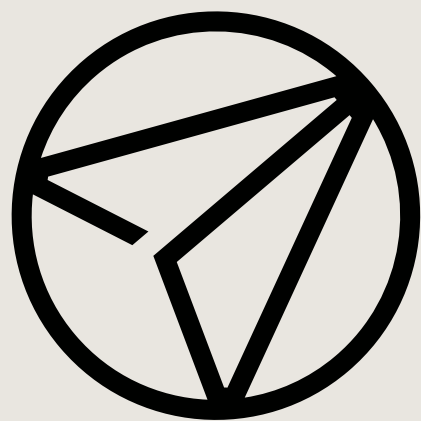
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