



National Grid ESO

The role of energy storage in a net zero electricity system

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Contents

- Zero carbon operation
- Role of storage
- Scale of storage
- Future challenges for storage

Zero-carbon operation

Fossil fuelled generation is reducing fast, causing operational challenges

- Frequency management
- Inertia and voltage control



Our plan for 2025:

- For short periods we can operate the transmission system carbon free and can accommodate all the zero carbon generation the market provides



Notable records

- **85% zero carbon** on May 23rd 2020
- **66% share of wind** on Jan 29th 2022

Our plan for 2035:

- Zero carbon operation all the time
- Manage new challenges of flexibility and adequacy

Zero-carbon operation

Pathfinders

A new approach to managing key properties of the electricity system

- **Stability** – providing inertia without generating megawatts
- **Voltage** – finding new sources of and ways to absorb reactive power
- **Constraints** – reducing congestion and the cost of network constraints

Frequency management – Reserve and Response Roadmap

New, fast and flexible ways to keep frequency stable, including

- Dynamic containment – sub-second response to catch deviations
- Dynamic Regulation and Dynamic moderation are coming next

Loss of Mains change programme

Changing embedded generation settings to reduce unnecessary tripping – nearly 9,000 sites changed to date, nearly 15 GW of capacity.

System restoration

Distributed ReStart – Black Start using distributed/embedded generators.



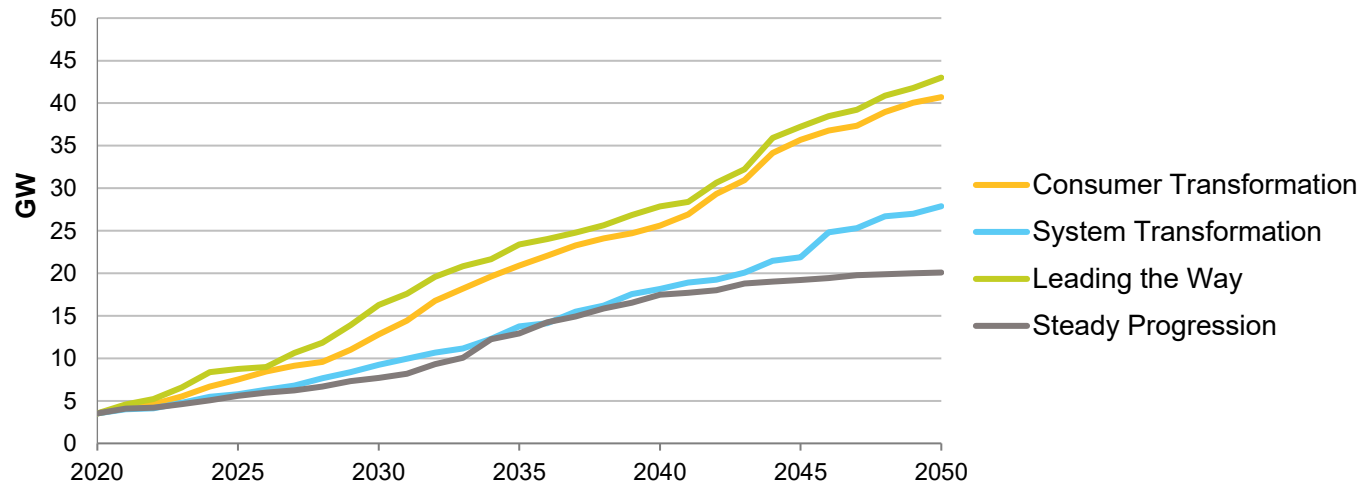
Role of storage in a zero-carbon system

Frequency	• Batteries well suited to very fast (<1 second) frequency response • Other technologies can support for minutes till other generation is dispatched
Stability	• Storage with a rotating synchronous generator can provide stability • Storage connected to wind farms to provide 'virtual synchronous machines'
Voltage	• Storage with a rotating synchronous generator can provide voltage support • Voltage support from inverter connected storage via power electronics
Thermal	• Can help by charging while behind an active export constraint (if they can later discharge when constraint is not active)
Restoration	• Storage with grid forming inverters can provide power or demand as part of a restoration plan (a distributed 'Black Start')
Flexibility	• Moving energy through time, within settlement periods to manage forecast errors and within day to flatten peaks and follow renewable generation
Adequacy	• Moving energy between seasons to ensure firm generation capacity is always sufficient to satisfy inflexible demand

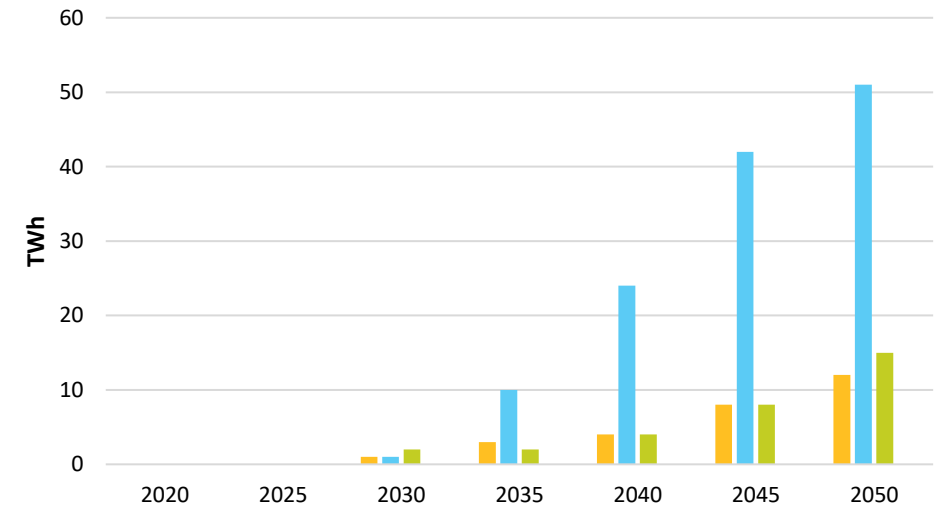


Scale of storage in a zero-carbon system

Electricity storage capacity (excluding V2G) in FES 2021



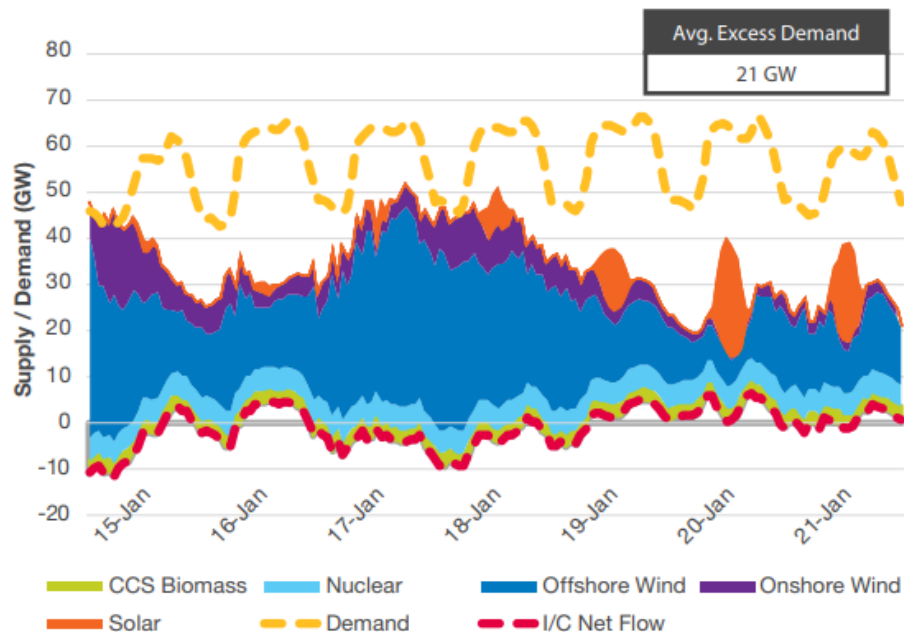
Hydrogen storage capacity requirements in FES 2021



- Our Future Energy Scenarios see the need for electricity storage growing rapidly after 2030
 - Consumer Transformation and Leading the Way have over 20 GW by 2035
 - System Transformation has 14 GW plus 10 TWh hydrogen storage by 2035
- Acceleration after 2030 as renewable share grows and storage shifts from mainly balancing services to mainly moving large volumes of energy
- Wide range in storage need is driven by uncertainty about roles of competing technologies

Scale of storage in a zero-carbon system

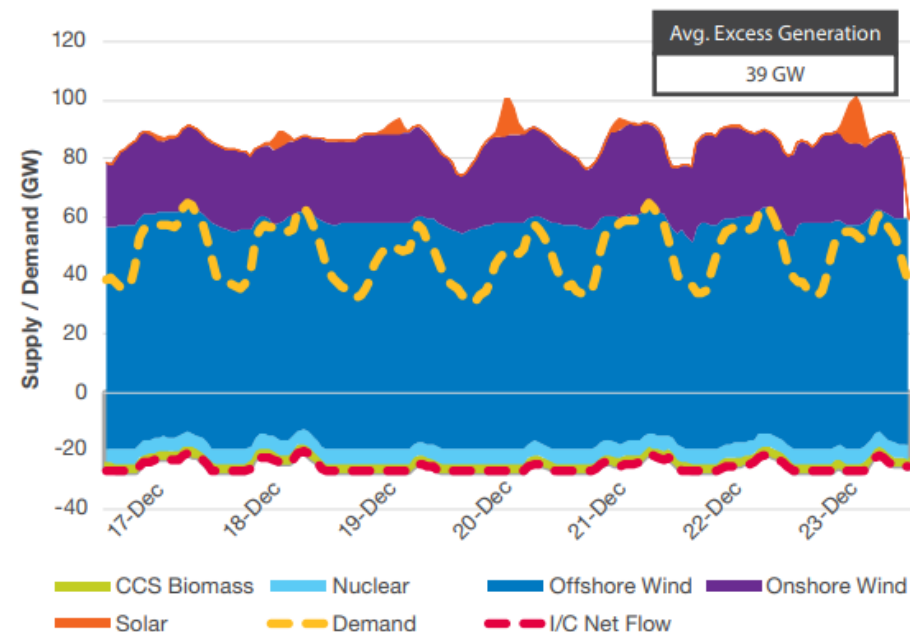
Excess Demand Scenario, January 2035: Leading the Way
(2017 weather data)



A highly weather-dependent renewable-system will have periods of excess demand when wind and solar generation is low. For a period of one week in January 2035 our modelling shows almost continuous excess demand at an average of 21.1GW. This gap must be filled by flexible capacity including demand side response. Generation stack starts from the net interconnector position.

- 2035 will have long periods where demand and zero carbon generation are out of balance
- These are examples of possible extreme weeks
 - Peak imbalances of 30-50 GW
 - Energy imbalances of 3-7 TWh over the week
- This presents a large opportunity for storage, or something else, to fill that gap

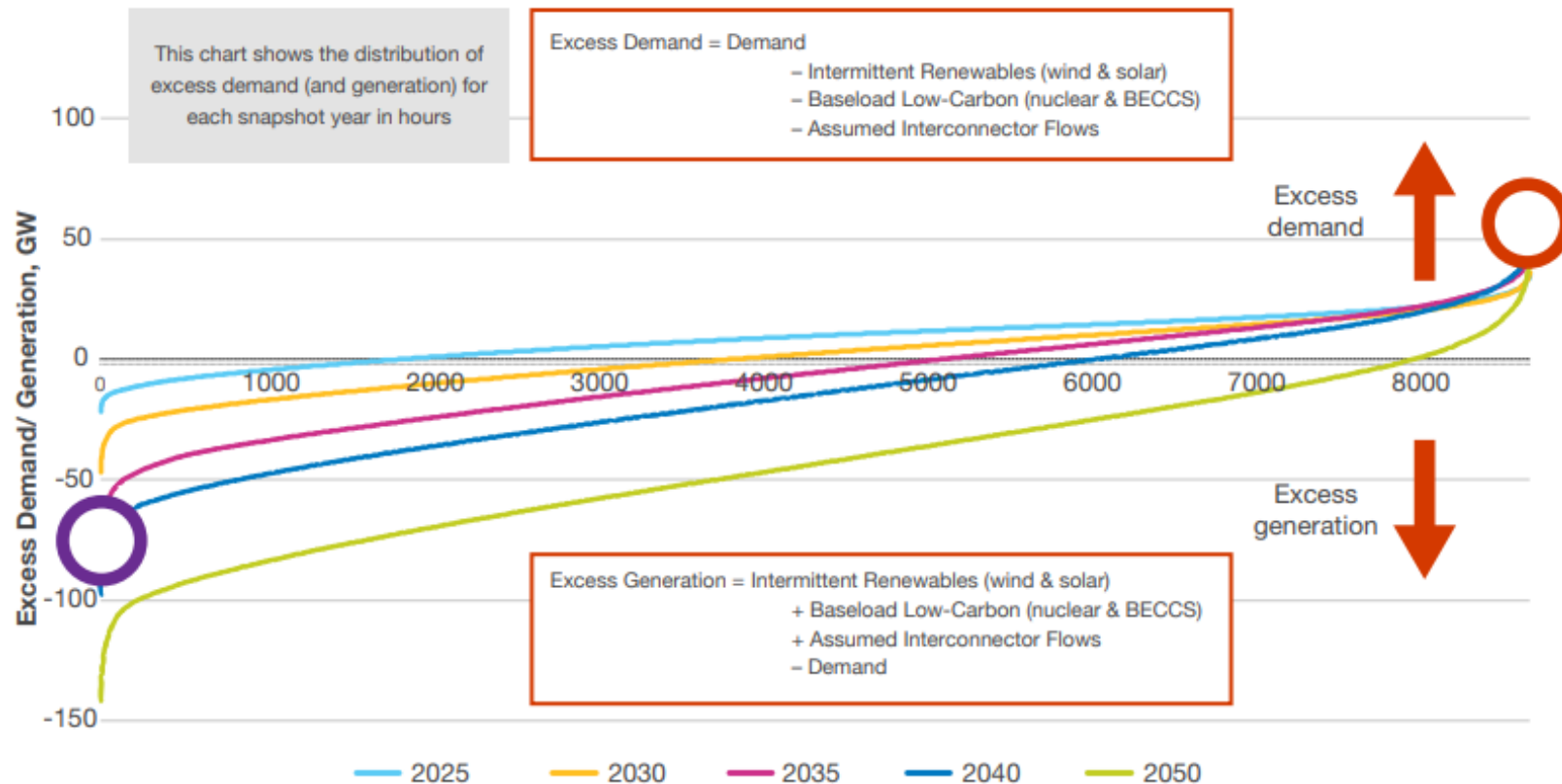
Excess Generation Scenario, December 2035: Leading the Way
(2015 weather data)



An intermittent renewable-heavy system will have periods of excess generation during periods of low demand. For a period of one week in December 2035 our modelling shows almost continuous excess generation at an average of 38.6GW. Generation stack starts from the net interconnector position.

Future challenges for storage

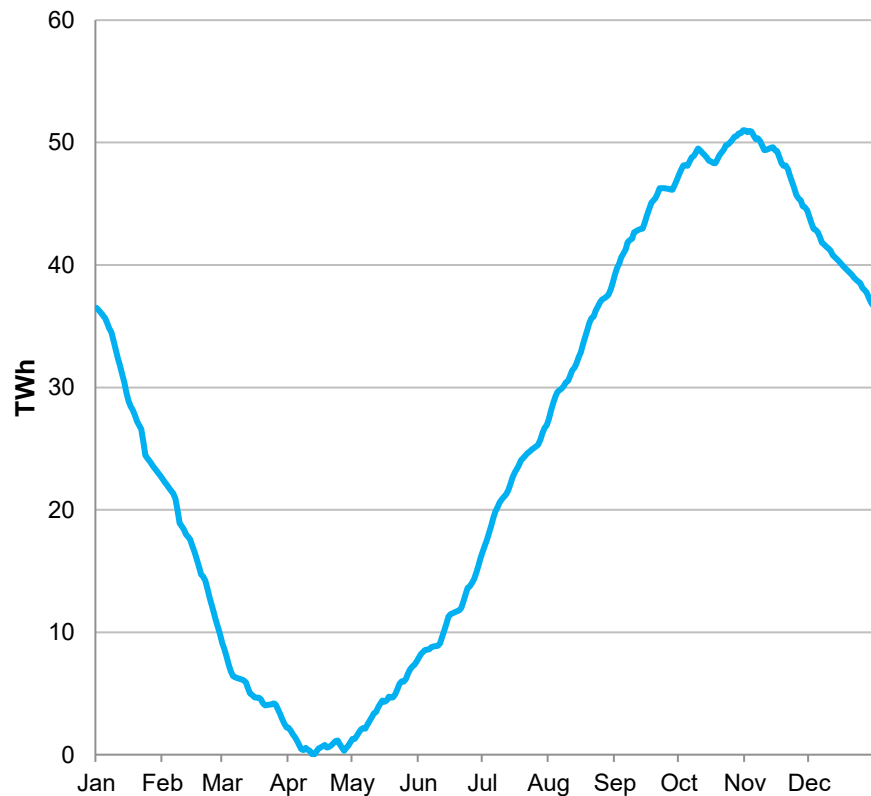
Excess Demand/Generation Distribution (GW): Leading the Way



- For some of the year there will be too much zero carbon generation and at other times there will not be enough
- Storage can help by charging when the curve is below the axis and discharging when it is above the axis
- Over time the imbalance shifts from mostly excess demand to mostly excess zero carbon generation
- We will need market arrangements that drive the right investment and operation decisions all the way from now to 2050

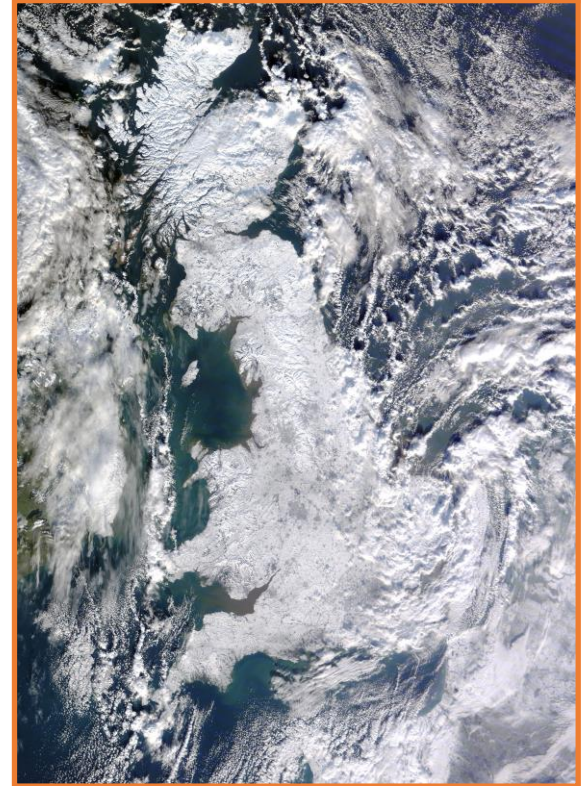
Future challenges for storage

Hydrogen storage daily stock levels in 2050
(System Transformation scenario)

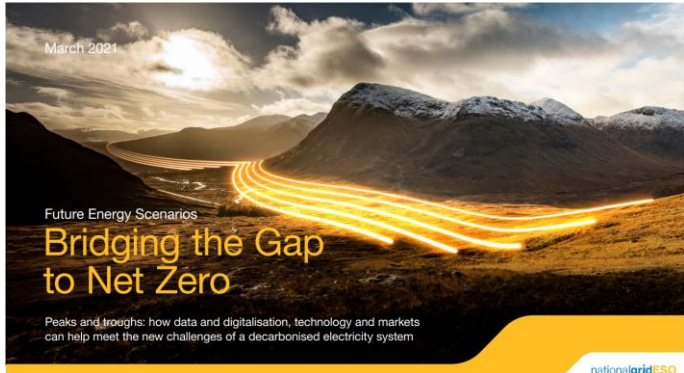


- Zero carbon heat, from heat pumps or hydrogen boilers, will need something that can flex supply to match very seasonal demand
- Storage could do this, absorbing excess zero carbon generation in summer and releasing it in the winter
- This would mean very large storage volumes with very low utilisation levels
- Ensuring adequacy for rare extreme winters (e.g. 1-in-20 years) would mean even larger volumes and even lower utilisation
- Is this the right solution for consumers and what market arrangements would be needed to deliver that?

December 2009



How to solve the challenges



- We need to work with the energy industry to solve these challenges
- Please engage with us through our channels:
 - What the future might look like – **Future Energy Scenarios**
 - How energy markets will need to change – **Bridging the Gap** and **Net Zero Market Reform**
 - How balancing services will need to change – **Markets Roadmap** and **Operability Strategy Report**

