



# Energy Storage in the UK

When the wind doesn't blow...

10<sup>th</sup> October 2023

# agenda

■ why energy storage?

■ technology options

■ StrataStore Project: compressed air energy storage case study

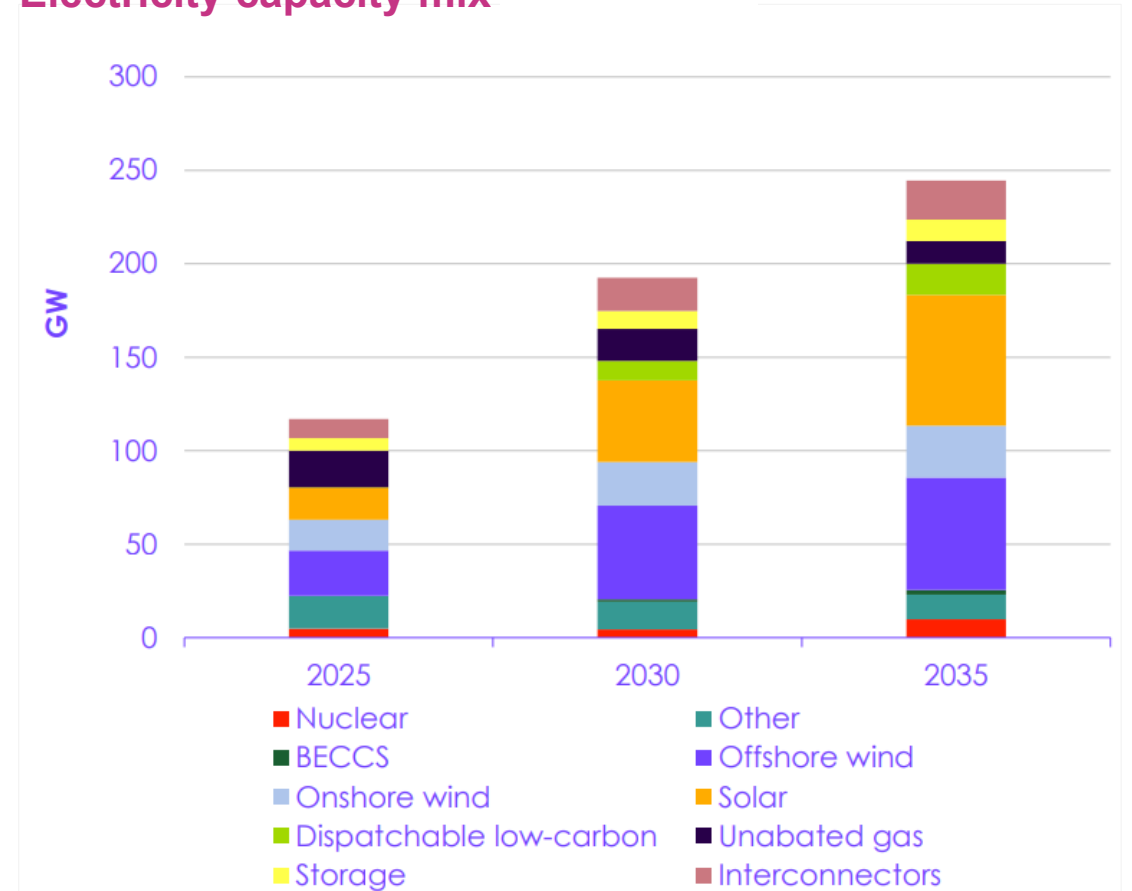


# Why energy storage?

## UK future predictions for generation

- ✓ “Installed capacity” increases markedly
  - ✓ Dominated by solar and wind
  - ✓ All variable in nature
- ✓ Growth in Storage to 11 GW and Dispatchable Low-Carbon to 17GW
- ✓ Demand increase – Electrification of:
  - ✓ Transportation
  - ✓ Heating
  - ✓ Industry
- ✓ Growth in demand
  - ✓ ~50% by 2035
  - ✓ ~100% by 2050

## Electricity capacity mix

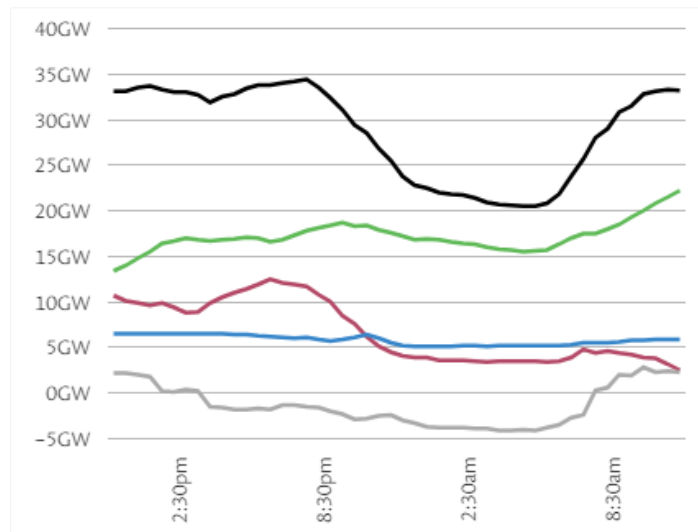


[Delivering a reliable decarbonised power system - Climate Change Committee \(theccc.org.uk\)](https://theccc.org.uk)

# Why energy storage?

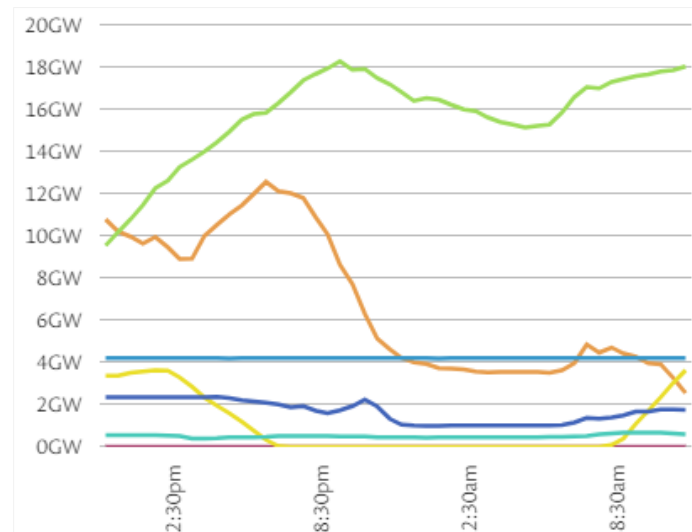
## An example day in the UK

### Demand and Generation



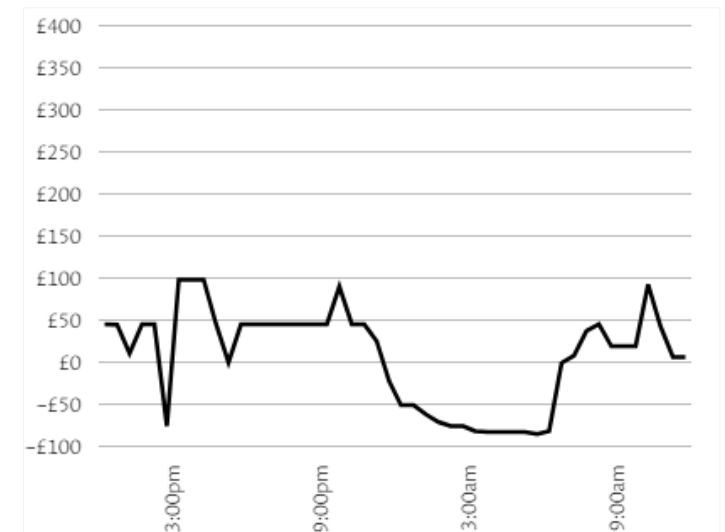
- Fossil Fuels
- Renewables
- Other
- Imports / Exports

### Generation



- Coal
- Gas
- Solar
- Wind
- HydroElectric
- Nuclear
- Biomass

### Wholesale Price



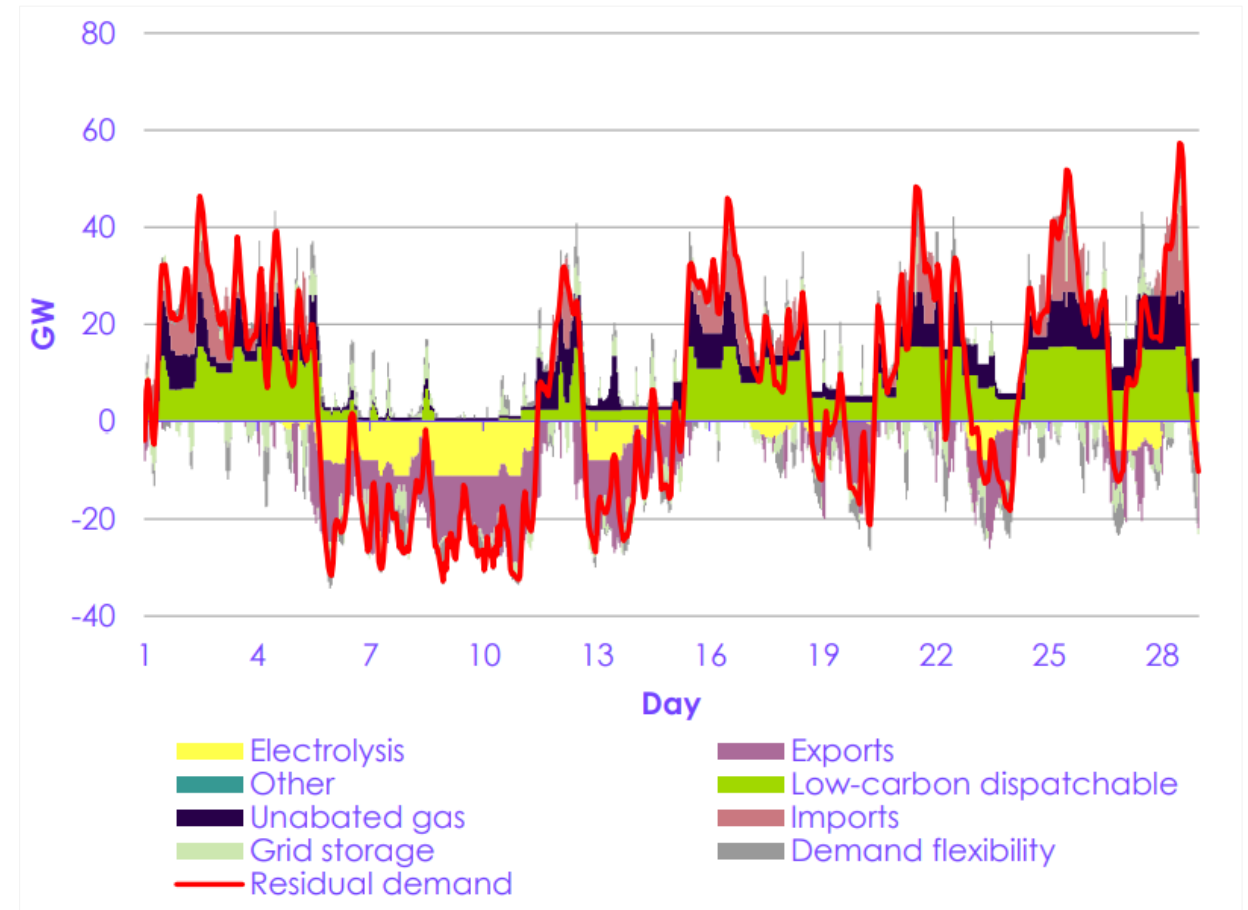
<https://grid.iamkate.com/> Data from 5<sup>th</sup> / 6<sup>th</sup> October 2023

# Why energy storage?

## UK storage requirement

- ✓ Daily swings managed through:
  - ✓ Demand flexibility
  - ✓ Grid storage
- ✓ Longer duration periods of surplus or deficit
  - ✓ Produce hydrogen when the wind blows
  - ✓ Low carbon dispatchable to meet sustained periods of excess demand

## Residual demand (highest four-week period)



[Delivering a reliable decarbonised power system - Climate Change Committee \(theccc.org.uk\)](https://theccc.org.uk)



# UK net zero challenge

transition from fossil fuel-driven generation combined with growth in demand

## supply / demand imbalance

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- ✓ Increasing **volatility of residual demand** due to greater reliance on renewable generation sources
- ✓ Flexibility to **maximise use** of renewables
- ✓ Both within-day and seasonal **flexibility required**

## grid services

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- ✓ Proportion of **synchronous generation will fall** as renewables replace thermal generation
- ✓ **Reducing system inertia** readily available for secure operations
- ✓ Variability in transmission line loading triggers greater need for **voltage support services**

## network congestion

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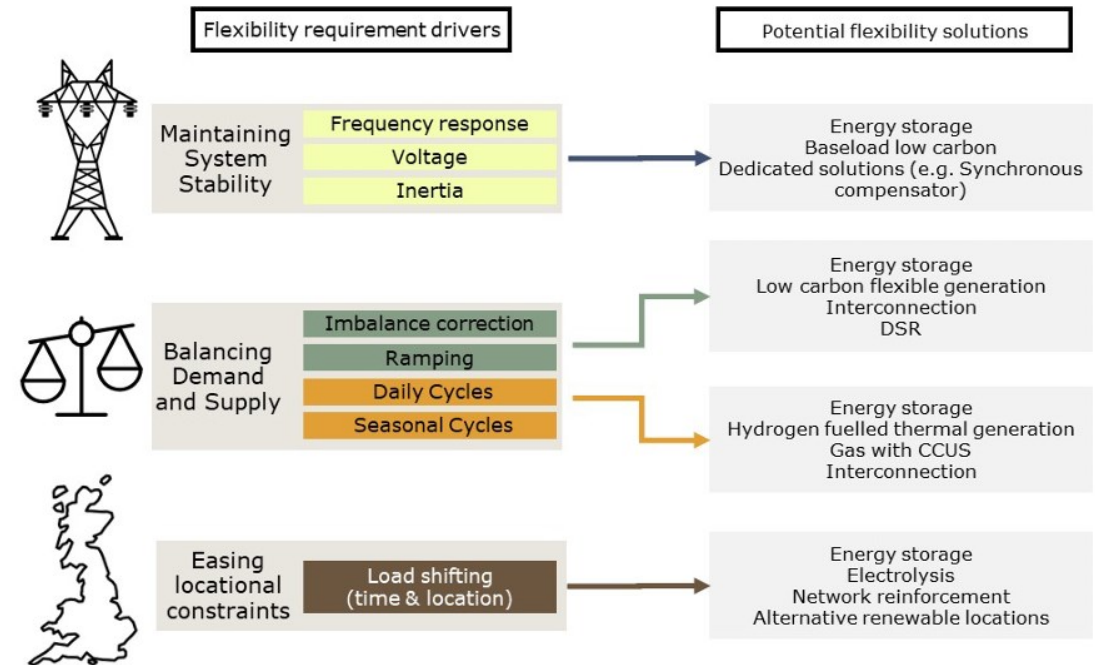
- ✓ Renewable resources are **not evenly distributed** across the country
- ✓ To access best renewable resources generation will be sited **further from demand centres**
- ✓ Additional flexibility can **avoid expensive** network reinforcement or renewable **curtailment**



# UK net zero challenge

## flexibility options & BEIS

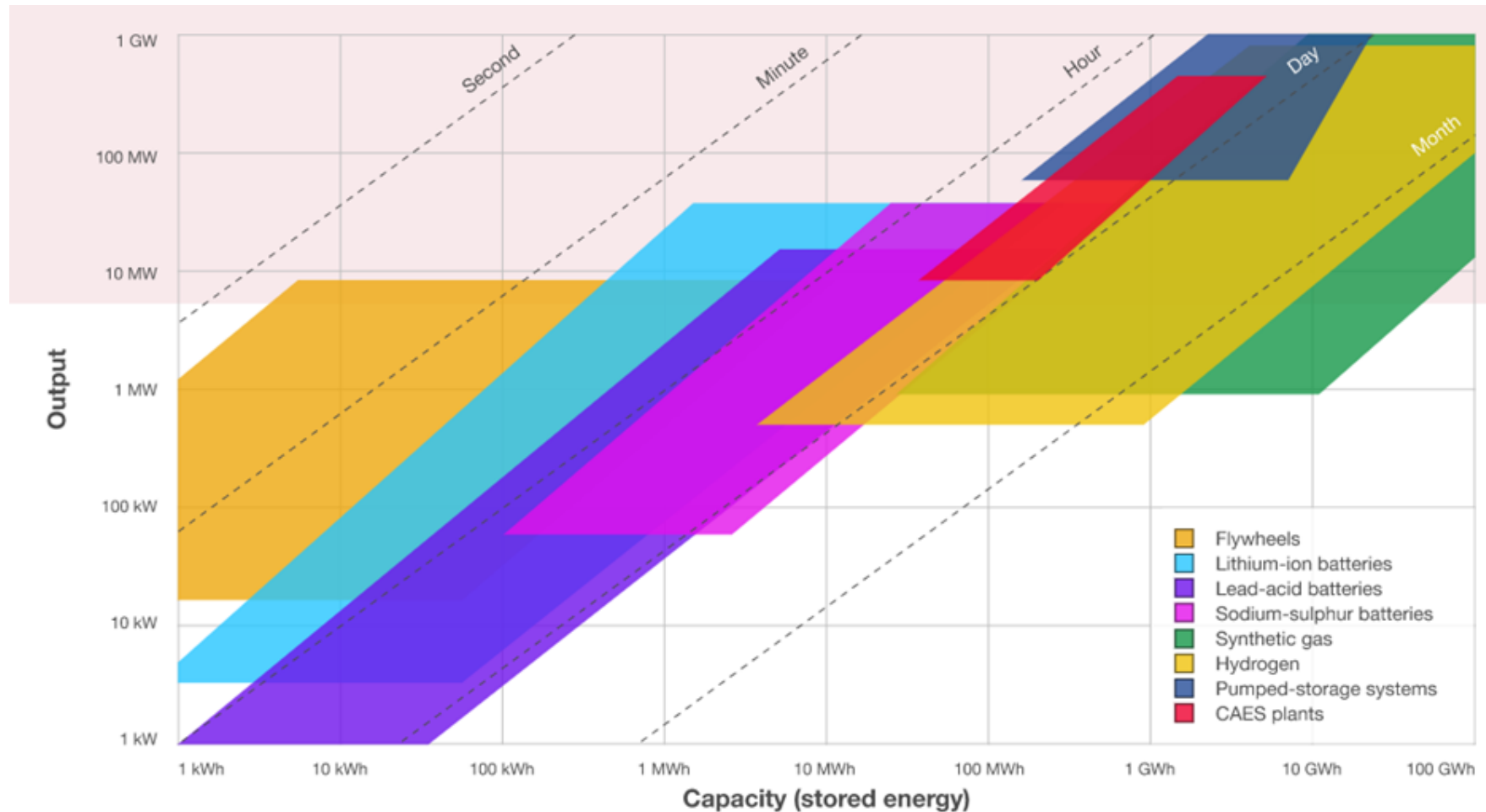
- ✓ Energy Storage is a *solution* to all the flexibility needs
- ✓ Longer duration storage solutions estimated to reduce net zero systems costs by *£13bn-£24bn*
- ✓ BEIS Longer Duration Energy Storage Demonstration (LODES) competition
  - ✓ Aiming to *accelerate* commercialisation of innovative LDES projects
  - ✓ *Agnostic* technology support



Notes: 'Baseload low carbon' is assumed to include nuclear, biomass and biomass with CCS capacity. Low carbon flexible capacity is assumed to include hydrogen fuelled and gas with CCS capacity.

Ref. "Benefits of Long Duration Electricity" BEIS Research Paper Number 2022/019

# Energy storage technology mix



Capacity and output ranges as well as typical storage durations in which different storage technologies are considered appropriate due to their characteristics.

Source: "Technologie-Roadmap Stationäre Energiespeicher 2030", Fraunhofer Institute for Systems and Innovation Research, Karlsruhe, 2015





# StrataStore

CHESHIRE ENERGY STORAGE CENTRE



HYDROSTOR



edf

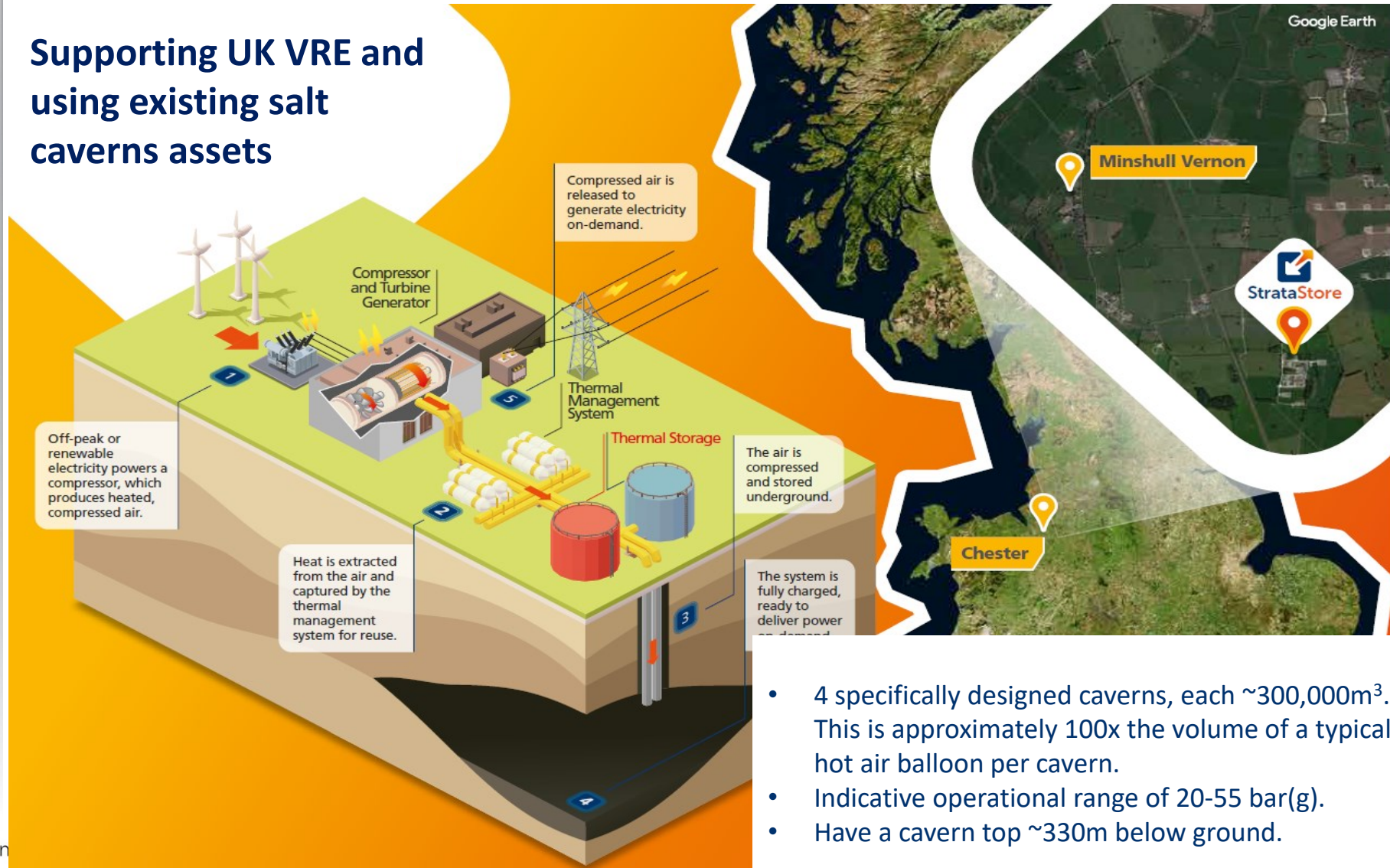


io consulting

**Reliable, Safe,  
and Affordable**  
long duration  
energy storage  
enabling Britain's  
sustainable  
net-zero future.

# StrataStore A-CAES Project

Supporting UK VRE and  
using existing salt  
caverns assets



- A site which has previously been used to store natural gas in underground caverns within a salt (halite) layer.
- Currently being retired, meaning it can be used for alternative duties.
- Located just north of Crewe in Cheshire.
- Owned by EDF Energy Gas Storage Ltd.
- Connected to the natural gas high pressure national transmission system.
- Supported by on-site management and technical teams.

- 4 specifically designed caverns, each  $\sim 300,000\text{m}^3$ . This is approximately 100x the volume of a typical hot air balloon per cavern.
- Indicative operational range of 20-55 bar(g).
- Have a cavern top  $\sim 330\text{m}$  below ground.

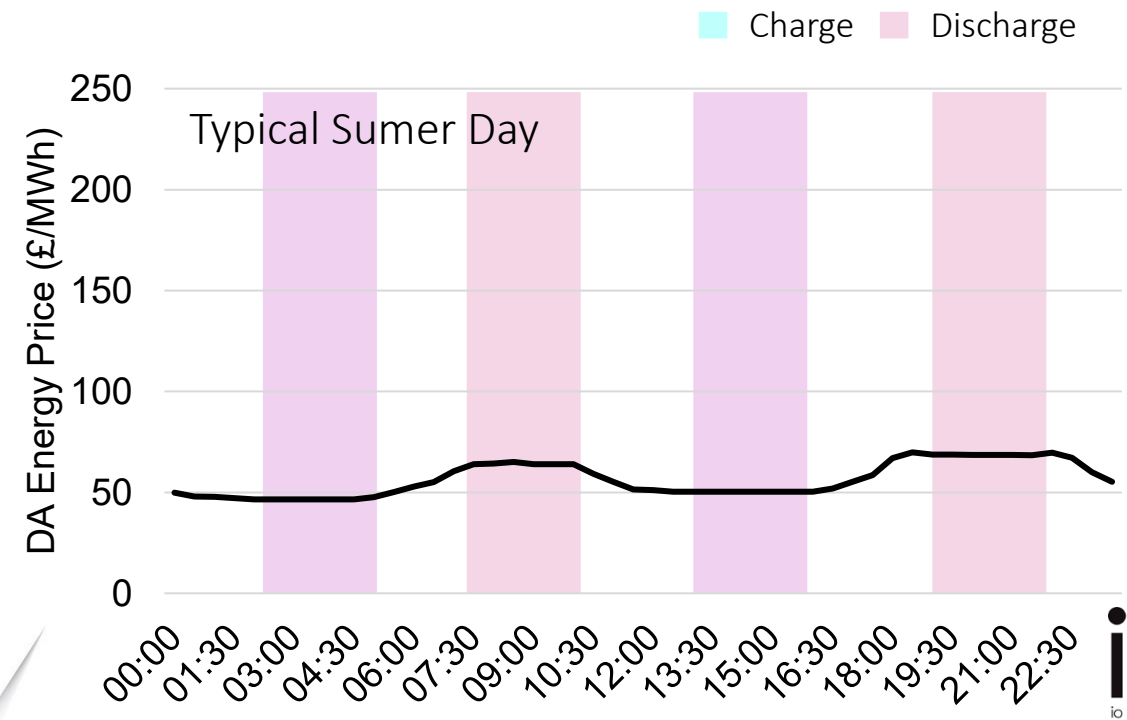
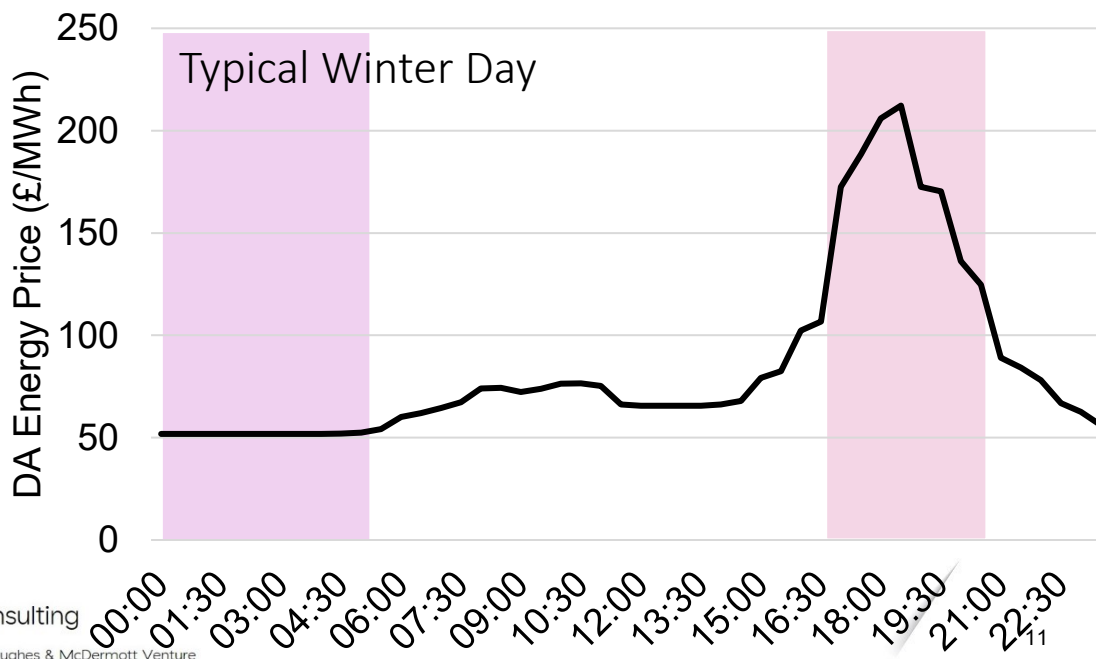
# UK Wholesale Market

## How does it work?

- ✓ Suppliers offer energy at a given price, fixed by the most expensive technology to enter a market (following a merit order structure)
- ✓ Energy Storage Operating strategy:
  - ✓ Charge when prices are low
  - ✓ Discharge when the prices are high
  - ✓ Revenue being the difference between charge & discharge prices

Day-ahead prices are taken from Afry Consulting for future years, for a weather scenario of 2018 and its central scenario.

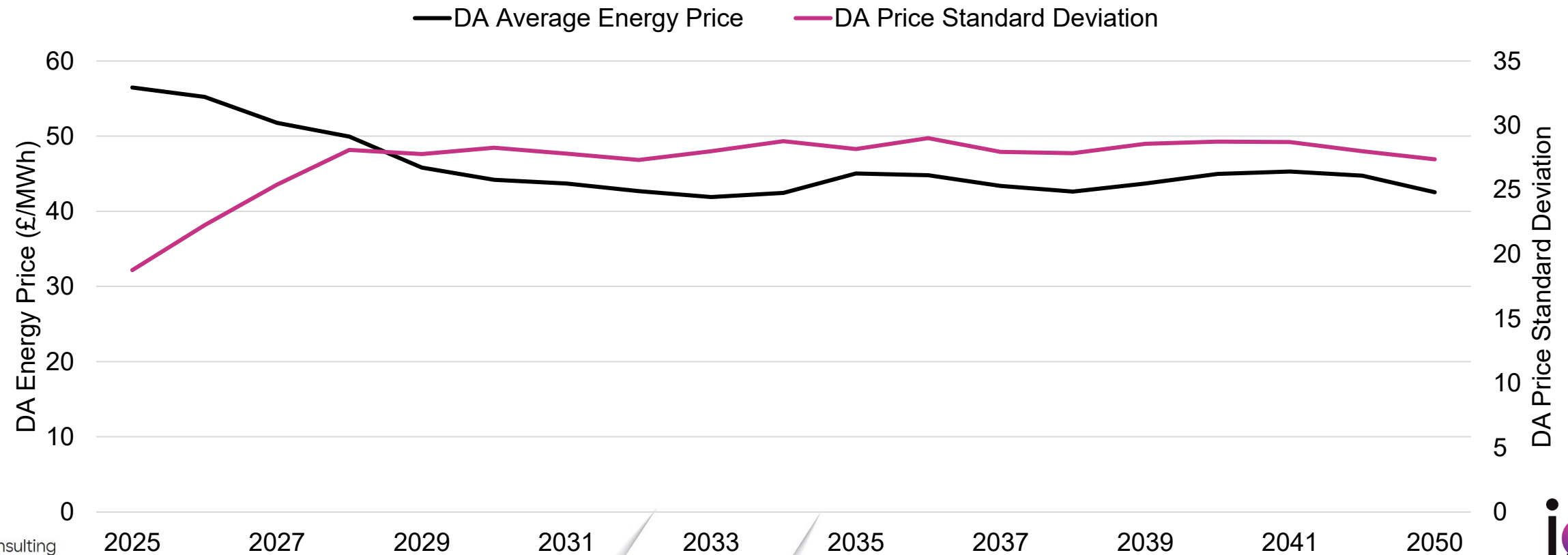
The central scenario refers to assumptions regarding commodity, fuel, and O&M. No sensitivity analysis was conducted on the low/high gas and carbon price scenarios.



# UK Wholesale Market

## Future forecasts

- / DA Average energy prices are forecasted to decrease over time
  - / Increased Variable Renewable penetration (very low marginal costs)
  - / Supported by energy storage
- / However, price volatility forecasted to increase creating increased arbitrage opportunities





# StrataStore: Revenue from current market arrangement

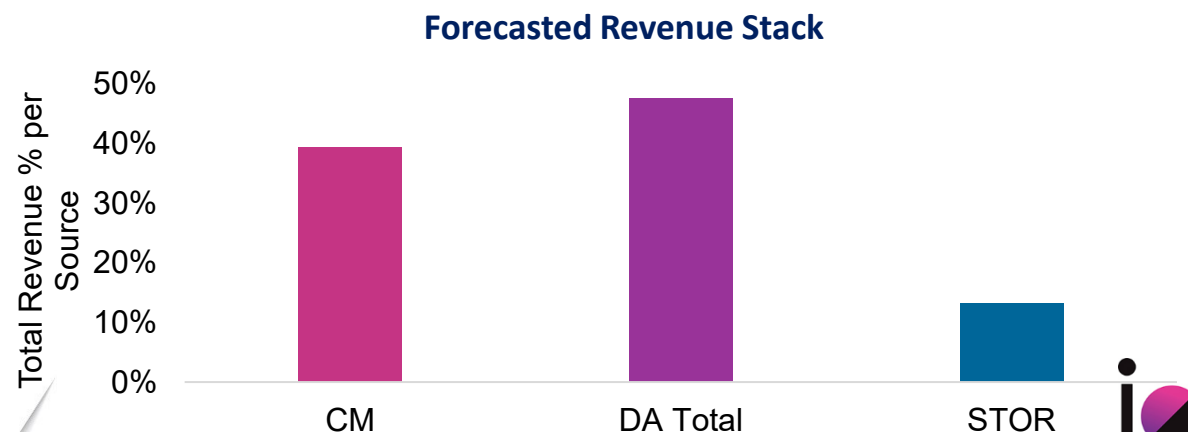
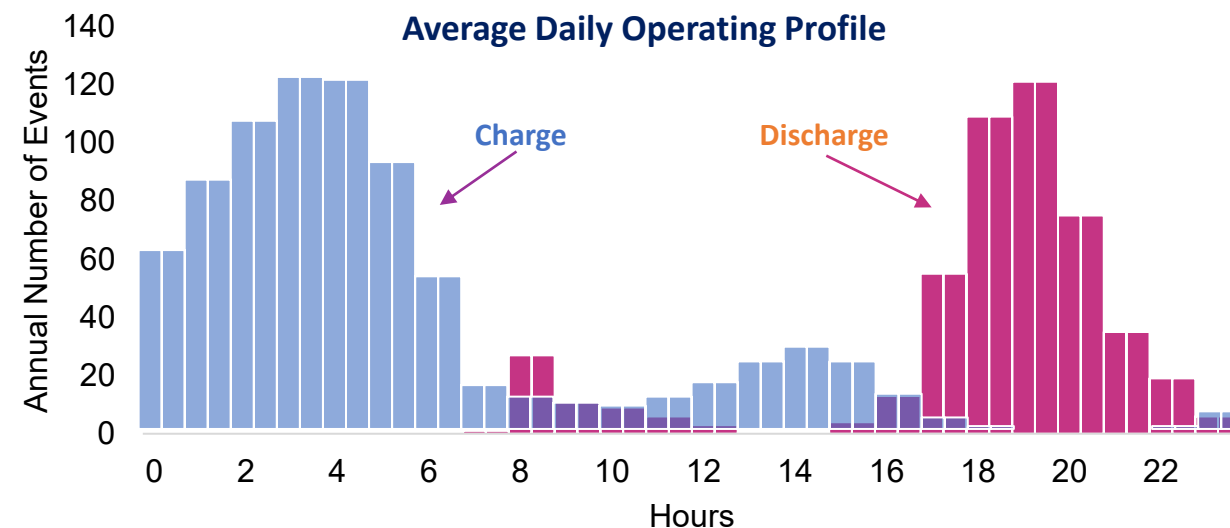
Forecasted Dispatch: 100 MW / 800 MWh

Prices Data	Value
DA	Afry Consulting Forecast (Central Scenario)
CM	30.59 £/MWh - Source: NG and Modo Energy
STOR	10 £/MWh - Source: Aurora Market Reports

System Parameters	
Storage Energy Capacity	600-800MWh
Storage Power Capacity	100MW
Storage Efficiency	60% / 65%
Grid Connection	Transmission System

Modelling Assumptions	25years operating life; no storage degradation nor self-discharge
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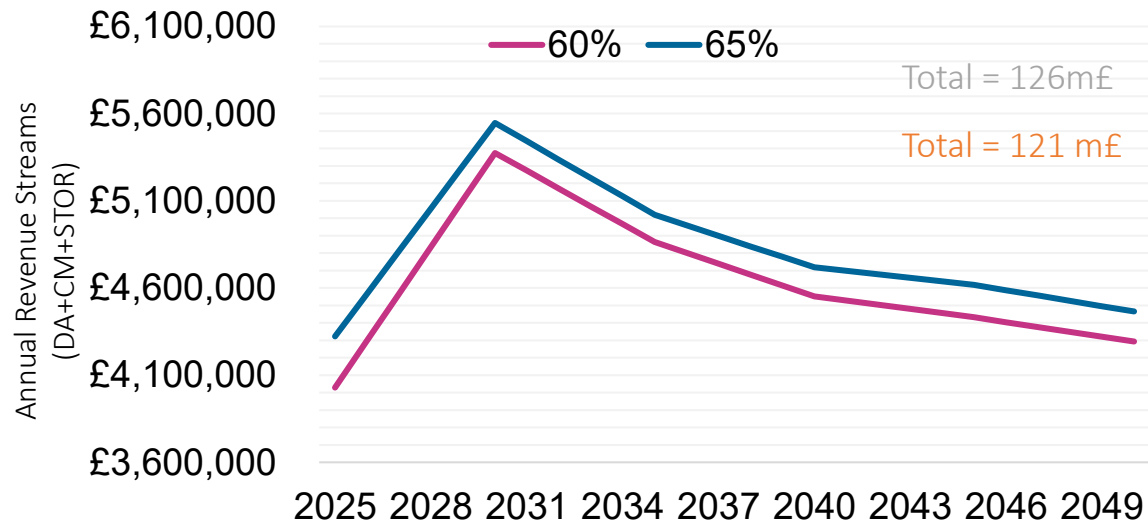
Results	
Operational	Monthly Number of Cycles Half-Hourly PC & PD profiles
Economic	Monthly Revenues (DA, CM and STOR)



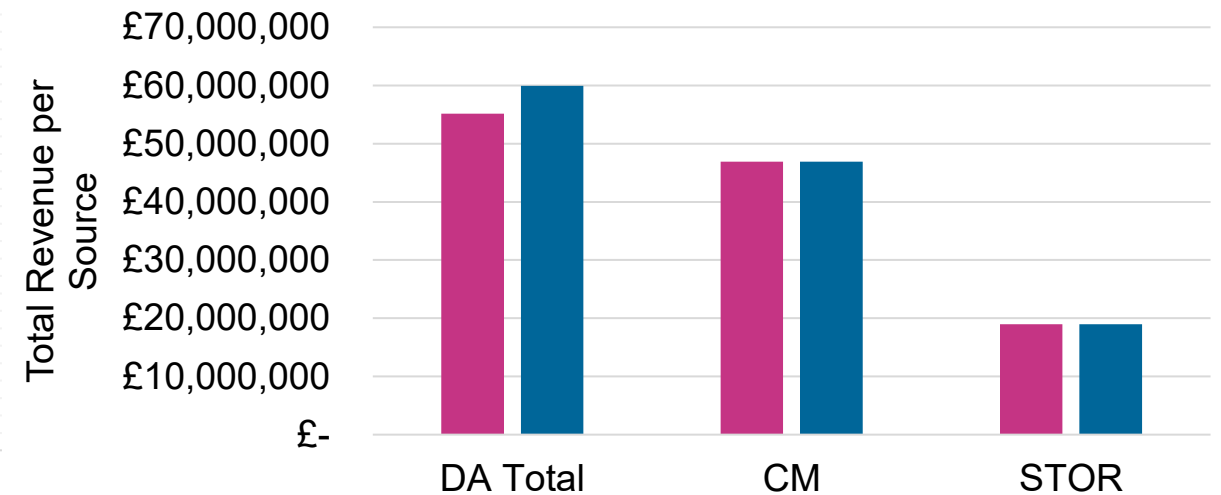
# StrataStore: Revenue forecast 100MW – 600MWh

100MW – 600Mwh - 6hr

Forecasted revenue based on current market mechanisms available



Forecasted revenue breakdown by category



✓ Average revenue: £4.80/kW-month or £6.57/MWh

✓ Circa 10% of the forecast day-ahead price



# StrataStore: Price Sensitivity

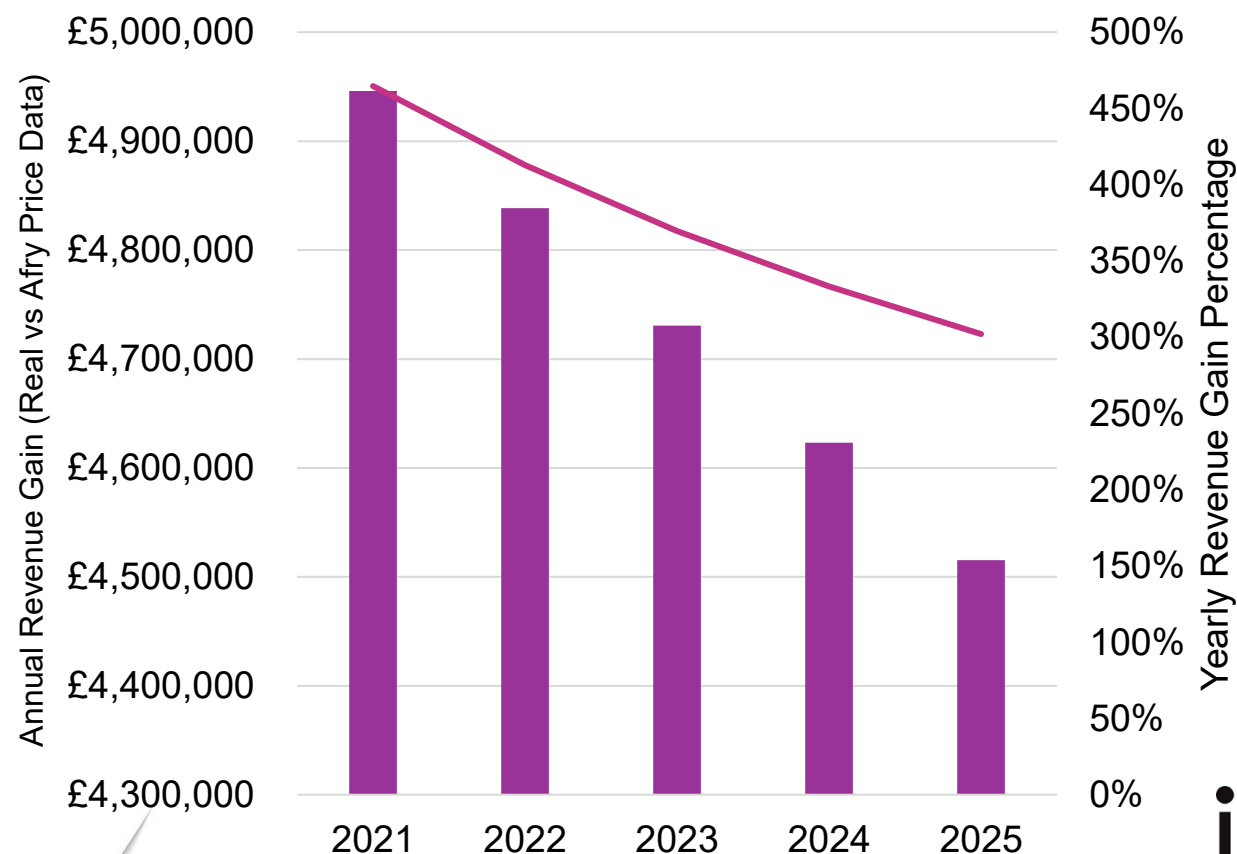
2021 Revenues considering real prices - Source: Aurora

	January	February	March	April	May	June	July	August	September	October	November	December	Total
DA revenues	£ 657,310	£ 280,835	£ 342,916	£ 231,864	£ 146,264	£ 111,260	£ 61,457	£ 81,060	£ 1,681,674	£ 762,305	£ 1,048,345	£ 605,032	£ 6,010,323

2021 to 2025 Revenues considering  
forecasted prices - Source: Afry Consulting

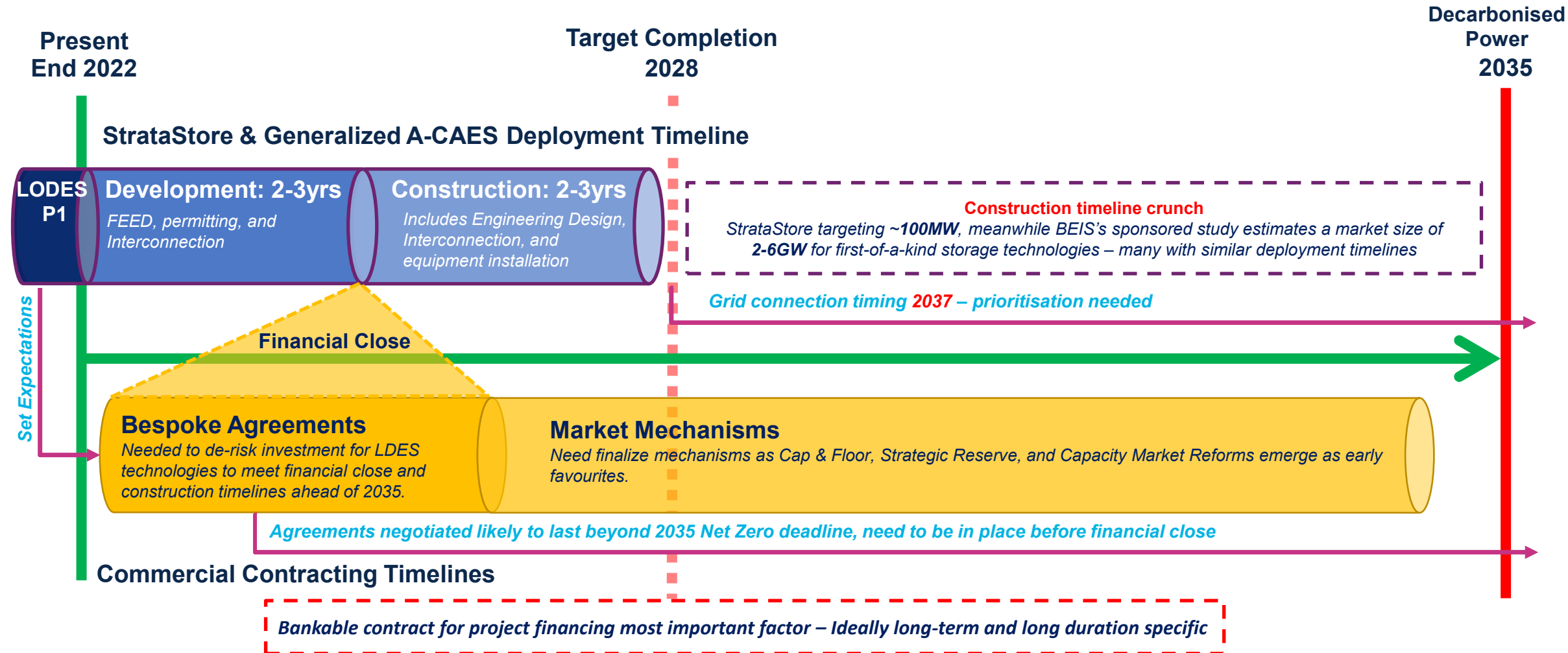
	Revenue	Gain	Gain (%)
2021	£ 1,064,141	£ 4,946,181	465%
2022	£ 1,171,826	£ 4,838,496	413%
2023	£ 1,279,511	£ 4,730,811	370%
2024	£ 1,387,196	£ 4,623,126	333%
2025	£ 1,494,880	£ 4,515,441	302%

In 2025, if the energy prices remain as high as today, the project annual revenue streams will be increased by a 300% representing a revenue gain of 4.5 m£.



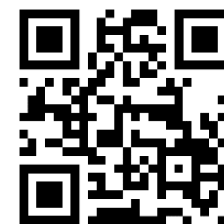
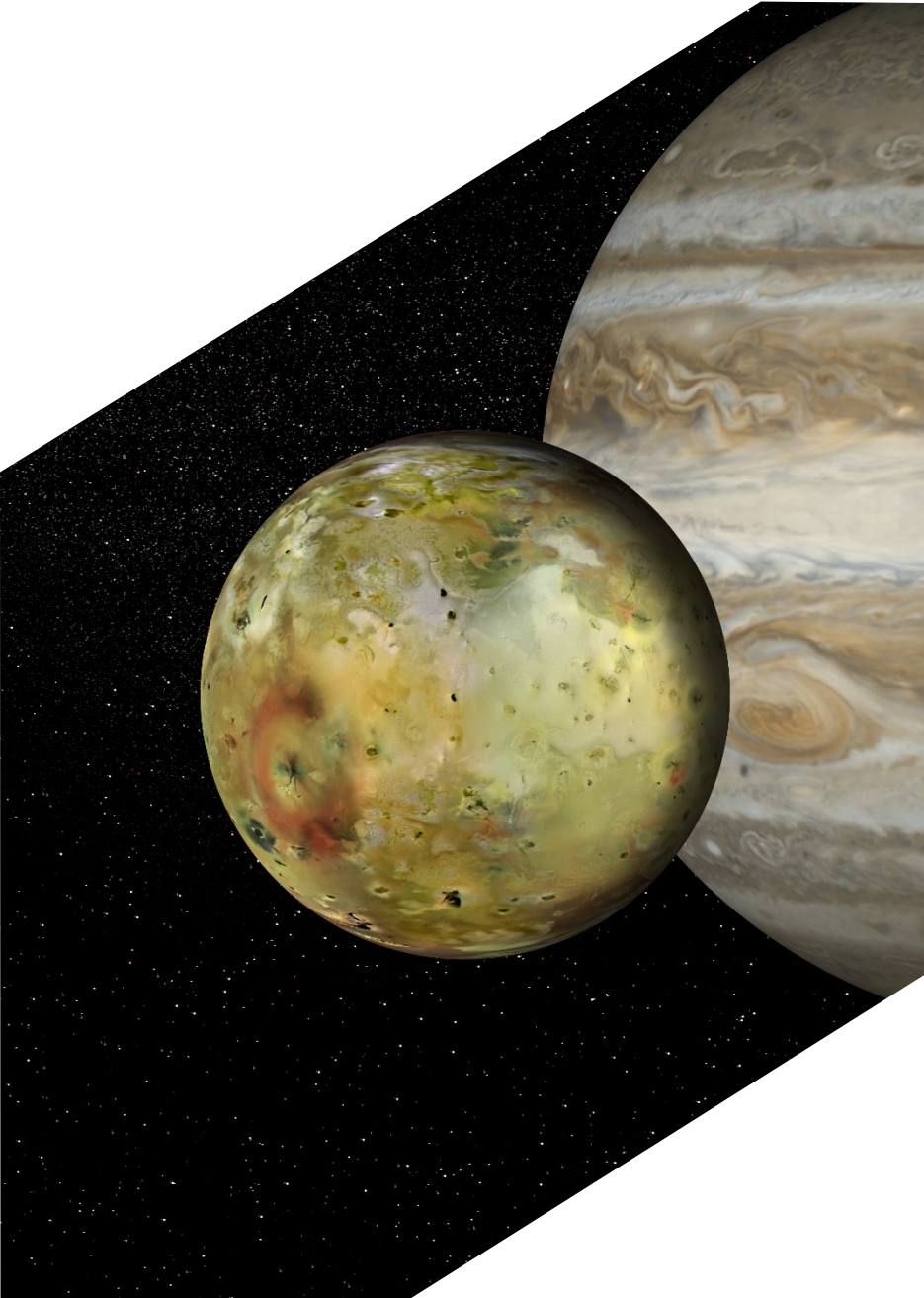
# Headwinds Facing StrataStore Deployment

Lack of synchronisation between long development cycles, commercial markets and UK Net Zero goals





QA



[ioconsulting.com](https://ioconsulting.com)

thank you



