Electricity Storage Markets Opportunities in the UK

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1 Introduction

In response to NEXA Advisory's proposal, Swanbarton Limited presents this document outlining the electricity storage market in the UK. Our expertise in energy storage solutions puts us in an excellent position to provide in-depth analysis and strategic insights tailored to the challenges and opportunities within these markets.

This document sheds light on the critical aspects of battery storage investment, market dynamics, and regulatory environments in these regions, drawing parallels and contrasts with the Australian National Electricity Market (NEM). Our analysis mainly focuses on medium- to long-duration storage technologies, which are gaining prominence against evolving energy demands and grid stability requirements. We are including comments on recent deployments, especially in 2022 and 2023

We explore practical strategies and models used in the UK, assessing their applicability and potential modifications for the NEM's unique energy-only market framework. Swanbarton Limited is pleased to support NEXA Advisory's work to analyse the complexities of battery storage investment, facilitate informed decision-making, and foster sustainable growth in the energy storage sector.

1.1 Scope

The UK energy storage market is constantly evolving. Therefore, to both provide an overview of this market and a snapshot of its current state, it uses the following case studies:

- Battery deployments: Q2 & Q3 2023 – the most recent system deployment in the UK and outline current trends.
- Revenue Streams: 14th November 2023 – 13th December 2023 for the battery deployments of Q2 & Q3 2023.

2 UK Energy Metrics

This section outlines quantitative data associated with the UK energy storage market.

2.1 The current capacity of electricity storage deployed

As of the end of Q3 2023, there are 111 operational BESS sites in the UK. The total battery energy storage system (BESS) capacity in Great Britain is 3.1 GW and 3.8 GWh across all durations and battery technologies.

2.2 Capacity of electricity storage as a percentage of total available (nameplate) generation capacity

- Total UK generation capacity: 76.7 GW (2022)
- Renewables generation capacity: 24.6 GW (~32%)
- BESS capacity: 3.1 GW (4.3%) (Oct 2023)

2.3 Technology types (noting the ~ 3 GW of pumped hydro in GB)

Figure 1 shows the maturity of generation and storage technologies currently deployed in the UK. The following is a summary of the storage technologies presently deployed in the UK:

2.3.1 Non-BESS Technologies

- Pumped Hydro: 2860 MW
- Non-pumped hydro: 1676 MW (generating over 5000 GW/year)

2.3.2 BESS Technologies

- Lithium Ion
  - These make up the vast majority of utility-scale storage.
- Other:
  - Flow Batteries are the only other utility-scale storage active in the UK energy markets. However, these are small-scale systems. Two notable projects:
    - Invinity (deployed) – Energy Superhub Oxford: 2MW / 5MWh
    - Invinity (Pipeline) – National Grid: 7MW / 30MWh
    - Other flow batteries, including ZnBr installed by Lotte, ZBB, and Redflow, have been small-scale demonstrations.

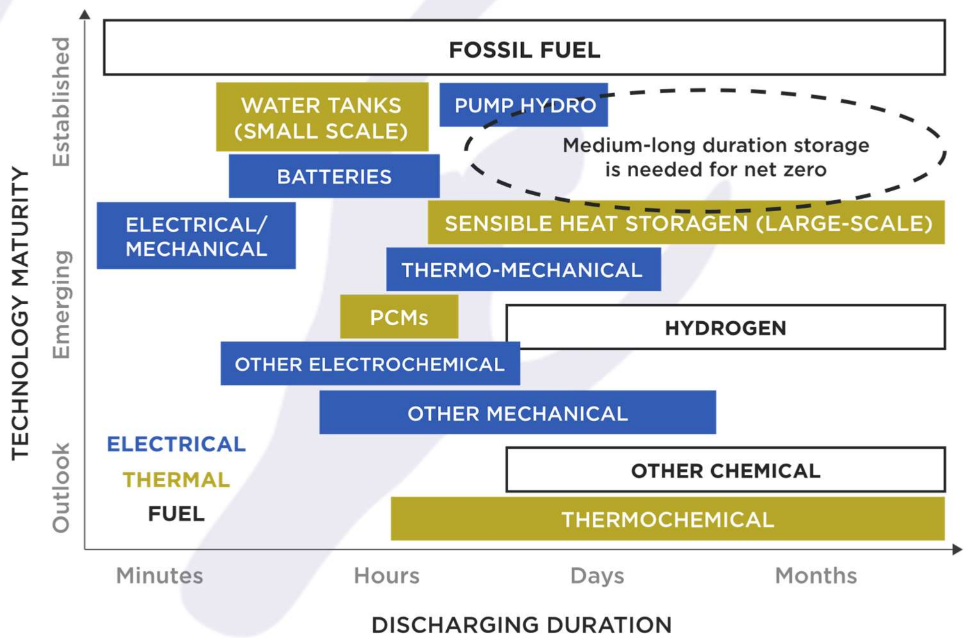

Figure 1: Technology maturity and scale of energy storage technologies. Source: UK Energy Storage Roadmap

2.4 Typical battery capacity (MW / MWh)

2.4.1 Note on battery size

In Q2 and Q3 of 2023, only two BESS were installed with a power rating of over 50MW. Before 2020, BESS over 50 MW were considered 'nationally significant infrastructure projects' (NSIPs) and required 'development consent' from the Secretary of State for BEIS (now DESNZ). This artificial barrier, which gave a simple planning route for projects under 50 MW, led to a surfeit of smaller projects. Some large sites were then developed in multiples of 49 MW. Planning reforms for battery projects were revised, simplifying arrangements for combined solar or wind and storage projects. Since 2020, BESS over 50MW can be granted planning permission from the Local Planning Authority (LPA) under the Town and Country Planning Act. Further legislative changes arising from the first legal definition of electricity storage have clarified the planning regimen[1].

2.4.2 System BESS capacity assessment

Q2 & Q3 2023 exemplify the typical utility-scale BESS currently coming online in the UK market. In Q2 & Q3 of 2023, 16 new battery energy storage sites of >7 MW were commissioned. This information is summarised in Table 1.

[1] https://researchbriefings.files.parliament.uk/documents/CDP-2023-0168/CDP-2023-0168.pdf

A total capacity of 413 MW of BESS was brought online in Q2 2023. 290 MW was achieved in Q3, significantly lower than the forecast 500MW. This was due to multiple EPCs ceasing trading in recent months, forcing some battery owners to re-contract the completion of their projects.

The average power rating of new batteries was 37.4 MW, while the median was 23.7 MW. The average was skewed by one large site coming online:

- Dollymans - a 100MW/100MWh
    - Statkraft operates the site
    - Dollymans is the first 100 MW battery to operate as a single Balancing Mechanism Unit (BMU) ID.

Significantly larger BESS are currently under construction. The largest site where construction has begun is SSE Renewable's 320MW/640MWh asset in North Yorkshire. In November 2023, multiple BESS projects were announced, such as Statera's 300MW/600MWh BESS in Essex and Sungrow's 100MW BESS, which recently grew in storage capacity from 260MWh to 330MWh[2].

2.5 Typical battery duration

Most battery systems have been of short duration. However, long-duration storage is in the pipeline. In the UK T-4 (2025-2026) Capacity Market auction, around 60% of capacity awarded to storage was for systems of 2 hours or longer. An example of this uptake in longer-duration systems is Sungrow's pipeline 100MW asset, which has grown from 2.6 to 3.3 hours.

Table 1 shows the BESS durations of systems deployed in Q2 & Q3 in the UK and Figure 2. To summarise these results:

Q2 2023:

- Mean: 1.37 h
- Median: 1.20 h

Q3 2023:

- Mean: 1.80 h

[2].https://www.energy-storage.news/sadly-neglected-uks-new-battery-strategy-misses-potential-of-bess-trade-group-says/

- Median: 2.00 h

2.6 Is this dependent on the revenue streams available?

The widespread industry view is that BESS income is weighted towards frequency and ancillary services revenue rather than energy management or timeshifting. Hence, the investment case for longer-duration storage is generally weaker, leading investors to opt for short-duration BESS.

However, increased performance of wholesale and arbitrage means longer-duration systems are becoming more prevalent.

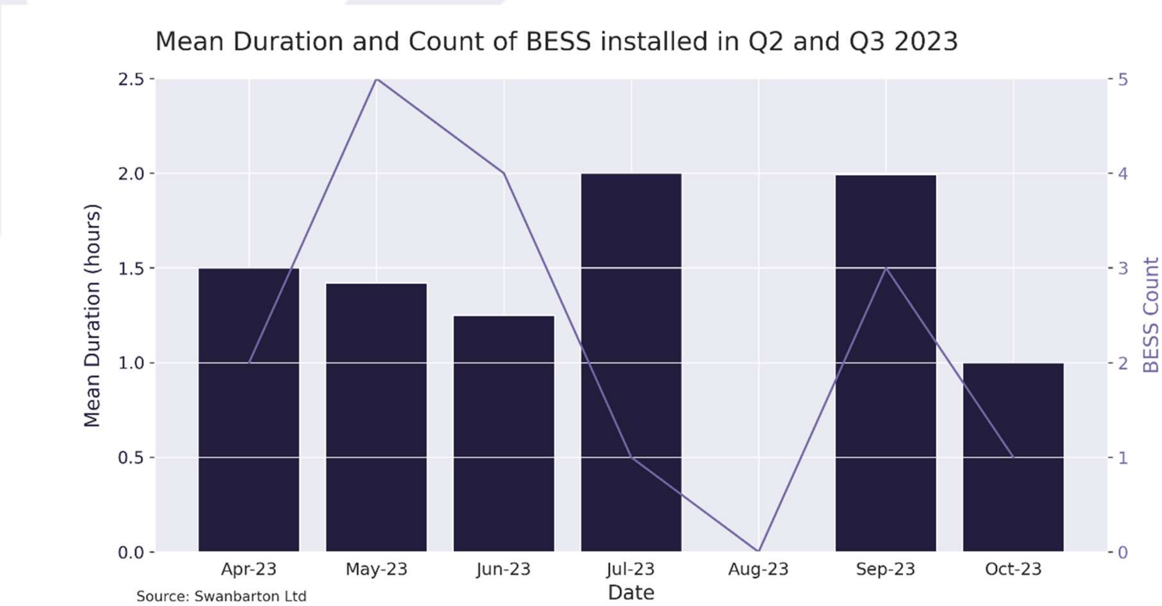

Figure 2: Mean duration and count of BESS installed in the UK in Q2 and Q3 2023

Table 1: Overview of BESS Commissioned in Q2 & Q3 2023 in the UK

Site Name	Location	Energised Date	Power (MW)	Energy (MWh)	Duration	Revenue (£/MW) 13/11/2023-13/12/2023	Notes
Dunsinane	North Scotland	Apr-23	49	49	1.00	£ 5,698.02	
Broadditch	South East England	Apr-23	11	22	2.00	£ 6,215.59	
Chapel Farm	East England	May-23	49.5	98	1.98	£ 4,639.92	
Briton Ferry	South Wales	May-23	21.7	26	1.20	£ 1,526.74	
Tir John	South Wales	May-23	23.7	28	1.18	£ 1,211.12	
Flatworth	North East England	May-23	18.4	22	1.20	£ 1,390.19	
Willoughby	East Midlands	May-23	20	31	1.55	£ 1,644.82	
Dollymans	South East England	Jun-23	100	100	1.00	£ 2,085.91	
West Gourdie	South And Central Scotland	Jun-23	49	49	1.00	£ 2,559.95	
Tollgate	East England	Jun-23	49.5	49.5	1.00	£ 3,114.47	
Farnham	Southern England	Jun-23	20	40	2.00	£ 5,852.89	
Winchester	Southern England	Jul-23	19	38	2.00	£ 4,354.16	
Clay Tye	East England	Sep-23	99	198	2.00	£ 4,140.85	Consisting of two sides of 49.5 MW and 99 MWh each
Wishaw	South And Central Scotland	Sep-23	50	100	2.00	£ 4,727.50	Transmission Connected
Bustleholme	West Midlands	Sep-23	50	100	2.00	£ 5,948.35	Transmission Connected
Newtonwood	East Midlands	Oct-23	50	50	1.00	£ 1,539.21	
Averages			**42.49**	**62.53**	**1.51**	**£ 3,540.61**	

3 Qualitative Assessment

3.1 Are batteries typically "standalone" utility-scale or deployed at existing or new renewable generation projects?

As of October 2022, only 10% of utility-scale storage in the UK was co-located with renewable energy[3]. In Q2 and Q3 of 2023, none of the utility-scale storage sites deployed were co-located.

Despite the clear advantages of co-locations, it has not taken off for several reasons:

- Increased project complexity: This affects everything, from contracts to funding to operations. For example, co-located sites often need to negotiate complex network-sharing agreements to reach the contract stage. Until now, focusing on independent projects has been more straightforward and more cost-effective.
- Focus on large-scale standalone systems: Larger-scale systems allow investors to capitalise on high-value ancillary services. Large-scale systems tend to be transmission-connected, and investors concentrate on AS revenue rather than energy trading through PPA or other market mechanisms.
- Different business models: The changing revenue streams for BESS currently give little certainty of income, with primarily merchant trading of AS. On the other hand, large-scale renewable energy assets, such as solar power, are targeting long-term fixed revenues, perhaps with Contracts for Difference (CfDs) or PPAs. Investors' confidence in both business cases has been limited so far.
- Concern about retrofits: Retrofit exposes sites to loss of government subsidies and carefully negotiated PPAs to danger and requires the change of an already operational site.
- Tax Anomalies: On small installations, the imposition of 20% VAT on retrofitted BESS when fitted to solar installations disincentivises end users, as new solar and storage installations are exempt from VAT. Other tax anomalies, such as business rates, can delay or defer investment. This "anomaly" is still unresolved despite calls from industry bodies, such as Solar Energy UK, to remove the VAT for retrofitted BESS, a consultation on the matter , and action to be taken in the recent Autumn statement. However, the actual impact of these anomalies is uncertain due to the ability of VAT-registered companies to claim the VAT back.

[3] Modo Energy, Co-location explained, 27 October 2022

3.2 Sources of revenue

3.2.1 Ancillary services (new/emerging/existing)

1) Dynamic Containment (DC):
    a. Purpose: To rapidly respond to frequency changes in the grid following a large power imbalance (such as a power station failure).
    b. Technical Aspects:
        i. *Response Time*: Batteries must respond within 1 second.
        ii. *Duration*: Capable of sustained output for at least 15 minutes.
        iii. *Bidirectional Response*: Ability to both charge and discharge to manage frequency. Dynamic Containment is divided into Dynamic Containment Low (DCL) and Dynamic Containment High (DCH). DCL is engaged when the frequency drops below the standard range, necessitating battery discharge to raise the frequency. Conversely, DCH is activated when the frequency exceeds the upper limit, requiring battery charging to lower the frequency, thus ensuring a balanced and stable grid operation.
        iv. *Measurement and Compliance*: Continuous monitoring and reporting on response accuracy.
    c. Revenue Potential: High premiums due to the rapid response and high accuracy requirements.
2) Firm Frequency Response (FFR):
    a. Types:
        i. *High-Frequency FFR*: Activated when the frequency is higher than normal; BESS discharges to lower it.
        ii. *Low-Frequency FFR*: Activated when the frequency is lower than normal; BESS charges to increase it.
    b. Technical Aspects:
        i. *Response Time*: Typically, it is within 10 seconds for high frequency and 30 seconds for low frequency.
        ii. *Availability*: Must be available during contracted periods.
        iii. *Bidding Process*: Participation through a tendering process.
    c. Revenue Potential: Based on the tender price and the actual delivery of services.
3) Dynamic Moderation and Dynamic Regulation:
    a. *Purpose*: Newer services similar to DC, developed following the successful deployment of DC, focused on issues of less immediate frequency.
    b. Technical Aspects:

   i. *Dynamic Moderation*: Responds to smaller, more frequent frequency deviations.
   ii. *Dynamic Regulation*: Adjusts for continuous minor frequency imbalances. Dynamic Regulation is segmented into Dynamic Regulation Low (DRL) and Dynamic Regulation High (DRH). DRL is utilised when there's a slight drop in frequency, requiring a moderate discharge from the battery to elevate the frequency. In contrast, DRH is used when there's a slight increase in frequency, prompting a moderate charge to the battery to reduce the frequency, thus aiding in maintaining a finely balanced grid frequency over continuous operations.

c. Revenue Potential: Emerging markets with growing revenue opportunities as grid reliance on renewables increases.

3.2.2 Wholesale and Balancing Mechanism (BM)

1) Day-Ahead and Intraday Markets:
   a. Operation:
      i. *Day-Ahead Market (DAM)*: Energy is traded one day before delivery. BESS operators can bid to supply or absorb energy based on forecasted prices.
      ii. *Intraday Market*: Trading continues until a few hours before delivery. It allows for adjustments based on real-time conditions.
   b. Technical Strategies:
      i. *Energy Arbitrage*: Buying energy when prices are low (usually during high renewable generation) and selling when high (peak demand times).
      ii. *Optimisation Software*: Utilising advanced prediction and optimisation algorithms to maximise profit.
2) Balancing Mechanism (BM):
   a. Purpose: To balance supply and demand in real-time.
   b. Technical Aspects:
      i. *Bid and Offer*: BESS can offer to either absorb excess energy or provide energy to the grid.
      ii. *Response Time*: A fast response is typically required (within minutes).
   c. Revenue Potential: Prices in the BM can be significantly higher, especially during periods of high imbalance. However, volumes can be relatively low, and assets may not be dispatched due to control room procedures.

There is industry pressure for the NG ESO to explain skip rates for dispatching BESS more transparently.

3.2.3 Capacity Market (CM)

In the capacity market, these systems compete for contracts to provide standby power to the grid during periods of high demand or when the grid is under stress. In the UK, utility-scale BESS are increasingly participating in the capacity market.

The CM supports BESS, with a growing number of storage assets being awarded contracts. In the 2023-24 Capacity Market auction, BESS were awarded 627MW, nearly a two-thirds increase compared to the previous year. The 2026/27 T-4 Capacity Market auction awarded approximately 5 GW of nameplate capacity in new-build batteries secured contracts, of which around 770 MW is of four-hour duration.

However, in the UK, the CM is enshrined in law with its driving policy set out by the Department for Energy Security and Net Zero (DESNZ). It is designed "to ensure security of GB's electricity supply at least cost to consumers" but is also explicitly stated to be "technology neutral – it does not seek to procure allocated volumes of capacity from specific types of technology."[4] DESNZ highlights that, while sustainability is a goal, the primary function of the CM is energy security: "[the CM] will help create the market structures to deliver a net zero power system by 2035, subject to security of supply." In reality, this means the CM primarily supports non-renewable peaking plants, such as gas, to ensure system energy security.

Because shorter-duration batteries cannot provide the capacity to cover long periods of generation shortfall, de-rating factors were introduced to encourage longer-duration energy storage. In simple terms, a 1-hour duration BESS is de-rated to about 11% of its nominal capacity, whereas a 9-hour battery is de-rated to 76% of its nominal capacity. In comparison, a diesel engine is de-rated to 95% of its nominal capacity[5].

Capacity market revenues are seen as an additional income stream, not the prime reason for investment. However, the CM regulations are complex, and compliance is expensive and time-consuming, so many developers do not find the CM attractive for small, standalone installations. Large operators and aggregators may find more favourable opportunities.

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[4] https://www.gov.uk/government/publications/contracts-for-difference-and-capacity-market-scheme-update-2023

[5] A diesel or OCGT is derated in the CM, to allow for some uncertainty in its availability.

The prevalence of non-renewable assets being awarded CM contracts can be seen in Figure 3 and Figure 4, where the vast majority of energy systems are still gas. The issue is further compounded by the nature of the market, which rewards power rather than energy. This has historically disincentivised the construction of long-duration (>2hr) energy storage systems.

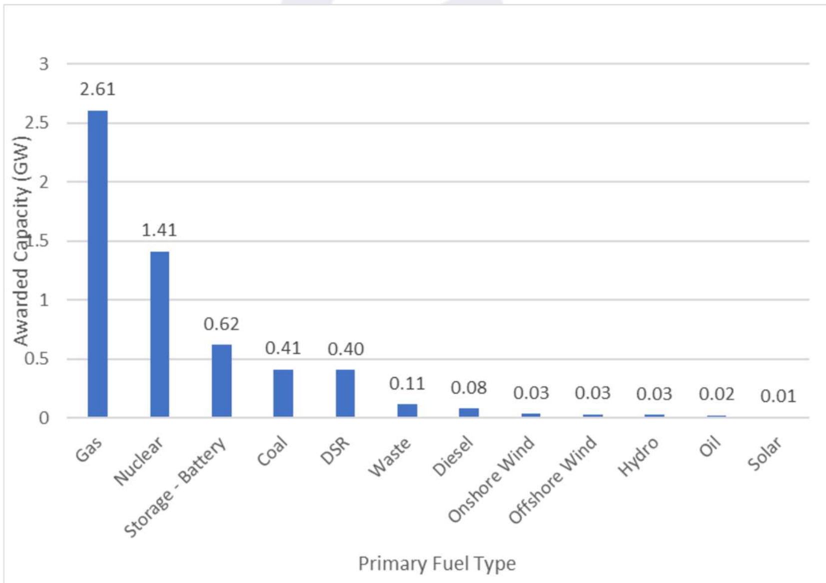

Figure 3: T-1 Auction results breakdown of Capacity Agreements awarded by fuel type for the 2023/24 Delivery Year (GW). Source: DESNZ (2023) Contracts for Difference and Capacity Market Scheme Update 2023

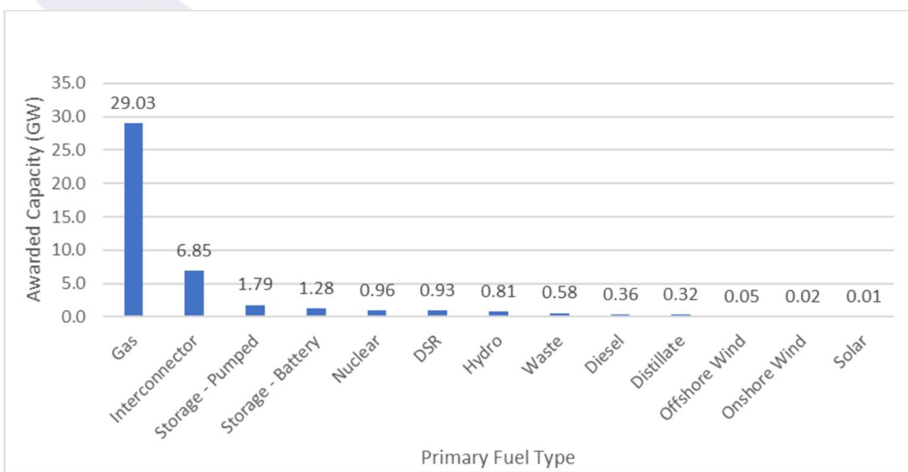

Figure 4: T-4 Auction results breakdown of Capacity Agreements awarded by fuel type for the 2026/27 Delivery Year (de-rated capacity). Source: DESNZ (2023) Contracts for Difference and Capacity Market Scheme Update 2023.

3.2.4 Contracts for Difference (CfDs)

CfDs are agreements where the difference between the ‘strike price’ (a price for electricity reflecting the cost of investing in a particular low-carbon technology) and the 'market price' is reimbursed when market prices are low and repaid at times of high market prices< This reduces investment risk in exchange for forgoing higher revenues when market prices are high. If applied to BESS, it would offer a guaranteed price for the energy they store and release, ensuring revenue stability. CfDs could improve BESS projects' financial viability by providing a more predictable income stream, thus encouraging investment. This financial mechanism is particularly important for integrating renewable energy sources with BESS, as it aids the management of variability and intermittency.

3.2.5 PPAs

Power Purchase Agreements (PPA): can offer short– or long-term (10-year plus) security of income by fixing a guaranteed price per MWh generated by the renewable element (with potential for inflation-linkage in some cases). For collocated projects, this represents the most straightforward revenue stream and can reassure investors and lenders who may not have otherwise financed standalone BESS projects (which can be seen as newer or more 'merchant' in nature)

3.2.6 Others

- BESS Optimisation Floor: long-term (up to 10-year) minimum profit 'floor' guaranteed by the optimiser trading the BESS (£/MW capacity/ per annum). As mentioned, the optimiser will pursue revenues via energy trading arbitrage and flexibility support services to the National Grid ESO. The asset owner and trader will share the financial benefit of overperformance above this "floor".

- Green Certificates: Renewable assets sell their power and associated "green certificates" (issued by Ofgem on behalf of the Government) via a power purchase agreement (PPA). PPAs can last 1-15 years—for example, Renewable Energy Guarantees of Origin ("REGO").

3.3 The value of the services to the electricity storage provider allows us to compare to revenue in the NEM[6].

While National Grid ESO publishes all the prices set in ancillary services auctions, including actions recorded in the Balancing Mechanism Reporting Service (BMRS)[7], which Elexon operates, this data must be mined for each unit, and then the data must be collated. This is a complex process and the domain of a few specialist companies,

[6] See https://nembess.com/ as an example of the data we will be using for Australia
[7] https://www.bmreports.com/bmrs/

such as Modo Energy. These companies provide fee-paying subscribers with sanitised and more easily understood comparative data.

3.4 Have any particular services strongly driven investment in electricity storage (e.g. enhanced frequency response) and electricity storage with particular technical characteristics?

The initial auctions for four-year contracts for enhanced frequency response initiated the first significant movement for investment in BESS. The forecast revenue stream encouraged investment when coupled with a capacity market contract. The tender was six times oversubscribed, and the strike price was less than a quarter of the initial expectation due to the keenness of the market. The tender and contract period was not repeated, and contract lengths in other services, initially for two years, have been reduced. However, investment continues as the investors have found confidence in the BESS product and business.

While specific services drive investment in the GB BESS market, the lack of suitable points of connection and associated market uncertainty are the primary controlling obstacles to that investment. The headline figures of the BESS pipeline (see Figure 5) are unrealistic, with many speculative projects announced, while the actual pipeline of deliverable projects is compact. Centrica has a database of over 400 sites suitable for renewable projects, but over 90% of them cannot progress because of grid connection issues[8], while other issues, such as a shortage of BESS systems and trading in project sites between project promoters, are also significant impactors. A more detailed overview of these obstacles and other barriers is in Section 3.8.

[8] https://watt-logic.com/2023/07/06/grid-connection-delays/

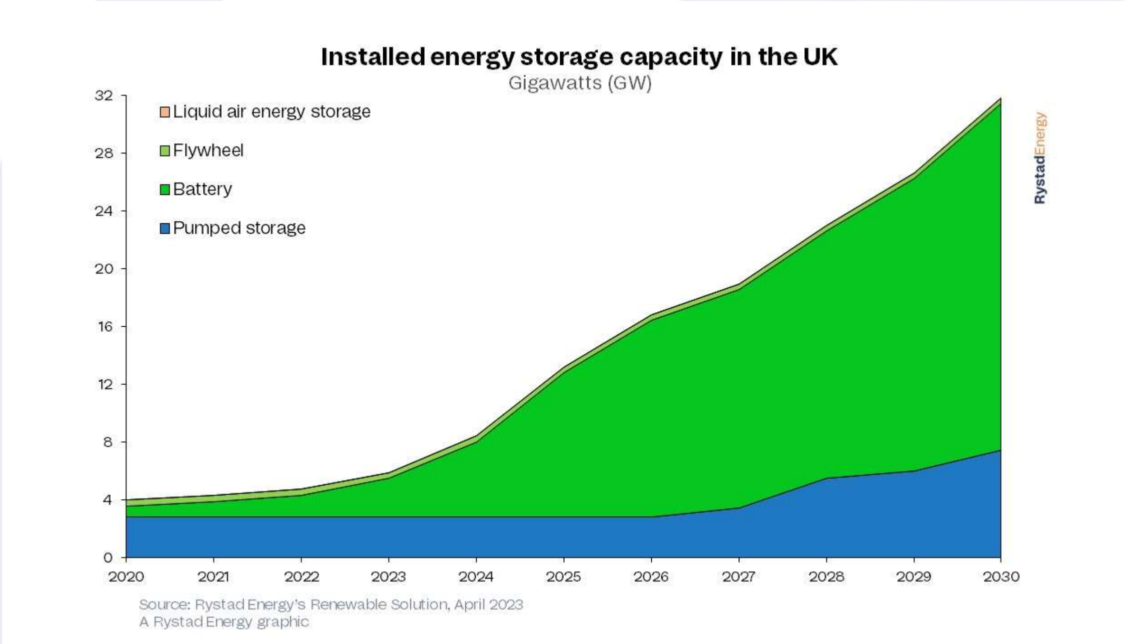

Figure 5: Estimated UK BESS deployment pipeline.

3.5 The balance between the various sources of revenue and "stackability".

Table 2 shows the revenue stacks of the BESS installed in the UK in Q2 and Q3 of 2023. These are typical of the market forces in the UK as of December 2023.

Table 2: Revenue stack of BESS installed in the UK in Q2 & Q3 2023

Site	DCL	DCH	DML	DMH	DRL	BM	WS	Total	DCL %	DCH %	DML %	DMH %	DRL %	BM %	WS %
Dunsinane	£ 183.46	£ -	£ -	£ -	£ 1,039.54	£ 560.42	£ 3,949.44	£ 5,732.86	3%	0%	0%	0%	18%	10%	69%
Broadditch	£ 88.99	£ 229.02	£ 360.44	£ 64.32	£ 294.34	£ 498.21	£ 4,847.88	£ 6,383.20	1%	4%	6%	1%	5%	8%	76%
Chapel Farm	£ 119.11	£ 287.27	£ 558.92	£ -	£ 289.78	£ 460.03	£ 2,986.92	£ 4,702.03	3%	6%	12%	0%	6%	10%	64%
Briton Ferry	£ 169.90	£ 409.52	£ 23.96	£ -	£ 968.46	£ -	£ -	£ 1,571.84	11%	26%	2%	0%	62%	0%	0%
Tir John	£ 173.26	£ 403.37	£ 23.04	£ -	£ 685.48	£ -	£ -	£ 1,285.15	13%	31%	2%	0%	53%	0%	0%
Flatworth	£ 159.83	£ 386.46	£ -	£ -	£ 887.04	£ -	£ -	£ 1,433.33	11%	27%	0%	0%	62%	0%	0%
Willoughby	£ 222.26	£ 459.06	£ -	£ -	£ 997.55	£ -	£ -	£ 1,678.87	13%	27%	0%	0%	59%	0%	0%
Dollymans	£ 40.00	£ -	£ -	£ -	£ -	£ 878.61	£ 1,110.77	£ 2,029.38	2%	0%	0%	0%	0%	43%	55%
West Gourdie	£ 866.31	£ 788.46	£ 40.02	£ 23.67	£ 77.16	£ 444.69	£ 308.08	£ 2,548.39	34%	31%	2%	1%	3%	17%	12%
Tollgate	£ 1,085.31	£ 959.92	£ -	£ -	£ -	£ 58.51	£ 969.76	£ 3,073.50	35%	31%	0%	0%	0%	2%	32%
Farnham	£ 137.88	£ 231.45	£ 244.01	£ -	£ 544.21	£ 242.78	£ 4,297.31	£ 5,697.64	2%	4%	4%	0%	10%	4%	75%
Winchester	£ 65.64	£ 91.60	£ 1,451.19	£ 35.79	£ 2,742.31	£ -	£ -	£ 4,386.53	1%	2%	33%	1%	63%	0%	0%
Clay Tye	£ 168.71	£ 319.34	£ 483.10	£ -	£ 106.15	£ 491.31	£ 2,636.63	£ 4,205.24	4%	8%	11%	0%	3%	12%	63%
Clay Tye 2	£ 116.79	£ 346.58	£ 535.72	£ -	£ 10.91	£ 616.46	£ 1,778.59	£ 3,405.05	3%	10%	16%	0%	0%	18%	52%
Wishaw	£ 171.13	£ 203.15	£ -	£ -	£ 2,072.30	£ 117.21	£ 2,135.94	£ 4,699.73	4%	4%	0%	0%	44%	2%	45%
Bustleholme	£ -	£ -	£ -	£ -	£ 1,078.23	£ 1,102.96	£ 3,925.49	£ 6,106.68	0%	0%	0%	0%	18%	18%	64%
Newtonwood	£ -	£ -	£ -	£ -	£ -	£ 684.86	£ 785.86	£ 1,470.72	0%	0%	0%	0%	0%	47%	53%
Average	**£ 221.68**	**£ 300.89**	**£ 218.85**	**£ 7.28**	**£ 693.73**	**£ 362.12**	**£ 1,748.98**	**£ 3,553.54**	**8%**	**12%**	**5%**	**0%**	**24%**	**11%**	**39%**
Avg (>0)	**£ 251.24**	**£ 393.48**	**£ 413.38**	**£ 41.26**	**£ 842.39**	**£ 513.00**	**£ 2,477.72**	**£ 3,553.54**	**9%**	**16%**	**10%**	**1%**	**29%**	**16%**	**55%**

3.6 The volatility/certainty of each revenue stream [9]

The volatility of the revenue streams can be seen in Figure 6. There is high volatility between revenue streams regarding total revenue and percentage split between individual streams.

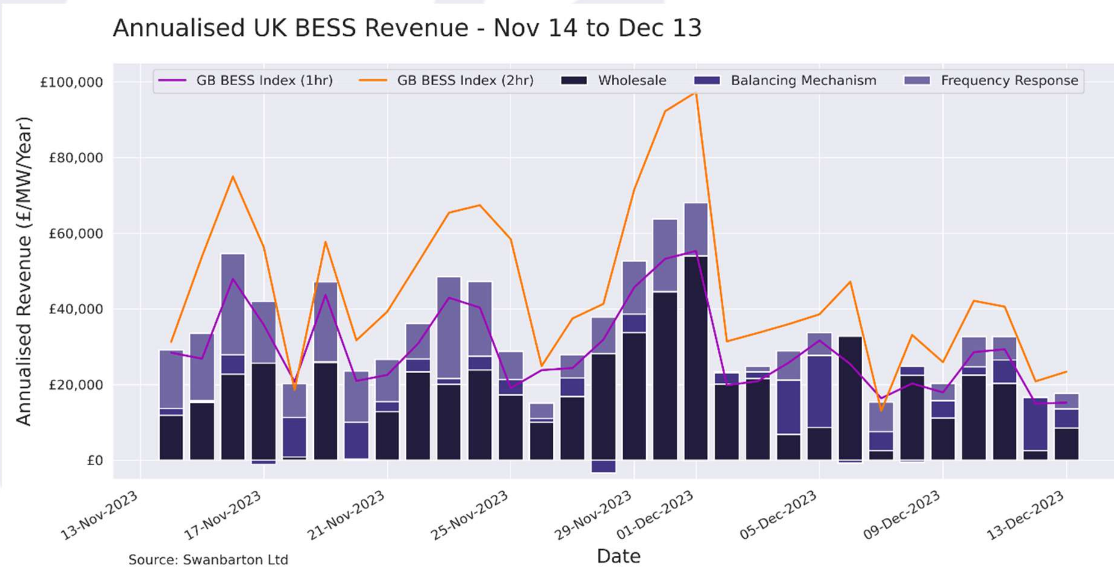

Figure 6: Annualised revenue streams for all BESS in the UK, comparing the BESS index of 1-hour and 2-hour systems.

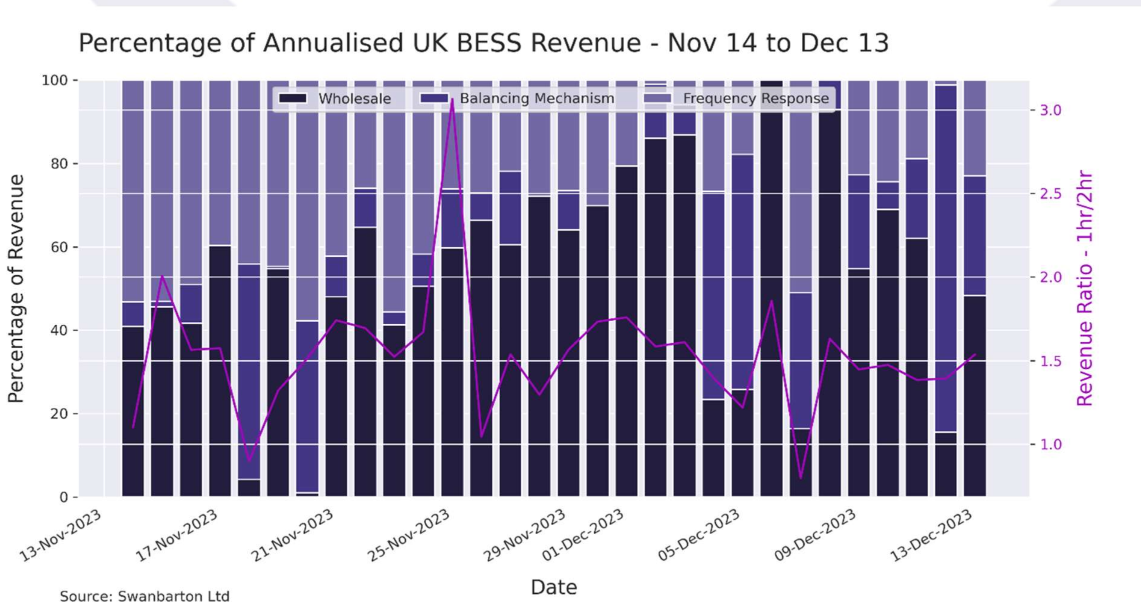

Figure 7: Annualised revenue streams for all BESS in the UK by percentage, with a ratio comparison of revenue between 1-hour and 2-hour systems.

[9] See as an example the Neoen table in this report: https://reneweconomy.com.au/australias-big-batteries-what-do-they-do-and-how-do-they-make-money/

3.7 Overview of government support for electricity storage, particularly longer-duration storage

BEIS, now DESNZ, has a policy to promote smart technologies, including storage, as part of the forward flexibility plan. BEIS was aware of the distortion in the market and the lack of incentives for LDES, so it encouraged investment in LDES through two open competitions. One stream was to promote first-of-a-kind installations of extant technologies; the second was to support the development of less mature and untested technologies. Both demonstrations have been internationally recognised as vigorously promoting an ambition to accelerate the deployment of LDES. While not as expansive as the Californian Storage Mandate, the results will likely increase industry confidence.

3.8 Are there any barriers that continue to thwart investment in electricity storage?

For instance, speed over duration, standalone versus with generation, (service specification versus regulations and rules – like P2 Security of Supply and changes needed to RO scheme)

1) Regulatory Uncertainty and Market Design: The UK energy market's current design often fails to classify electricity storage, leading to regulatory ambiguity. Unclear guidelines on network charges for storage assets complicate investment decisions, especially under OFGEM regulations.
2) Complexity of Revenue Streams: In GB, storage systems' ability to stack multiple revenue streams (energy arbitrage, frequency response, Capacity Market participation) presents a challenge in revenue predictability. Fluctuating wholesale energy prices and evolving National Grid requirements affect long-term revenue modelling.
3) Grid Integration and Interconnection: GB lacks standardised procedures for connecting storage to the grid, raising costs and delaying projects. This challenge is more pronounced for standalone systems, which cannot leverage existing generation infrastructure for interconnection.
4) Queue Management for Grid Connections and Connection Agreement Issues: Long connection queues have thwarted the development of many potential BESS sites. At the end of June 2023, 1,028 projects amounting to 326 GW were waiting to increase their connection capacity, while only three sites with a combined capacity of 1.2 GW wanted to reduce[10]. Ofgem has introduced a new policy to streamline the grid connection process in the UK. Starting from 27th

[10] https://watt-logic.com/2023/07/06/grid-connection-delays/

November 2023, this policy aims to clear 'zombie projects' - stalled or speculative developments - from the queue, thereby reducing wait times for viable energy projects. Implemented by National Grid ESO, the policy departs from the 'first-come, first-served' approach, introducing strict milestones for project progression within connection agreements. Non-compliant projects risk termination, facilitating quicker connections for ready-to-go generation and storage projects critical for achieving net zero targets

5) Trade-off in Storage Duration and Efficiency: Selecting storage technology in the UK often involves balancing discharge duration against efficiency. Technologies such as flow batteries, which are suitable for longer-duration discharge, have lower efficiencies than shorter-duration, high-efficiency lithium-ion batteries, affecting their applicability for various grid services.
6) Capital Costs and Scaling Challenges: Despite the decreasing costs of storage technologies, initial capital investment remains substantial. Achieving economies of scale necessary for cost-effectiveness is challenging, especially given the UK's current investment climate and regulatory framework.
7) Rising Interest Rates and High Capital Costs: Increasing interest rates significantly impact the financing of new storage projects. These higher rates elevate capital costs, affecting the internal rate of return and deterring potential investors, particularly for nascent technologies.
8) Stringent Technical Requirements for Grid Services: UK grid services, such as those for frequency regulation, demand rapid response times that not all storage technologies can meet cost-effectively. This limits market participation and revenue potential for various storage technologies.
9) Policy Instruments and Incentives Impact: Current policy instruments, like the RO scheme, are ineffective in promoting storage integration with renewables. Adjustments recognising and incentivising storage can enhance investment. However, policy changes introduce market uncertainty, influencing long-term investment decisions.
10) Market Penetration of Emerging Technologies: In the UK (and in many other) markets, emerging storage technologies (such as flow batteries) face hurdles in market acceptance. Substantial R&D investment and scepticism due to their unproven nature in practical applications are significant barriers.

4 Annex A: Capacity Market

The UK Government has recently (19th December 2023) released its "Contracts for Difference and Capacity Market Scheme Update 2023"[11].

The UK's policy regarding the Capacity Market is set out by the Department for Energy Security and Net Zero (DESNZ). The purpose of the CM is "to ensure security of GB's electricity supply at least cost to consumers". The CM is explicitly stated to be "technology neutral – it does not seek to procure allocated volumes of capacity from specific types of technology".

However, the UK Government is trying to make access to the BM easier for Battery Storage Capacity Market Units (storage CMUs). A key challenge faced by battery storage CMUs is the degradation of the performance of the battery cells and how this is managed over the asset's lifetime. An asset must provide the contracted power for the contract's lifetime, up to 15 years. However, most batteries will degrade over this period, with lower energy capacity, power rating or both. The latest review of the capacity market directly addresses this point to assess the best methods for encouraging storage in the CM[12].

Again, it is worth noting that the central focus of the CM is energy security. The Government highlights this by stating that current reviews of the CM "will help create the market structures to deliver a net zero power system by 2035, subject to security of supply." In other words, they would prefer to maintain gas-fired generation on the network if that ensures system energy security.

[11] https://www.gov.uk/government/publications/contracts-for-difference-and-capacity-market-scheme-update-2023

[12] https://www.gov.uk/government/consultations/capacity-market-2023-phase-2-proposals-and-10-year-review