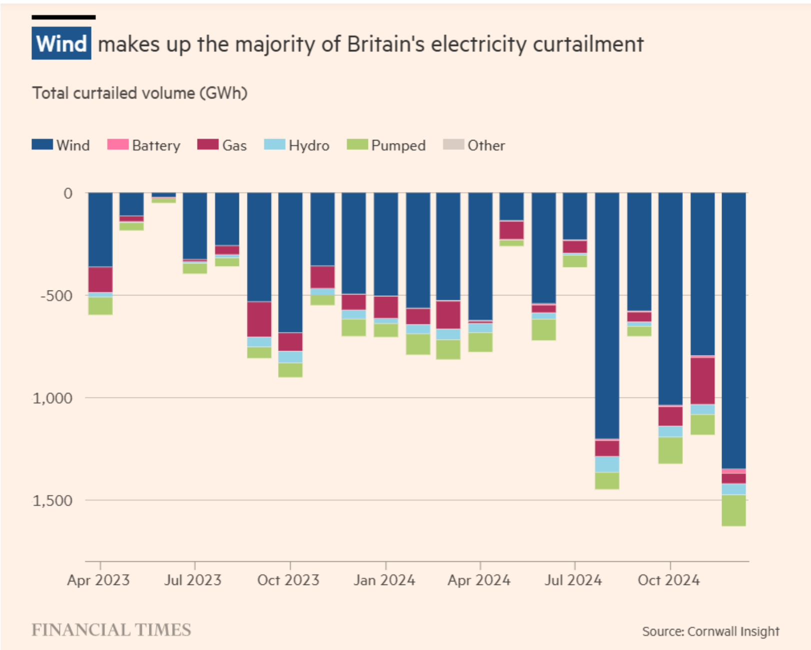
NatWest Questions – Outlook 2025 Call, REA Response

<u>Curtailment</u>

1. **Do you have any data to show the total potential generation that is lost to renewables being taken offline due to excess supply on certain days and insufficient storage?**

Despite increased investment in grid infrastructure, network expansion, and energy storage in the UK, existing limitations continue to result in significant energy losses when supply exceeds demand. This phenomenon, known as curtailment, forces renewable sources like wind to be taken offline to balance the grid. As renewable capacity grows faster than the infrastructure needed to store and distribute surplus energy, the issue has worsened.

In 2022, approximately 3.4 terawatt-hours (TWh) of wind energy was curtailed—enough to power one million homes for a year. Between 2015 and 2021, more than 13% of the UK's total wind energy generation was curtailed. In 2024, nearly 10% of Britain's planned wind output was lost, along with almost 30% of Northern Ireland's. A key factor is the lack of capacity to transfer electricity from wind farms in the north (Northern Ireland and Scotland) to high-demand areas in the south. While curtailment rates may appear to have decreased from 13% to 10%, the absolute volume of lost energy has grown due to the overall increase in generation. In 2024 alone, approximately 6.7 TWh of wind energy was curtailed—nearly double the 3.8 TWh lost in 2023. As seen in the image below, in the month of December 2024 alone, around 13500 GWh was lost in curtailed energy from wind.



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To address this challenge, the UK plans to invest an average of £9 - 10 billion per year over the next two years to strengthen its power grids and support its clean energy targets. A significant portion of this funding will go toward integrating new offshore wind capacity, with over 10,000 kilometres of new submarine cables set to be installed by 2035.

2. Are you able to quantify the financial value of this lost generation potential?

The financial burden of wind energy curtailment in the UK has grown significantly in recent years. In 2021, the cost of curtailing wind farms to manage grid constraints surged from nearly £300 million in 2020 to over £500 million. Between 2020 and 2021, curtailment cost the UK a total of £806 million and wasted enough renewable electricity to power 800,000 homes.

Since 2021, inadequate transmission capacity for wind power alone has resulted in losses of approximately £1 billion per year due to system constraints. Between 2020 and 2023, curtailment costs exceeded £1 billion, with 2022 alone seeing a record £2 billion in expenses. These costs primarily arise from compensating wind farm operators for lost revenue and the inefficiencies associated with shutting down and restarting generation.

A stark example of these financial losses occurred on 18 December 2023, when wind generation set a new record. By 8:30 a.m. that day, Britain had already lost well over £6 million due to curtailment, according to Robin Hawkes, a data visualization expert at Octopus Energy. By the end of the day, the total cost of curtailment had reached £12,630,126, broken down as £4,172,190 for switching off wind turbines and £8,457,935 spent purchasing alternative energy sources.

3. Given that the lost potential on days of excess supply is some of the cheapest forms of power (particularly wind) and the additional capacity used on days of excess demand is some of the most expensive (gas peakers), is there any way to quantify the potential pricing impact of being able to store cheap electricity to save using the most expensive forms?

The financial benefits of storing renewable energy and preventing curtailment are significant, particularly when compared to the costly alternatives of importing electricity, compensating renewable developers for curtailment, and relying on expensive British gas peaker plants. Rather than continuing to spend billions on these inefficiencies, the UK would be far better off redirecting this money toward investments in energy storage, ensuring that surplus renewable energy is captured and used rather than wasted.

Wind curtailment alone cost the UK £920 million in 2023, largely due to grid constraints, particularly at the B6 boundary between Scotland and England. Without intervention, these costs are projected to rise significantly, reaching as much as £3.5 billion per year by 2030. However, analysis from energy storage developer Field suggests that up to 80% of these curtailment costs could be eliminated through improved battery storage. This represents a potential annual saving of over £700 million, funds that would be far better spent on expanding and modernising the UK's energy storage capacity rather than paying to turn off renewable generation.

Beyond curtailment costs, the UK's reliance on gas-fired peaking plants to replace lost renewable energy is another major financial burden. Gas peaker plants are among the most expensive electricity sources, costing the UK £670 million in 2023 at the B6 boundary alone. These plants not only carry high operational costs but also expose the country to volatile global gas prices, pushing electricity prices higher for consumers. As the REA has often called for, if surplus wind power were stored and deployed during peak demand periods, the need for gas peakers would fall dramatically, saving hundreds of millions per year while reducing the UK's dependence on fossil fuels.

Additionally, the UK's growing reliance on imported electricity is another pressing issue. In 2024, 15.7% of the country's electricity was imported, costing over £250 million per month—a staggering £3 billion annually. This dependency on interconnectors leaves the UK vulnerable to foreign market fluctuations and geopolitical risks, further inflating costs for consumers. By maximising the use of domestically generated renewable energy through storage solutions, the UK could significantly reduce its reliance on expensive imports, strengthening energy security while keeping electricity costs under control.

The UK Government needs to ensure that excess renewable energy is stored rather than wasted, creating a more resilient and cost-efficient energy system. This shift would not only lead to significant financial savings but would also accelerate the transition toward a sustainable, self-sufficient energy future, benefiting both consumers and the wider economy.

<u>Private investment – LDES and BESS</u>

4. **You mentioned the level of private investment expected to flow into this sector- what kind of private investors, and at what quantum, are they investing in these assets? LDES and even BESS.**

Both BESS and LDES have seen significant private investment in this sector from various sources and with the confirmation of the UK Government's cap and floor mechanism for LDES, this support will only incentivise and mobilise the private sector.

For BESS examples of private investment and involvement is seen across the landscape. Prominent private equity firms are actively investing in UK battery storage developers. For instance, KKR invested $750 million in Zenobe, a leading UK battery storage developer. Whilst investment funds are allocating substantial capital to BESS projects. Gresham House Energy Storage Fund plc (GRID) invests in a portfolio of utility-scale operational BESS in Great Britain, aiming to provide shareholders with sustainable dividends and capital growth. Additionally, infrastructure funds such as DIF Capital Partners committed £200 million to Field, a UK-based battery storage developer and operator, to accelerate the development of its 4.5 GWh pipeline of grid-scale BESS projects.

The UK's battery storage capacity is projected to expand to 24 GW by 2030, attracting investments of up to $20 billion and accounting for 9% of Europe's total grid BESS capacity. This growth trajectory is supported by the increasing deployment of renewable energy sources and the corresponding need for grid stability solutions.

For LDES, as mentioned above, the UK Government has introduced a cap and floor mechanism to support investment in the sector and strengthen the country's energy storage infrastructure. This initiative is set to facilitate the development of the first large-scale LDES facilities in nearly four decades, providing much-needed stability to the UK's renewable energy grid.

Additionally, the UK Infrastructure Bank has committed £165 million to support Highview Power in building the country's first commercial-scale liquid air energy storage plant. Meanwhile, the National Wealth Fund has invested in two LDES projects, signalling growing public-sector backing for long-duration storage solutions.

Given the high upfront costs and associated risks of LDES projects, it will be crucial to see which initiatives successfully secure a place in the cap and floor scheme when it opens for applications in Q2 this year. This selection process will provide insight into the types of projects that can attract both government backing and private investment, shaping the future of LDES deployment in the UK.

Crucially, we hope that this government support will act as a catalyst for further private investment in LDES, offering investors greater confidence in the long-term viability of these projects. By reducing financial uncertainty, the cap and floor mechanism could unlock significant private sector funding, accelerating the growth of large-scale LDES infrastructure and helping the UK meet its renewable energy and net-zero targets more efficiently.

When the data is released, the REA will be happy to report back to NatWest on these developments.

<u>Cost of BESS versus LDES</u>

5. **I wondered what the cost is of LDES vs "traditional" battery storage solutions. It sounded like LDES is the way forward and might have an easier time with approvals and so it would be good to understand the difference between the two.**

Comparing the costs of traditional BESS and LDES is challenging due to differences in technological maturity, scalability, and infrastructure needs. I have broken this down to look at Capex, Opex and their associated grid costs etc.

Capital Expenditure (Capex)
BESS, primarily based on lithium-ion technology, benefits from economies of scale and modularity, making it relatively cost-effective to deploy. The Capex for BESS includes the cost of battery modules (typically £250-400/kWh), inverters, transformers, and balance of plant components. Installation costs are relatively low due to BESS's plug-and-play nature, and projects can be deployed within months.

In contrast, LDES technologies – such as pumped hydro storage, compressed air energy storage, and flow batteries – require significant infrastructure investment. Costs vary widely depending on the technology, but in general, LDES Capex is much higher than BESS, often involving large-scale engineering works such as reservoir construction, underground caverns, or new material innovations. These high upfront costs contribute to longer project development timelines, often stretching over multiple years.

Operational Expenditure (Opex)
BESS has moderate Opex, including land leasing costs (£5,000-£15,000/MW per year), maintenance, insurance, and battery degradation management. Maintenance costs range between £5-10/kW per year, with additional expenses for battery replacements over a system's 10–15-year lifespan.

LDES, on the other hand, can have lower long-term Opex due to the durability of many of its technologies. Pumped hydro and compressed air storage, for instance, can last for decades with minimal efficiency loss. However, LDES still incurs high maintenance costs for physical infrastructure and environmental management. Additionally, site-specific factors, such as geological assessments or water rights for pumped hydro, can add to ongoing operational expenses.

Grid & System Costs
Both BESS and LDES incur grid-related expenses, but the scale and nature of these costs differ. BESS projects must pay grid connection fees, which can be significant—up to £50,000-£100,000 per MW in congested network areas. Additionally, BESS operators face Use of System (DUoS) and Transmission Network Use of System (TNUoS) charges, which increase operating costs.

LDES, depending on location, may incur higher interconnection costs due to its reliance on specific geographic features (e.g., reservoirs for pumped hydro or underground caverns for compressed air storage). However, if strategically located near renewable generation sites, LDES can reduce grid congestion and benefit from lower transmission costs in the long term.

As mentioned, directly comparing BESS and LDES costs is difficult due to fundamental differences in their purpose and technological maturity. BESS is optimised for short-duration applications such as frequency response and intra-day balancing, while LDES is designed for energy shifting over longer durations (6/8+ hours, up to seasonal storage). Additionally, BESS benefits from a well-established supply chain and declining costs, whereas LDES remains in an innovation phase with high R&D and scale-up expenses. BESS projects are increasingly financed through private investment due to predictable revenue streams, while LDES relies on government incentives and demonstration funding.

In the future, BESS costs are expected to continue declining as lithium-ion battery manufacturing scales and alternative chemistries such as sodium-ion emerge. Meanwhile, LDES costs will remain high in the short term, but technological advancements, policy support, and economies of scale could bring costs down in the long run. The UK government's Longer Duration Energy Storage Demonstration Programme and Net Zero Innovation Portfolio will be crucial in de-risking LDES investments and accelerating cost reductions.

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