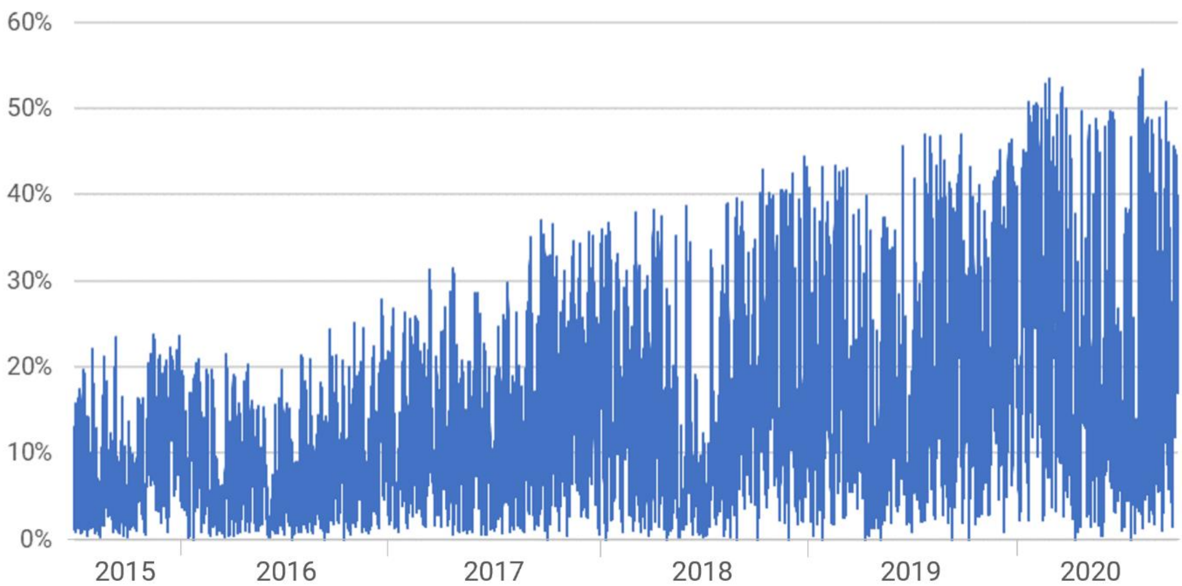
Energy Storage Solutions – how to harness renewable energy generation

The transition towards low carbon, renewable energy generation is building momentum globally. While renewables are expected to contribute significantly towards meeting climate change objectives, the transformation in the way we generate electricity to power our everyday lives nevertheless poses challenges to existing energy transmission networks. This is because renewable energy generation is intermittent: wind speeds are temperamental and therefore wind generation oscillates, irradiation levels are not always sufficient to deliver solar power generation (and solar generation is 'offline' at night), and rainfall patterns (among other factors) impact hydroelectric power generation.

By contrast, conventional forms of power generation, such as that produced from burning fossil fuels or by nuclear power plants, for example, are generally capable of providing a far more reliable and continuous supply to meet 'baseload' power requirements – that is to say the minimum amount of power required at any given time. The relative unpredictability of renewable energy generation, combined with its increasingly dominant position in the energy mix is why, in the UK for example, there remains a need for natural gas and nuclear power stations in order to help balance the supply and demand requirements of the grid. However, investment in energy storage solutions will provide scope for the full potential of renewables to be harnessed, by capturing output during times of high generation and smoothing the delivery of power to the grid.

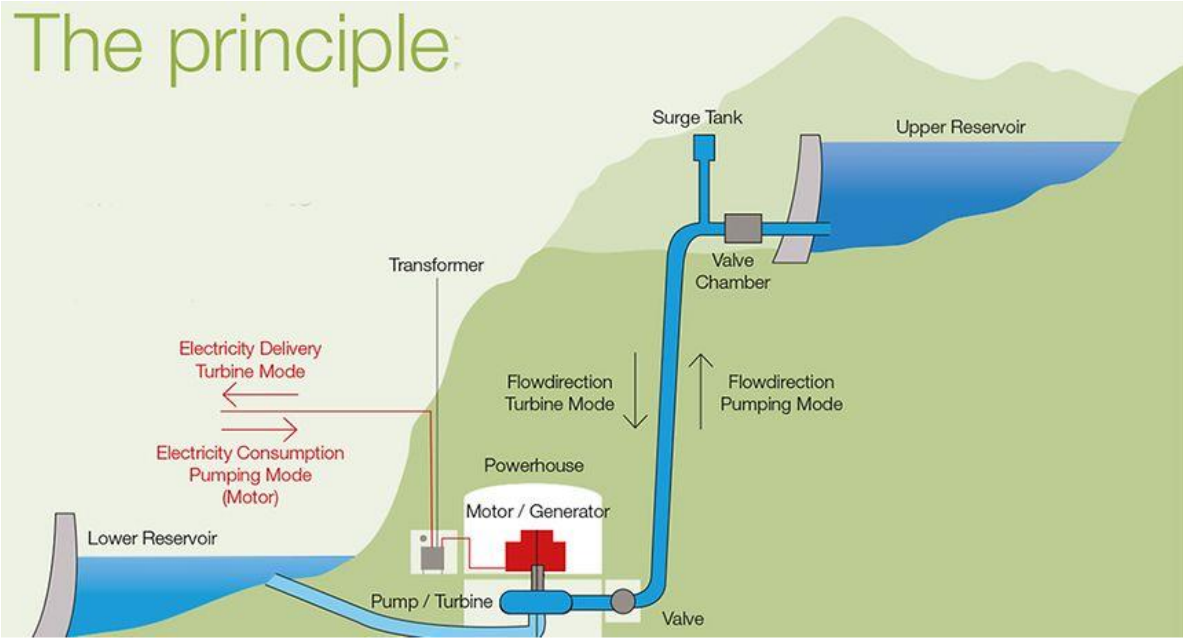
The chart below shows the percentage of total UK electricity generation from wind power, 1st July 2015 to date. The grid is balanced within 30-minute periods (i.e. 48 discrete periods per day). The data shows (1) growth in overall generation from wind reflecting rapid project deployment, (2) wind power generation is highly volatile, which creates challenges in balancing supply and demand.

Wind Power: Percentage of Total Generation

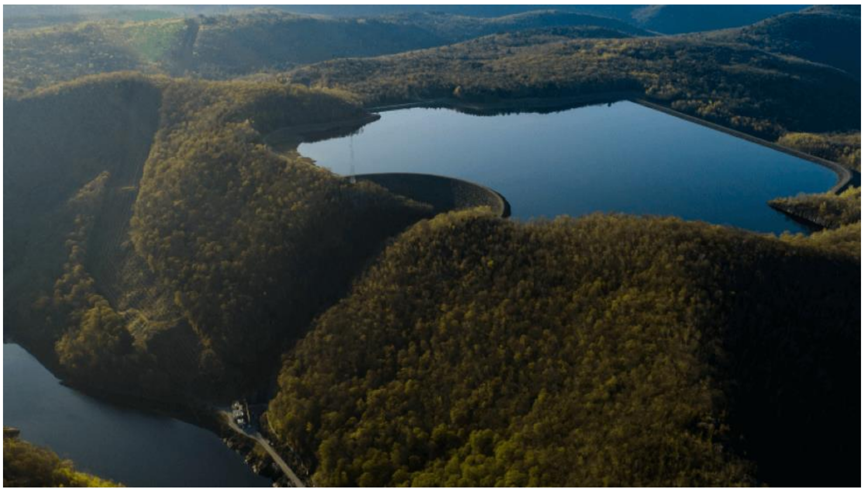


Source: ELEXON Portal, Balancing Mechanism Reporting Service

Pumped-Storage Hydroelectricity. The oldest form of large-scale energy storage, the use of pumped-storage hydropower can be traced back to c.1900 in Italy and Switzerland. The principle of this method is simple: two reservoirs are required, each located at different altitudes. When water is released from the upper reservoir to the lower reservoir it is channelled through a turbine and generator to create electricity. The water is then pumped back from the lower reservoir to the upper reservoir and represents a store of gravitational potential energy until the water is released once again. Pumped-storage hydropower can provide a dynamic (i.e. proportionate) response to balancing grid requirements, offering critical backup during periods of excess demand.



Although the losses associated with the process of pumping water back to the upper reservoir results in pumped-storage being a net consumer of power overall, if used in conjunction with sources of renewable energy generation it can help to resolve the intermittency issues associated with wind or solar power generation (described above). Using low-cost surplus, or off-peak electric power, to run the pumps – for example, when wind generation is above grid requirements – it can be stored for periods of higher demand, which will typically be associated with higher electricity prices.



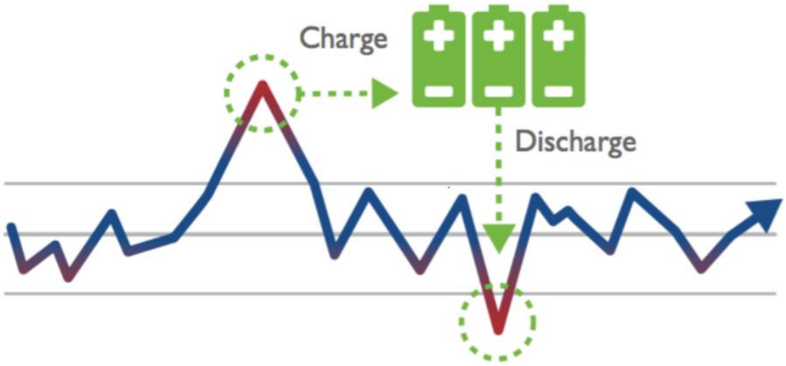
The 600 MW Jack Cockwell hydroelectric storage station located in northern Massachusetts is owned by Brookfield's renewables division.

The facility plays an important role in providing flexibility and stability to the electrical grid.

Pumped-storage hydroelectricity accounts for over 90% of the world's existing storage capacity, but the development of new solutions such as battery technologies now provides alternative options. The geographic requirements for pumped-storage (and hydroelectric power generation in general) means that batteries will prove more scalable in some areas. The world's largest pumped-storage assets are located in the U.S., China, Japan and Continental Europe, although the Dinorwig power station situated in Snowdonia national park, which was commissioned in 1984, is the world's tenth largest hydroelectric scheme.

Battery Storage Solutions. In recent years, cost-effective battery-storage technology has emerged as a solution to the intermittent nature of renewable energy generation by storing electrical energy as chemical energy. The majority of utility-scale battery assets use Lithium-ion technology, which is currently the most cost-effective and possibly most versatile option, being capable of adaptation to cater to both small scale applications, like powering an electric vehicle (EV), or multi-megawatt grid-scale applications able to power thousands of homes.

Grid-scale battery-storage assets can store energy at times of oversupply and release that power back into the grid during periods of higher demand. This ability to import and export power rapidly can help keep, for example, the UK grid's electrical frequency at 50Hz.



The UK electricity grid is maintained close to a frequency of 50Hz.

Batteries can be employed to provide or absorb power as required.

There are multiple revenue streams available to battery-storage operators (below is not an exhaustive list) and unlike renewable power generators, revenues attracted by battery storage assets are not linked to absolute power prices.

- Firm Frequency Response – the battery asset provides a rapid and dynamic response in reaction to changes in the grid's electrical frequency, by either importing or exporting power.
- Asset Optimisation (trading) – supply and demand on the grid is balanced within discrete 30-minute periods. A battery operator can buy power during periods of excess supply (lower prices) and sell power during times of high demand (higher prices) thereby profiting from the margin. In the UK there are structural pricing dynamics throughout the day with a clear trough in prices during the day and a peak in the evening.
- Capacity Market – the battery operator receives a fixed fee, on an availability basis. The battery asset must be available to deliver power to the grid whenever called upon.

In addition to standalone battery assets, battery storage is increasingly being integrated alongside renewable energy generation assets. The introduction of storage capacity allows the wind or solar farm operator greater flexibility over when power is sold, rather than simply being required to sell output as it is generated (when there may also be risk of curtailment if generation is too high). This provides the operator with scope to sell electricity at better prices as well as store excess production rather than wasting it.

Tesla 100 MW Powerpack battery storage system integrated into the 99-turbine, 309 MW Hornsdale Wind Farm located in Jamestown, South Australia and developed by John Laing and Neoen.

The addition of battery storage has enabled the site to provide frequency control services to Australia's national electricity market in a region that has suffered from power shortages.

The build out of energy storage solutions will not only save wastage and the need for fossil fuel power generation capacity, but will also help to reduce energy-system costs. The UK's Electricity System Operator (ESO), National Grid, has (at the time of writing) paid more than £190m of constraint payments to wind farm generators in 2020. These payments are made when the supply of electricity from wind is too high and – without sufficient storage capacity – there is no choice but to curtail output to balance the grid. This has been particularly acute during 2020, owing to the reduction in electricity demand associated with the economic shut-down. Ultimately, these constraint costs are borne by the consumer and without more storage capacity, planned growth in offshore wind installations in particular will potentially drive constraint payments even higher.

Unsurprisingly, National Grid refers to battery storage as a 'vital tool', that will play a wide range of roles in balancing the grid. It appears likely that the availability of regulated revenue streams for battery operators will broaden. The potential to lower constraint payments and the build-out of storage capacity is likely to put downward pressure on wholesale electricity costs over time, owing to the fact that battery assets will help to smooth the deployment of power throughout the day, charging at off-peak times and discharging in the evening, for example, when there is a peak in demand.

Moving towards a zero-carbon energy system in the UK will depend on a significant increase in battery storage capacity. The National Grid forecasts that UK battery storage capacity could reach 2.3GW in 2025, which would represent growth of approximately 160% compared with the 0.88 GW of capacity available at the end of 2019. On a global view, energy consultant Wood Mackenzie anticipates that global energy storage capacity will grow at a compound annual rate of 31% between now and 2030, even factoring in a slight dip in 2020 owing to the impact of the Coronavirus pandemic on activity levels. This would see the global battery storage market reach 741 GW cumulative capacity, of which the U.S. will account for approximately half.

Separately, as more consumers switch to using electric vehicles, the concept of Vehicle-to-Grid (V2G) will become important – a smart charging system whereby V2G would supply energy back to the home or grid in times of demand and recharge at more optimal times.

There are clearly a range of benefits to come from an increase in global storage capacity. As renewable energy sources begin to reach a tipping point in terms of their contribution to the electricity supply mix, these storage assets will represent critical energy infrastructure in the future world of high renewables penetration.

The **VT Gravis Clean Energy Income Fund** invests in energy storage assets through the ownership of publicly traded companies. This includes specialist energy storage companies that own and operate free-standing, utility scale battery storage assets and pumped hydro assets, as well as renewable energy companies that have integrated battery storage capabilities within operational wind and solar projects.

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