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Battery Energy Storage Systems – The Essential Jigsaw in the Puzzle

With the Government's intention to end unabated coal generation in Great Britain by 2025 and the consequential increase of renewable power to the UK Grid, Battery Energy Storage Systems (BESS) will be an ever-growing critical element of the UK's new energy system. John Danahy (Partner), from the Real Estate team, and Rob Broom, from the Energy & Natural Resources team, look at the role of BESS in the UK's transition to a low carbon economy.

John Danahy and Rob Broom

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1. The Transformation of the UK's Energy System

1.1 The changing nature of the energy system (as power distribution moves from a centralised to a more decentralised model) in the UK is a result of various interrelated factors relating to the UK's transformation into a low carbon economy, including: (i) the government's intention to implement the end of unabated coal generation by 2025 (see figure 1 below illustrating the last remaining coal power stations); (ii) the UK's legally binding climate change targets established by the Climate Change Act 2008, which commits the UK to reducing emissions by at least 80% in 2050 from 1990 levels, and which requires the government to set legally binding "carbon budgets", each establishing a cap on the amount of greenhouse gases emitted in the UK over a five-year period; and (iii) the UK's ratification, in 2016, of the COP21 – Paris Climate Agreement, which aims to limit global warming to well below 2°C and to pursue efforts to limit it to 1.5°C.

1.2 The UK's fifth carbon budget (enshrined in law on 20 July 2016), which covers the period between 2028 and 2032, permits power stations to produce between 50g and 100g of carbon dioxide per kilowatt-hour (kWh) of electricity they generate. This is a reduction from 718g in 1990. It is estimated that to achieve a reduction in the carbon intensity of electricity from the current 450g to under 100g of carbon dioxide equivalent per kWh (CO2e/kWh) by 2030, this will require that a minimum of 80% of the UK's electricity be sourced from low carbon technologies[1].

In addition, analysis by Regen suggests that to achieve these targets by 2030, this would require 40GW-50GW of new-build wind (offshore and onshore), solar, plus contributions from hydro, anaerobic digestion, marine energy and microgeneration[2]. The diverse mix of renewable (intermittent) generation will put further pressure on the UK electricity grid network and has resulted in increased attention on Battery Energy Storage Systems ("**BESS**") and their potential to ensure system stability, optimise low carbon generation, reduce price volatility and increase energy security.

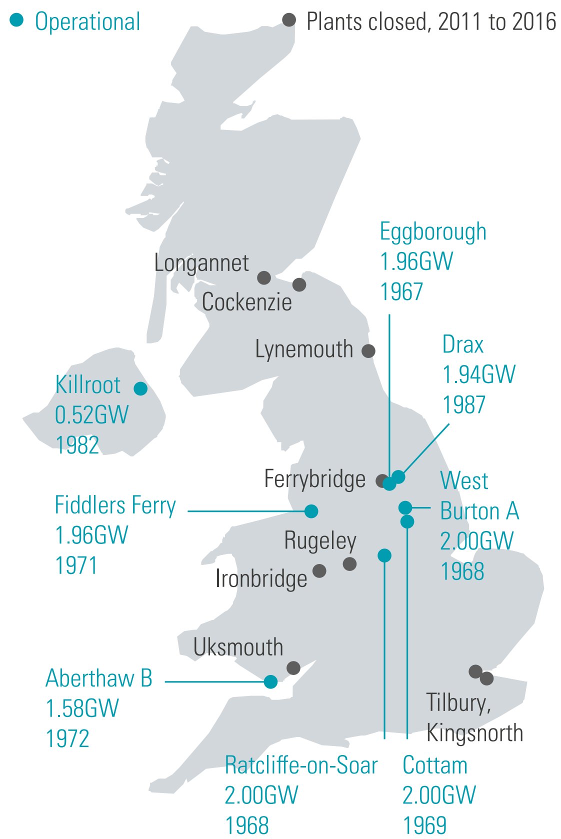
1.3 It is noteworthy that 2017 was a year in which several clean energy records were broken, including (i) the first full day (7 June 2017), since the industrial revolution, without any coal power in the system; (ii) record days of solar generation (see figure 2 below); and (iii) tumbling prices for new offshore wind farms in the September Contracts for Difference (CfDs) competitive auction, in which three projects were successful in being awarded 15-year contracts – Dong's (1,386MW) Hornsea 2 and EDPR and ENGIE's Moray will begin generating in 2022-23 at £57.50/MWh, and Innogy and [3]Stratkraft's Triton Knoll (860MW) in 2021-22 at £74.75/MWh. All these factors, along with the ever-decreasing levelised cost of energy (LCOE) for renewables (especially utility-scale solar and wind), when taken together, can only reinforce the importance of BESS within this progressing low carbon transition.

1 Johnny Gowdy, "Energy Storage and the New Market for flexibility", *Energy World Magazine*, May 2017.

2 Regen, "Energy Storage – Towards a Commercial Model", 2016.

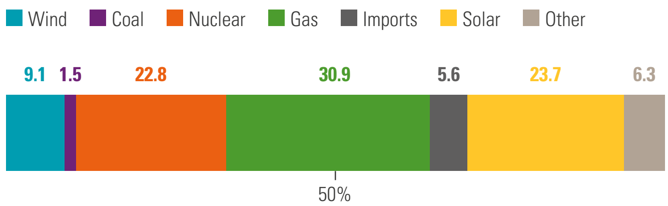
3 Since the auction, German clean energy firm Innogy has bought Statkraft's stake in the project.

Figure 1: Last remaining coal power stations – by capacity (GW) and year they were commissioned.



Sources: the *Guardian*, carbonbrief.org, E3G

Figure 2: Solar's percentage of UK power at 1 p.m. on 26 May 2017.



Source: MyGridGB

2. The Challenges of More Renewable Intermittent Generation for the Grid

2.1 National Grid, as system operator, under its licence is required to operate the UK's transmission system and to balance supply with demand, in order to maintain consistency in the power available. It does so through using the "Balancing Mechanism" (BM) to balance electricity supply and demand close to real time, through which cash is primarily paid to power generators to increase or decrease their output at short notice, and it is ultimately passed on to consumers through their energy bills.

Balancing is becoming ever more challenging with the growth of more intermittent and distributed generation. As a result, the costs faced by National Grid to balance the system are predicted to grow to £2 billion/year by 2021[4].

2.2 System frequency is determined and controlled by the real-time balance between system demand and total generation, and National Grid is required to control this – the limits specified in the Electricity Safety, Quality and Continuity Regulations 2002 are +/- 1% nominal system frequency (50Hz). The standard AC frequency of 50Hz is a function of the spinning inertia of large steam turbines, but as the number of large thermal generators on the system reduces, then the lower system inertia means the frequency can drift and become unstable[5].

2.3 To further maintain the integrity of the grid network, National Grid procures services to balance demand and supply, such as (i) frequency response services, e.g. Firm Frequency Response (FFR)[6] and Enhanced Frequency Response (EFR)[7], and (ii) reserve services, e.g. Short Term Operating Reserve (STOR) – National Grid's most important source of reserve energy. In response to declining system inertia, National Grid will inevitably require more capacity within these services to ensure system stability.

3. The Advantages of BESS

3.1 BESS can provide numerous benefits for system stability and security of supply, as well as helping decarbonise UK energy supplies, including:

a. **Integration of consistent renewable energy into the grid** – BESS can provide control power to limit fluctuations of feed-in, intermittent renewable electric power into the grid.

b. **Frequency response** – To avoid the possibility of damaging power imbalance scenarios adversely affecting the network since the magnitude of the imbalance is reflected in the grid frequency deviation (as stated earlier, this is +/- 1% of the nominal system frequency (50Hz)), BESS can assist with the control of grid frequency to minimise deviations, as they have the ability to respond quickly (in milliseconds) to grid, frequency or price signals, and can be used at any time, whenever they are required, making them a uniquely suited technology for EFR, FFR or other frequency response services, such as fast reserve (FR). National Grid's first EFR tender, in August 2016 (which secured 201MW of capacity at prices between £7 and £11.97/MWh, at a total cost of £65.95 million over the four years), has brought forward investment in eight battery storage facilities in the UK.

c. **Voltage control** – BESS can help to maintain the voltage profile within a defined range, with the aim of guaranteeing the standard of supply.

4 Haven Power, "Balancing costs could double within five years, says National Grid".

5 Shawn Coles, "Battery Energy Storage: The Back-up Power Solution that drives down your energy costs", *FinancialWire*, 11 January 2018.

6 EFR is a service, open to both BM and non-BM providers to provide frequency response in one second or less.

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d. **Providing reserve capabilities to intermittent renewables** – BESS can provide reserve capabilities to wind and solar generators, which is crucial in grids with high renewable penetration that have an irregular power generation.

e. **Peak shaving** – Peak shaving is a technique that is used to reduce electrical power consumption during periods of maximum demand on the power utility, in doing so, saving substantial amounts of money due to peaking charges. Peak shaving can be achieved by shedding load or by using onsite standby generation facilities during peak times. [8] As BESS can be charged either (i) directly from the grid when the electricity is cheap (e.g. during the green/amber DUoS band), or (ii) through onsite generation, such as solar, and then discharged during peak times to reduce DUoS and TUoS charges, it can also enable significant savings on electricity costs.

3.2 BESS can also be co-located with high-energy demand to provide backup and peak energy commodity and delivery cost avoidance. In addition, co-location with generation can enable BESS to optimise value from variable generation, arbitrage, avoid grid curtailment issues or enable local supply business models[9]. According to the UK Renewable Energy Association (REA) and an All-Party Parliamentary Group (APPG) on Energy Storage, Britain could have a 12GW battery market by 2021. However, the REA and APPG believe a more likely medium deployment scenario of 8GW by 2021 (up from 60MW of battery storage today), with the biggest boost for electrical storage in the UK to come from renewable energy generators adding batteries to solar and wind projects, so they can earn extra revenues from capacity markets and price arbitrage[10].

4. Examples of Available Revenue Sources for BESS Providers

4.1 Prospective and existing BESS projects can seek to obtain revenue from various sources, including:

STOR – STOR capacity is stand-by generation, which National Grid can call on to generate within four hours of instruction. The need for this generation can arise from demand forecast errors, unexpected loss of thermal generation and variable wind generation[11]. STOR projects are required to fulfil a number of criteria, including an ability to deliver at least 3MW of reserve, an ability to react within 240 minutes of an instruction, an ability to deliver for a minimum of 2 hours and have a recovery period after provision of reserve of less than 20 hours.

Capacity Market (CM) – The aim of the CM scheme is to encourage sufficient capacity to "prevent the lights going out" by providing backup for more intermittent and inflexible low carbon generation sources. Capacity providers secure a capacity payment revenue stream (set at the level of the CM auction clearing price), in return for which they commit to being available to deliver energy in periods of system stress or face exposure to penalties if they fail to deliver. In the December 2016 T-4 CM auction (delivery for 2020-21) storage secured 3.2GW of CM contracts; specifically, four battery projects that had previously been successful under National Grid's EFR tender were provided with 15-year contracts as new-build generators under the auction. It remains to be seen how the storage sector will respond to the new de-rating factors (from 96% to as low as 17.89% in the T-4 auctions for 30-minute duration batteries, with 21.34% set for the T-1 auction) being introduced before the January and February CM 2018 auctions, in particular how they will affect around 7GW of battery projects that won pre-qualification across the T-1 (2.1GW) and T-4 (4.8GW) auctions. BESS with long-term contracts to provide STOR are not eligible to participate unless an irrevocable declaration is made to terminate the STOR contracts if awarded a CM agreement.

EFR –EFR depends on a reliable control system that monitors power grid frequency in real time and ensures the system responds in less than one second[12]. As EFR providers must be able to respond within one second to frequency deviations, meaning battery storage, in particular lithium ion, is a solid choice technology suited to this scheme. A further technical requirement is that EFR providers are required to be capable of delivering a minimum of 1 MW of response. This may be from a single unit or aggregated from several smaller units. Maximum response of 50MW is permitted.

FFR – The minimum power capacity to provide the FFR service is 1MW. This may be from a single unit or aggregated from several smaller units. In relation to the speed and duration in which participants need to respond, in accordance with the Grid Code, for a Low Frequency (LF) service, i.e. an increase in output, this can be either primary (full output within 10 seconds, sustained for a further 20 seconds) or secondary (full output within 30 seconds, sustained for 30 minutes). For a High Frequency (HF) service, this needs to be achieved within 10 seconds and sustained indefinitely[13].

Non-intermittent Power-Purchase Agreement (PPA) – To enter into a non-intermittent PPA, the BESS installation must be able to generate at an agreed power level for an agreed time period.

8 Baldor, "Energy Management Best Practices, Peak Shaving Generators".
9 Ibid 1.
10 Jason Deign, "The UK could install 12 GW of Energy Storage by 2021, it depends on many variables", 1 January 2018.
11 Pöyry, "Smarter Network Storage Low Carbon Network Fund, Electricity storage in GB: SNS4.13 – Interim Report on the Regulatory and Legal Framework".
12 LogicEnergy, "What is Enhanced Frequency Response and Which Are Its Benefits?" .
13 National Grid, "Firm Frequency Response – Frequently Asked Questions".

4.2 BESS providers can also stack several of these revenues together. In fact, Claire Spedding, National Grid's head of business development, issued a warning to developers, stating "I would make one appeal, which is: don't put all of your eggs in one basket and build your entire business case around FFR."[14] UK developers are more likely to look at a number of different revenue streams to make BESS projects economically viable, which is certainly an approach we are seeing with a number of client projects we are advising on at Squire Patton Boggs.

5. Challenges for BESS Projects

5.1 Whilst the biggest revenue opportunity available in the UK for around 70% of projects is from grid services, such as frequency response, the limited availability and short length of grid services contracts is the largest challenge in monetising battery projects. Furthermore, whilst BESS projects can seek to supplement their trading revenue by charging their installations when prices are low and then selling power when wholesale prices are high, the spread between wholesale peak and off-peak prices is currently not wide enough and, therefore, less attractive. Renewable generators looking to co-locate a battery with an existing generation project face another barrier – if the generation project receives a subsidy for being renewable, only green power can be used to charge the battery if it shares the same meter. If the battery were to be charged straight from the grid and then discharged, the generator could put its subsidy at risk by mixing brown power into its export. The solution is to run the battery though a separate meter, but this adds a further layer of complexity[15].

5.2 Whilst some challenges remain, BESS provide key solutions to enable the better management of overall energy system costs and stability, which is an essential part of the transition to a clean and affordable low carbon economy – watch this space!

14 Andy Colthorpe, ""Don't put all your eggs in the frequency response basket", National Grid warns storage developers", *Clean Energy News*.

15 SmartestEnergy, "Making the commercial case for Battery Storage".