SERIES 17

CPD fundamentals

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MARK THROWER MANAGING EDITOR

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Batteries and energy storage

Paul Bennett is managing director of BSSEC Ltd

Balancing the electricity supply with demand has always been a challenge for the energy industry. This has been further complicated as we've entered an era when widespread integration of renewable generation is being commonplace.

In the last few years, battery storage seems to be the technology dominating the agenda of conferences, magazines and sales pitches across the energy industry.

As the cost of battery technology continues to fall, many experts within the energy industry believe that battery storage is going to become a crucial part of the electricity network, potentially increasing the reliability and flexibility of the electricity grid.

For years, the technology has been considered intangible, expensive, unreliable and riddled with technical challenges. However, advances in battery storage and battery management within the last decade has made the technology financially and strategically viable for a growing number of organisations; so much so that some utilities providers now appear willing to fund battery storage on their customers' behalf.

On a domestic scale there are changes too. It's now more feasible than ever to combine solar generation with domestic-scale batteries to decrease your personal reliance on the grid energy, and to sell excess energy to your supplier through a purchase agreement.

It is becoming increasingly clear, during an age reliant on fluctuating renewable generation, that battery storage is now part of the solution to ensuring grid demand and supply are matched. Battery storage may just be the next big thing.

Up until a few years ago, the uptake of battery storage in the UK was slow. Some experts believe that the growth of battery storage facilities within the UK has been hampered by a lack of formal regulations. Others believe that the initial slow uptake in the UK is simply due to the nature of the electricity market; nobody can confidently build a business case simply because nobody knows what changes will occur to the energy markets and policies. Perhaps the only certainty is that energy prices are likely to rise in the future.

The grid-scale battery storage market in the US appears to have developed significantly quicker than the European market, although Europe is beginning to catch up. Famously, Tesla delivered and commissioned the 20MW/80MWh Mira Loma Battery Storage Facility in Nevada just 88 days after being awarded the contract. In Arizona, battery storage is now competing with gas 'peaker' plants to help to effectively balance the grid.

The UK's introduction to battery storage projects has grown almost exponentially in the last six years. In 2012, planning applications were submitted for 2MW of battery storage – by 2018, this figure had risen to 6,874MW. Companies exploring this technology in the UK include E.ON, Shell, AES, Mitsubishi, EDF Energy, Vattenfall and numerous others.

There's no sign that this growth will slow down any time soon; research by Navigant Research predicts that global storage capacity will see a 60 per cent compound annual growth rate through to 2020.

There are two main drivers to the installation of battery storage: operational benefits and financial benefits. The benefits for larger consumers, such as increased resilience and energy independence, are often overlooked. However, with each of the following benefits comes uncertainties and obstructions to the business cases for battery storage:

• **backup power** – operators of data centres, telecommunications networks and high-precision manufacturing simply cannot afford to lose their electricity supply, because power is a critical part of their business. While battery storage is unlikely to be considered as a replacement for an uninterruptible power supply (UPS) and generator, it certainly presents an increased resilience to power failures. Whilst this may not present a robust business case in itself, it may be considered as an added advantage when installing a system;

• **avoiding distribution (DUoS) charges** – large consumers often pay for electricity passed through the distribution network and consumed at their site, based on the time of day that electricity is used (represented by red, amber and green colour bands). The 'red band' represents the time of the highest demand and carries the highest charge. Intelligent planning and use of battery storage can see batteries charged during a 'green band' period and discharged during a 'red band' period to reduce the cost of electricity to the site – and savings can be significant;

• **avoiding transmission (TNUoS) charges** – business users of electricity are charged based on their share of demand of the transmission period during peak periods. Charges are set based on usage during the

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three highest half hourly periods of demand during the winter months (known as 'Triads'). Although these dates are never known until the March/April after the winter, they typically fall between 16:30 and 18:00. Intelligent usage of battery storage can allow users to discharge their batteries during these times to ensure that they are awarded a lower tariff;

• **reduction in kVA requirements** – businesses with large peak loads often must pay a significant premium for their kVA capacity. Introducing large-scale battery storage can enable users to take the majority of their electricity from the grid, and then use the batteries to deliver the additional energy to meet the peak load for a short period when required. This then reduces the requirement to purchase kVA capacity, which can represent a significant cost saving;

• **electric vehicle charging** – the growth of the electric vehicle market is going to place a large demand on the grid. Charging on-site batteries at strategic times and then subsequently discharging these batteries into vehicle batteries as/when required will enable electricity purchasers to avoid DUoS and TNUoS charges and can help to balance grid demand;

• **oversizing renewables** – perhaps the most undersold advantage is that battery storage gives the ability to oversize renewable generation. For example, by oversizing a solar PV array to exploit the available space, the peak supply from solar will likely exceed on-site demand. However, storing the excess energy for use when the panels are not generating may yield enough financial savings to justify the increased capital expenditure.

There are several in-front-of-the-meter drivers for battery storage, including:

• **frequency response** – the National Grid has an obligation to keep the frequency of the electricity grid at 50Hz, plus or minus 1 per cent. Traditionally this is managed by ensuring there is sufficient generation and demand held to manage all credible circumstances that may result in frequency

Conventional Batteries:		
	Advantages	**Disadvantages**
Lithium-ion	High energy density Low standby losses High tolerance to cycling Flexible discharge time	Expensive, although costs are reducing
Nickel-Cadmium (NiCd)	High energy density Long life cycle Perform well in range of temperatures	Highly toxic
Lead-acid	Most developed/mature battery technology Low cost/performance ratio Short life cycle	Low energy density As they discharge higher power, usable capacity decreases Slow to charge Short usable life (3-4 years) Variable maintenance requirements
High Temperature Batteries:		
Similar to conventional batteries, but reactions only occur at high temperatures		
Sodium Sulphur (NAS)	Early stages of development Long duration of energy storage High round trip efficiency High energy density	High cost
Sodium Nickel Chloride (NaNiCl)	Used in electric vehicles	Limited overcharge and discharge
Flow Batteries:		
Electrolytes are stored in tanks and are pumped through electrochemical cells which convert the chemical energy to electricity. Many organisations are exploring the use of flow batteries for grid-scale energy storage. The advantages are that flow batteries typically offer significantly longer lifespans (up to 20 years in some scenarios) and typically cost around 50 per cent less than lithium-ion equivalents.		
Redox Flow Battery (RFB)	High level of discharge Long life span	Low energy density – until recently, too low for battery storage application, but this is improving
Others:		
Zinc-air batteries	Zinc-air batteries are another technology that is increasingly being used. Zinc is used for the electrolyte and air is used for the cathode. This is particularly competitive because zinc is widely abundant and cheap.	

Table references: (Renewable Energy Association, 2016), (Patel, 2017)

variations.

Firm Frequency Response (FFR) is where a battery storage operator provides a service to the National Grid to reduce or increase supply when instructed to do so, enabling almost instant balancing where required (as opposed to the tradition method of up/down scaling production at a set threshold).

In late 2016, the National Grid held a particularly competitive Enhanced Frequency Response auction, which is often cited for causing an accelerated uptake in battery storage applications. While this boost seemed advantageous at face value, it caused several concerns across the industry regarding FFR market saturation. The prices that battery storage operators are paid for these services are widely predicted to decline with time, so FFR may not present a long-term business case unless a price can be fixed for several years;

• **demand side response** – battery storage can be used as a tool to enable organisations to participate in demand side response (DSR) projects. Under DSR contracts businesses are paid to reduce their demand or switch to on-site generation during peak periods. Battery storage gives a third option to DSR, which is to switch to battery storage instead of reducing consumption, which enables day-to-day operations to continue as normal and will bring the additional advantages of payments from the grid.

• **capacity market charges** – the capacity market is designed to ensure sufficient reliable capacity is available by providing payments to encourage investment in new capacity or for existing capacity to remain open. For capacity providers, monthly payments for the provision of capacity are made to capacity providers in line with their capacity agreements. Flexible and adaptable management of battery storage can be used to generate revenue.

• **'black start' assistance** – Another application for battery storage is to use the stored energy to support the National Grid in the event of a 'black start.' In this application, the stored energy is used to help reboot the grid in the event of a crash. Contracts for this service are worth tens of millions of pounds a year.

There are several elements that make building a robust energy storage business case very challenging, and subsequently reduces the attractiveness of implementing battery storage solutions:

• **policy uncertainty** – perhaps the

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biggest uncertainty is that nobody knows what changes will be made to energy policy. This uncertainty is likely to continue until Ofgem finalises its ongoing charging review, which is not expected until 2021 or 2022 at the earliest. Significant changes are expected, although nobody can foresee these changes and this creates uncertainty;

• **charging structure uncertainties** – with behind the meter action to reduce charges, there is no guarantee that the existing distribution and transmission charging structure (e.g. DUoS, TNUoS etc.) will continue in its current format until the investment of a battery storage scheme may have paid for itself with financial reward. Therefore, it is crucial that operators are proactive and can act upon opportunities as they arise; and

• **contract value fluctuations** – If battery storage is used in front of the meter, changes to pricing paid for your services perhaps represents the largest threat. For example, if you provide DSR services or frequency balancing services, there's no guarantee that your payments will remain at the level they are once the original contract has expired and has been re-tendered. Some experts argue that the large uptake in FFR services since 2016 will result in the saturation of the frequency response market – whereas others argue that this has already happened.

These uncertainties however should not be the deciding factor when evaluating the potential to install a battery system. The uncertainties can be counteracted by innovation and adaptation. Where a financial saving/gain may disappear in the future, new markets and opportunities will inevitably emerge, and ensuring that the applications are variable will ensure that the risks can be managed. This is perhaps best explained by the fact that utilities providers are commonly self-funding battery storage solutions as they believe that storage is going to be a key part of the future of our energy grid.

One of the greatest advantages of battery storage is that it is easy to site – you need land and a supply of electricity. In many of the drivers and applications discussed above, there is a key factor that will determine the value of savings and payments: location.

Some parts of the National Grid are under greater stress and require greater balancing management than others. Situating battery storage in a strategic location where the grid requires careful management is therefore likely to yield valuable contracts. Some experts believe that the largest contracts will eventually be made in balancing mechanisms at grid supply point level.

Battery storage is becoming increasingly viable on a domestic scale, enabling homeowners to oversize solar PV arrays, store the chemical energy and use it during times when it is not generating to supply their domestic requirements. With domestic-scale batteries coming down in price (typically a domestic-sized battery costs in the region of £2,000-£8,000, depending on capacity), it is becoming increasingly affordable. Excess power can also be stored and sold to the grid to help balance supply/demand. This is becoming an attractive alternative to feed-in-tariff payments, which were scrapped from April 2019.

Battery technology development is advancing at a fast pace. An article written five years ago will be out of date by now simply due to rapid improvements in technology.

Different types of batteries have different operational and maintenance requirements. Some of the considerations that need to be accounted for are discussed below, but the exact requirements vary depending on the battery technology used and the application:

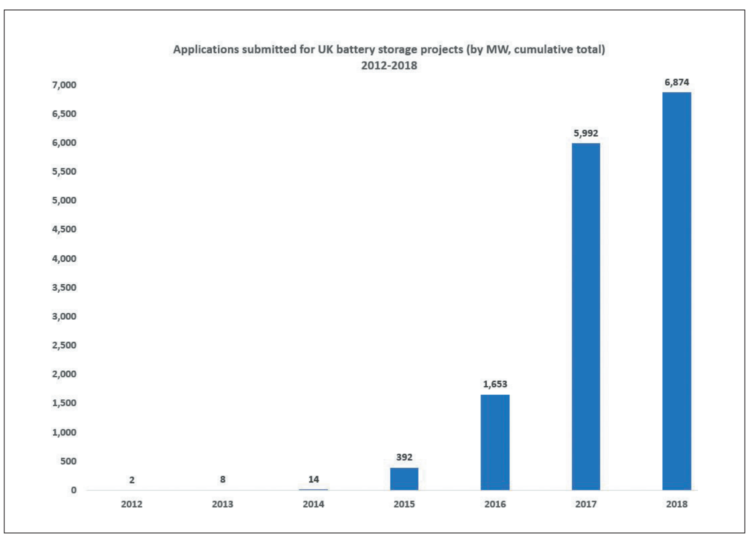
• **cyclic use** – different types of batteries will degrade in different ways based on the operation cycles that they use. It is important that the operation is optimised for the type of battery technology installed to ensure the system lasts and that the user benefits from the advantages that type of storage can bring.

• **degradation** – as battery technology is used, its capacity tends to reduce. The effects of this can be reduced and managed over time with appropriate maintenance schedules, for example by replacing older cells in a modular system. It is important that this is effectively and proactively managed and appropriate replacement schedules are implemented;

• **other costs** – these might include land rent, grid connection charges, replacement of other equipment (e.g. inverters), maintenance agreements, contract management and insurance; and

• **end of life costs** – at the end of life of a battery storage system, there is a large cost associated with decommissioning, recycling and/or replacement that needs to be accounted for.

Planning applications submitted for battery storage projects in MW



Recycling opportunities are available. For example, organisations such as Powervault are creating domestic-sized (up to 7.9kWh) 'second life' battery storage from recycled electric vehicle battery technology.

Useful Links

- Ofgem - www.ofgem.gov.uk
- Energy Institute – www.energyinst.org
- Committee on Climate Change - www.theccc.org.uk

Further reading

- *EMR Settlement Limited. (2018). Capacity Market. From EMR Settlement Limited: https://www.emrsettlement.co.uk/about-emr/capacity-market/*
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- *Steel, A. (2017, February 2). Energy Storage Market Outlook 2017: State of Play. From Renewable Energy World: https://www.renewableenergyworld.com/articles/print/volume-20/issue-1/features/storage/energy-storage-market-outlook-2017-state-of-play.html*

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ENTRY FORM

BATTERIES & STORAGE

Please mark your answers on the sheet below by placing a cross in the box next to the correct answer. Only mark one box for each question. You may find it helpful to mark the answers in pencil first before filling in the final answers in ink. Once you have completed the answer sheet in ink, return it to the address below. Photocopies are acceptable.

QUESTIONS

1. **Which type of organisation is increasingly appearing willing to fund battery storage on their customers' behalf?**
   - ☐ The National Grid
   - ☐ Utilities providers
   - ☐ Transmission network operators
   - ☐ Distribution network operators

2. **When has grid-scale battery storage begun to expand towards mainstream use?**
   - ☐ Within the last 20 years
   - ☐ Within the last 10 years
   - ☐ Within the last 2 years
   - ☐ Within the last 12 months

3. **What reasons have been cited for the slow uptake of battery storage in the UK? (Select all that apply)**
   - ☐ A lack of formal regulation
   - ☐ Policy uncertainty
   - ☐ Nature of the electricity market
   - ☐ Ability to connect to the grid

4. **How fast did Tesla deliver the Mira Loma Battery Storage Facility (Nevada) following the award of the contract?**
   - ☐ 88 days
   - ☐ 6 months
   - ☐ 9 months
   - ☐ 12 months

5. **How many MW of battery storage applications were made in the UK in 2018?**
   - ☐ 2MW
   - ☐ 1,653MW
   - ☐ 5,992MW
   - ☐ 6,874MW

6. **What are the two main drivers for installing battery storage?**
   - ☐ Operational benefits
   - ☐ Effective use of land
   - ☐ Financial benefits
   - ☐ Political benefits

7. **Which of the following is an advantage of battery storage? (Select all that apply)**
   - ☐ It allows you to avoid TNUoS and DUoS charges
   - ☐ It allows you to oversize renewables
   - ☐ It allows you to purchase a smaller kVA capacity
   - ☐ It allows you to provide balancing services to the National Grid

8. **When are Ofgem expected to finalise their charging review and potentially provide more certainly on policy?**
   - ☐ 2019-20
   - ☐ 2020-21
   - ☐ 2021-22
   - ☐ 2022-23

9. **Why do some experts believe that battery storage is a worthwhile investment despite uncertainties? (Select all that apply)**
   - ☐ It is believed that energy storage will become a key part of the energy grid
   - ☐ The price of land is increasing
   - ☐ Uncertainties can be counteracted by active adaptation
   - ☐ The price of batteries has bottomed out

10. **Why is location so important when negotiating in front of the meter battery storage contracts?**
    - ☐ Electricity costs more in different parts of the country
    - ☐ In some parts of the grid balancing mechanisms are in greater demand
    - ☐ Transmission losses vary in different locations
    - ☐ Some parts of the country have greater renewable energy generation than others.

Please complete your details below in block capitals

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