PÖYRY

PÖYRY POINT OF VIEW - APRIL 2016

Rise of the Batteries

Part 1 - Overview

This article was originally written for Utility Week.

There are many signs that batteries are becoming the preferred option for new investment in electricity storage. While many battery technologies are being developed, lithium-ion batteries are the best known because they are found in mobile phones, tablets, and electric toothbrushes. And in electric cars.

Even though they were only invented in the 1980s, lithium-ion batteries have become a part of everyday life – be it in a mobile phone, a tablet, or electric toothbrush.

And through their use in electric vehicles – hybrids and pure electric cars - a large family of lithium-ion technologies is well established. Although the numbers on the road is well below forecasters' expectations, they represent a substantial, and growing, sector of the car market.

As the batteries are such a high part of the costs of an electric car, there are strong incentives to improve production processes, reduce supply costs and improve performance. Tesla's Gigafactory, which started construction in 2014 will be a step change in the supply chain for batteries – with clear ambition to dramatically lower battery costs through economies of scale.

Availability of far cheaper batteries has coincided with developments in the power systems of nearly all countries that are decarbonising their energy economies by deployment of renewables. Solar PV and Windfarm output is dependent on the weather – so other forms of generation are needed to ensure demand is met. Coal plants would have historically been able to absorb such fluctuations, yet the UK and other countries are closing their coal fleets.

With large volumes of PV and onshore windfarms being connected to the distribution system, these networks are also increasingly stressed – for example, at the times that the generation output on a local distribution system exceeds the local demand, it cannot cope.

As well as matching generation with demand, grid operators need to maintain system frequency and voltages and, particularly for more islanded systems like GB and Ireland, this is now leading to the use of new technologies as an improved way to provide power at very short notice and to replace the conventional methods, which may currently be at lower cost, but with slower performance.

Increasing fluctuations in wholesale prices caused by intermittent renewables are also proving a driver to developers of storage to capitalise on its capability to buy power when prices are cheap and then sell back at a higher price, even if there are some losses in the total conversion cycle.

In the UK the LCNF has funded a number of projects which included energy storage, but two in particular illustrate the mould breaking nature of the technology:

- UKPN's Leighton Buzzard 6MW 10MWh Lithium-ion technology
- SHEL's Shetland 1MW 3MWh Lead-acid

More recently, and importantly without any particular market support, in January AES commissioned a 10MW battery adjacent to its Kilroot power station in Northern Ireland – largely targeting price differentials. On the other side of the Atlantic, California has set targets of deployment of 1.2GW of energy storage to deal with its own PV glut.

"We are now seeing a dramatic rise in uptake of battery technologies in large scale static applications," Anthony Price, Director of Swanbarton.

The revenue streams available to large battery projects like these are strongly influenced by the licences and electricity market rules and regulations. In principle the revenues can come from four main activities:

- Consuming electricity (i.e. charging up) when there is surplus of electricity
- Supplying electricity when in discharge mode (combined with consumption this effectively timeshifts power use)

- Playing a role in the local distribution network (to avoid or defer line or transformer upgrades, or to reduce demand charges or system charges which are measured at times of peak demand)
- Providing a range of reserve services to the TSO, e.g. frequency support

Currently an operator of a large scale battery is not able to simply access all of these because of our market structure, even allowing for the limitations on whether these value streams are additive. But that has not stopped progress.

"Our work on the UKPN project clearly shows that with the right market structures in place, battery projects can be highly attractive," Simon Bradbury, Principal Consultant at Pöyry.

It is also worth mentioning that like all distribution connected power units, there are a range of embedded benefits available: these now represent a considerable factor in overall project economics.

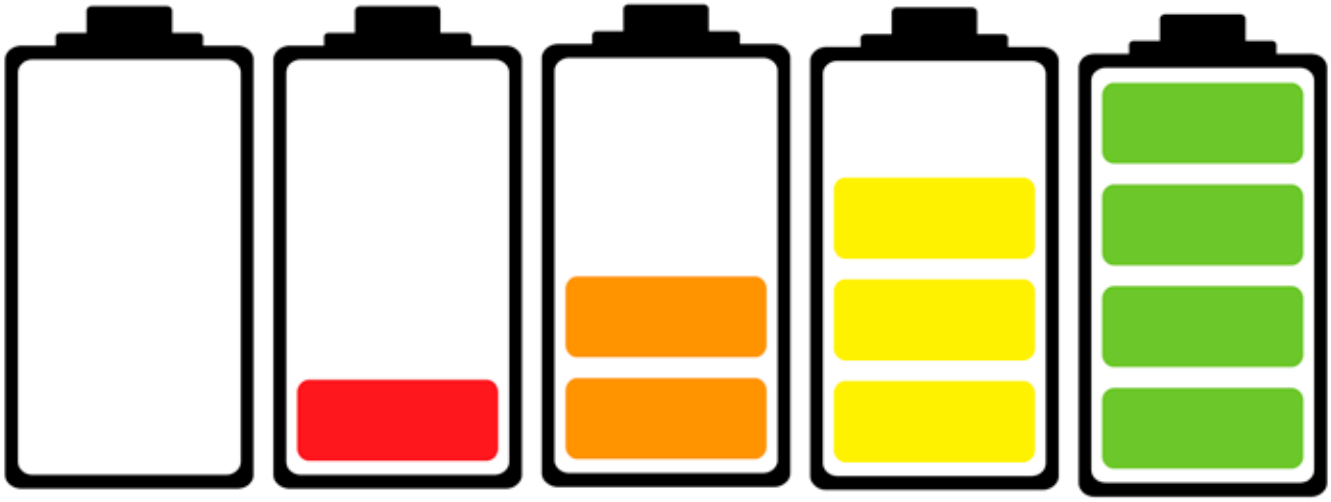
Interestingly, we have seen a shift towards a commercial framework over the past two years, which encourages early adopters to develop large scale battery projects which can now achieve satisfactory returns within the current market rules. The obvious market risks are also quite a problem. To some extent, the market risks are a particular concern to investors, who want certainty, and the contracts offered by TSOs (e.g. offering 1 year or 4 year contracts) can provide mitigation – whether this is equitable, or it is realistic to expect longer contract duration remains a moot point. It is certainly a step in the right direction and National Grid are to be applauded for their innovative approach to using advanced technology for new services.

With the outlook for more intermittent renewables being commissioned in coming years, the growing realisation by policymakers that batteries can offer a realistic and economic route to decarbonisation. Indeed, by enabling wind and PV deployment in so many ways, batteries could be at the heart of a revolution.

Undoubtedly, the drivers are there – large-scale batteries may play a key part in achieving renewable deployment - but the path to GW deployment of battery storage in the UK will have many trials and tribulations.

At risk of plagiarising Mark Twain it would be fair to say of batteries that "rumours of their growth are somewhat exaggerated" – but on the other hand the prospects look very exciting.

Part 2 - Market Challenges



Investors in grid connected battery systems, and developing energy technologies generally, need visibility over future revenues. The renewable energy sector, for example, secured long term, government backed, incentives and the result is obvious from the growth of UK renewable capacity and investment by pension funds.

For battery systems there is no equivalent. Income has to be built from multiple revenue streams that have short term contracts and uncertain payment levels. For example, local services for the DNO that save cost on its infrastructure, the potential to arbitrage high and low wholesale prices, by providing fast response services to the TSO (e.g. National Grid's EFR) or offering other grid support services, as well as the possibility of being a flexible demand responder.

Being generally distribution connected, battery projects are also eligible for various embedded benefits, and as time goes on, these are becoming more visible. But these are far from guaranteed for the project's lifetime. While project developers argue that batteries deserve special treatment, overhauling the rules could be something of a double-edged sword if it also provokes an upheaval of the many embedded benefits that the early investors in distribution connected batteries currently enjoy.

Until recently, the perceived wisdom was that battery projects needed multiple income streams to show a reasonable return, but even with current costs, there is the potential to make modest returns by cherry picking the most attractive services. And here is the conundrum – what services and income provide the best choice for the developer over the lifetime of the battery? If the choice is right, even allowing for the fact that some services are mutually exclusive, the return could be very exciting indeed.

This does not come without risk, however. Fully understanding the complex factors that affect value of response or flexibility in different timescales and their interplay will be crucial. The current boundaries and definitions of different flexible generation "products" seem very fluid, with much in the hands of National Grid.

"Investors know that these markets have no track record, and that they are bound to have

a great deal of interdependency, spilling from one to another. Developers should be worried that the potential for being undercut, however it happens, is very real. On the other hand, first movers could hold a lot of cards," Andy Houston, Senior Principal at Pöyry.

Better battery performance and decreased capex over time are likely outcomes of learning from early projects. In our experience, projects will struggle to raise finance if it looks like they'll be undercut in later years, especially if early investors want to exit in 3-6 year time horizons. If capex needs to be paid down in such a short time period, we can expect to see some high Fast Response prices between now and 2025.

"Prices for EV battery systems are now expected to be well below Euro200/kWh in 2020, we can see how the efforts made by car battery developers are now translating directly into benefits for static battery systems," Colin McNaught, Managing Consultant at Ricardo.

So should project developers be worried that their projects will be succeeded by cheaper better ones? There is no doubt that there are good prospects for battery cells to come down: larger production facilities and growing global demand are creating a virtuous circle of economies of scale. In parallel to this, better production techniques and more effective battery design and chemistry are nearing the production line. But the cells are only one of many components comprising a distribution-connected battery. The Power Control System, Inverter, Buildings, Land and other auxiliary plant can currently account for a major proportion of the total project. Some developers are looking to go beyond a containerised system to better optimise the auxiliary equipment already, but it is already clear that battery system providers will need to look beyond just the cell pack costs.

"There will be a great deal of value in optimising the battery operations – the industry has a long way to go to get the best out of them over their lifetime," Anthony Price, Director at Swanbarton.

So getting good market arrangements in place will be key to successfully deploying batteries. To some degree, Ofgem is already on the case through its considerations of Smart Networks, but such changes could take a long time – there is no clear strategy and defined position for the role of batteries in network operation.

Several storage developers are now arguing for a change in licences and market rules that would enable the full economic potential to be realised. It certainly does seem odd that any storage facility has to pay TNUoS charges for both charging and discharging. So future market rules may provide investors in battery systems some of the clarity previously enjoyed by the renewables sector.

"Storage developers have been asking for some degree of certainty in project revenues – longer contracts for some ancillary services would help to bring the cost of financing closer to that of other energy projects with fixed future income streams," Anthony Price, Director at Swanbarton.

Having suitable contractual guarantees of revenues in place is a crucial requirement for financiers. But are some developers being greedy in hoping for anything more than the four years on offer from National Grid in the EFR tender round? We think there is going to be some excitement in planning what happens at the end of the first contract period, as more batteries enter the market. AES's Kilroot battery may have set the cat amongst the pigeons in going ahead on a merchant basis but only time will tell.

Part 3 - Technical Challenges

Over the years, the power industry has readily adopted myriad technologies. “Generating plants come in many flavours, formats and sizes – but storage devices have just as many alternatives, if not more,” says Anthony Price, managing director of consultancy firm Swanbarton.

With the opportunity to deploy storage, and such a wide range of different technologies – batteries, flywheels or thermal and air systems are all at high readiness levels - expectations must be managed. Just as with generation plant, no single storage technology can do everything: investors will have to make important technical choices that will decide if investments deliver.

An understanding of current and future applications and the market, is vital if successful technical, commercial and investment plans are to be made on storage. As Colin McNaught from Ricardo has observed, “Some types of batteries may be ideal as means to provide frequency response services to the transmission system operator, but a quite different one would be needed if the battery is to be used for energy management services on a constrained network.”

Technically, progress is proceeding at an exciting pace. The lithium ion battery industry is awash with announcements from new and established manufacturers of the latest products and boasts a seemingly endless reduction in costs. If the market predictions for electric vehicles, both full EV and hybrid models, are even partially achieved, lithium battery production for EV’s alone will see economies in manufacturing that will push down the headline costs of electricity storage to new lows.

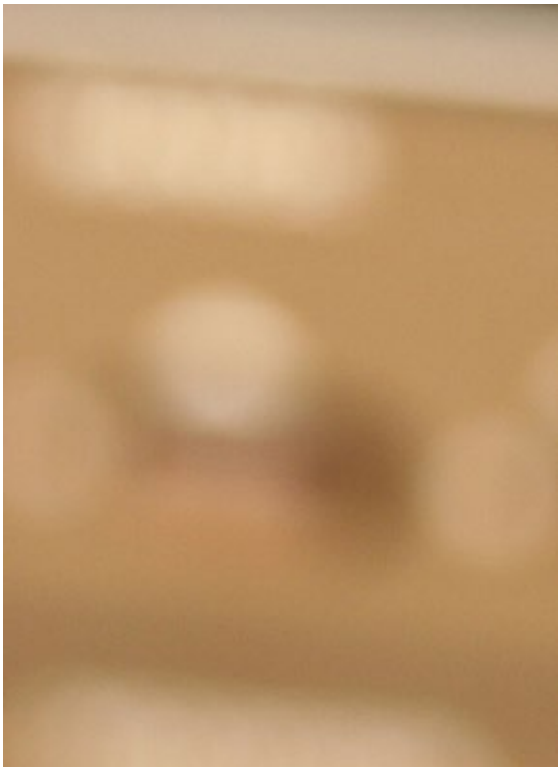
But although there is crossover between EV batteries and static ones there are also important differences. For example optimising long-term management and performance in power system applications is still in its very early days compared to EVs.

The operational duties of a battery define its performance parameters, and not only the technical specification of the battery, but of its ancillary equipment such as power conversion system and the battery management and control system.

But vehicle applications shape battery technology development. Full EVs maximise range, so EV batteries must maximise energy density.

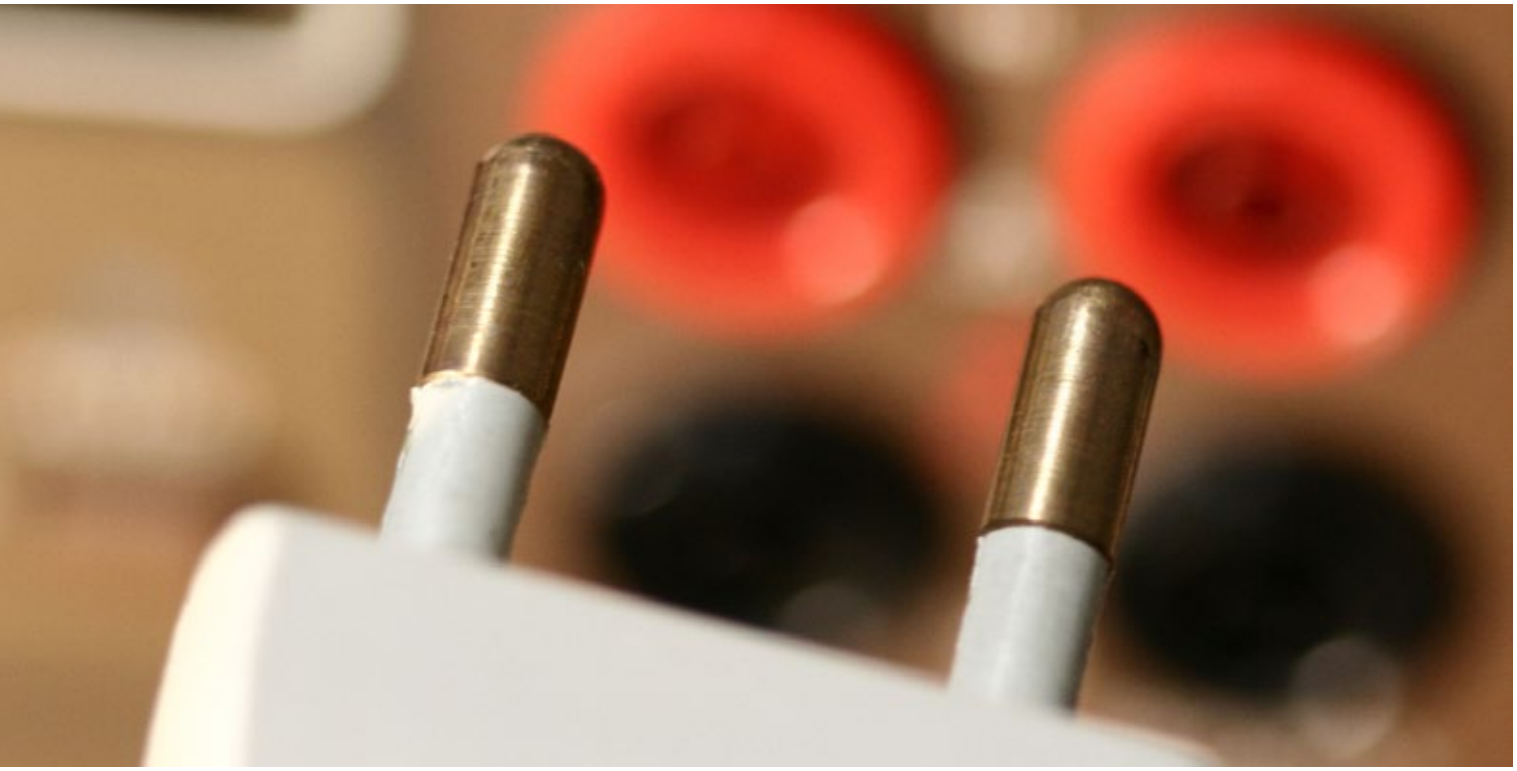
Even within EVs, plug in hybrid electric vehicle (PHEV) batteries need high instantaneous power, so PHEV batteries must maximise power density. Different battery chemistries will suit different applications in the power sector.

There could also be some nasty warranty issues if the car batteries are used actively in power systems as many propose in future “smart” electricity systems. Interestingly though, many of the electric vehicle manufacturers are connecting with potential providers of static applications, perhaps to develop large scale storage systems using ex-PHEV and EV batteries.



EV batteries’ lifetimes reflect the need for vehicles to have sufficient stored energy and power: emphasis on volume and weight is important for obvious reasons – batteries that have reached the end of their useful life in EVs could have a useful second life in static batteries.

Some of the biggest challenges will be accommodating the different battery types: will we see future large-scale battery projects, such as the Leighton Buzzard installation, become a home for batteries sourced new from some suppliers, and rehoused from others? Would that work – how will the plant manager be able to keep long strings of batteries balanced if they have been made at different times, to different specifications and all been subject to a different operational history? We already know of complications in establishing a spares strategy for a plant with a planned 15 year life.



"New technology also brings new problems, the electricity storage management system, whether for domestic, industrial or network scale, will need to be as secure against IT attack as every other component on the system," Dr Jez Kent, IT Security specialist at Swanbarton.

None of these challenges will be solved in isolation, a new methodology for controlling batteries will be needed, along with new power market models to make sure that the system can benefit from a better way of controlling the network on which we all rely.

Early battery storage projects will capture the lion's share of the future value of storage. One conundrum of using storage is that aggressive storage deployment tends to cannibalise its own prices. There is a law of diminishing returns and in theory, a perfectly balanced system would have maximum storage with minimum price volatility, and hence there is no capability for income in a true merchant based power market. But we suspect we are a long way from that stage.

It is more likely that by considering storage as part of the renewables strategy, that we could have a more efficient system: all new renewable generation would have to be self-balancing, either directly, or through contract with another party such as a dispatchable generator, load or storage device.

The push from the battery industry is encouraging: we will see much more progress in electric vehicles with improved batteries, and the increased production will lead to lower prices for batteries to be used in bulk stationary applications. The path to widespread deployment in the UK is far from certain, but there is progress.

"The message has been delivered, battery storage has arrived. Now it's the turn of the power industry to embrace the technology and turn it to commercial advantage," Anthony Price, referring to the recent report by the National Infrastructure Commission on Smart Power.

While rumours of tens of GW of stationary battery sales in the next few years should be viewed with caution, the prospects of a solid growth building on some excellent foundations do look very exciting.

PÖYRY
The connected company

About the Pöyry Point of View

Staying on top of your game means keeping up with the latest thinking, trends and developments. We know that this can sometimes be tough as the pace of change continues...
At Pöyry, we encourage our global network of experts to actively contribute to the debate - generating fresh insight and challenging the status quo. The Pöyry Point of View is our practical, accessible and issues-based approach to sharing our latest thinking. We invite you to take a look – please let us know your thoughts.

Pöyry has a global office network - please visit www.poyry.com/contacts for your nearest office.

Consulting. Engineering. Projects. Operations.

Smart solutions across power generation, transmission & distribution, forest industry, chemicals & biorefining, mining & metals, transportation and water. 6000 experts. 45 countries. 150 offices.

Photos: colourbox.com

PN 0033 2016/04 V1

www.poyry.com