Storage and the rise of the virtual power plant

Aggregation | Tesla's much-hyped battery announcement in April raised important questions over what business models will drive the deployment of stationary battery storage. As Andy Colthorpe reports, one answer is the virtual power plant, in which residential and commercial battery systems are aggregated to provide grid services

At the end of April, Tesla officially launched its range of energy storage batteries, for homes, businesses, off-grid and utility-scale applications. Energy storage landed on the mainstream news agenda, as newspapers around the world joined tech blogs in watching CEO Elon Musk's tweets drip-feed hints until the big night.

There was undoubtedly great satisfaction in both the storage and solar industries that Tesla's calculated publicity drive and its tie-ins with solar companies including installers SolarCity and Sunrun, power electronics makers SolarEdge and Fronius, and others, brought the technologies into greater public visibility.

Yet Tesla's dramatic entrance into the space does not in itself fill in the most important piece of the puzzle, namely to create a market for energy storage. While it is big news, too, that SolarCity as well as some of its big residential PV rivals like Sunrun will be marketing Tesla batteries, that alone will not yet convince the public to buy them in huge numbers.

Source: SolarCity.

An aggregate victory

The question mark hanging over the Tesla announcement, as it does over all discussions of battery storage deployment, is one of business models. The Tesla/Panasonic units may well be cheaper than their rivals', but the same familiar questions of who owns, deploys and operates energy storage within the structures of regulated electricity markets remain.

It seems that much of the mainstream media misunderstood, dismissed or skipped over the possible significance of what SolarCity – and others – intend to do with Tesla's residential Powerwall storage products. Some focused on the fact that at present, even in Tesla's home state of California, the majority of residential storage systems are sold to provide backup power, something that is hard to put a price on. Tesla and its partners will be trialling various business models in different regions, including direct electricity sales from individual storage boxes in Australia. However, with net metering in place in most of the US, storing solar power to use cheaply at night or to reduce time of use charges simply is not a compelling economic driver for storage at home as it is for commercial customers.

While energy storage is often said to be analogous to solar in terms of its development and deployment, one obvious but crucial difference is the bi-directional power flow of storage resources. Long term, SolarCity and others are interested in harnessing the bi-directional capabilities of batteries in several ways. One is aggregation – in essence using residential and commercial batteries as interconnected building blocks of much larger storage systems.

The aggregation of stationary residential and commercial storage units offers a promising business model to propel forward deployment of the technology.

As Chris Edgette, a consultant and director of the California Energy Storage Alliance (CESA) explains, aggregating storage systems can enable them to provide the same benefits to the electricity network that large-scale storage can offer, such as providing grid balancing services and preventing the need for expensive infrastructure upgrades.

The systems can be operated as a 'virtual power plant', even acting like generators and selling electricity in bulk at meaningful volumes. According to Edgette, while Tesla's residential systems will only be sold in its home state of California to provide backup from outages initially, successful aggregation trials might allow distributed systems to play a greater role in the network.

"Reliability for customers is a good selling point, but key to this market in the long term is in grid services," Edgette says. CESA and others are working to enable this at a widespread level in California, with Edgette optimistically projecting that regulations will be in place by the end of this year.

"An aggregated fleet of distributed energy storage resources can provide huge value to the distribution system, while providing flexible capacity to the grid. You can bet that Tesla has not overlooked this in their business model," Edgette says.

From blue sky to real world

It's not just in the US that the broad scope of value energy storage can provide, both at system and network level, is finally starting to be tapped. In Germany's maturing solar market, where residential storage systems have seen a significant upturn in sales, adoption has been largely driven by feed-in tariffs (FiTs) now expiring and it is now making better economic sense to self-consume solar than export it. Storage systems have also been subsidised, albeit modestly, to encourage uptake. Yet asking for further direct financial support at government level is one thing the energy storage and solar industries are wary of and companies are rapidly finding new ways to make storage pay.

Sonnenbatterie sells its lithium-ion battery systems into Germany's self-consumption market for residential and commercial PV, as well as recently opening sales channels into the US. In two separate programmes, the company's CEO Christoph Ostermann says, connected Sonnenbatterie systems will join the commercial frequency regulation market, as well as trading electricity in bulk to match supply and demand.

In the first of those projects, the company has partnered with Lichtblick, a utility company which operates 100% renewable energy assets. Sonnenbatterie is supplying its units to a pool of devices Lichtblick is using to provide 5MW of flexible capacity for the frequency regulation market. There are high technical barriers to entering the frequency response market, which is why Sonnenbatterie is only one of a number of contributors to Lichtblick's pool – or "swarm" – of devices, which also includes CHP and EV chargers. What's more, Ostermann estimates that it would take around 2,000 Sonnenbatterie units to build up to this required threshold, so while it would be possible for the battery company to do it alone, for now it seems more sensible to join Lichtblick's existing swarm.

In this example, Sonnenbatterie doesn't own the batteries once on a customer site; the utility controls the batteries, making direct payments to the end customer. At the moment the battery system maker is using the scheme as a value add-on to market batteries to potential customers, but the company's head of business development, Benjamin Schott, says that if it goes well, a profit sharing model with customers and the utility would be the next step.

The second of Sonnenbatterie's aggregation ventures will start small, with a few hundred systems operating in Germany's energy market on a peer-to-peer (P2P) trading basis, essentially using the virtual power plant concept to balance production and consumption of electricity regionally. Eventually, CEO Ostermann says, the same batteries that trade electricity could also be utilising spare capacity in the grid services and demand response markets.

While the P2P demonstration will use generated power to balance supply, other trials around the world, such as that by Germany's Next Kraftwerke and the UK's Open Utility, are also showing that storage system owners can become independent power producers (IPPs), selling electricity into the retail market. Together, these different applications could be a powerful hand for residential storage to be able to play.

Smoothing the disruption

It has often been said that solar poses a disruptive threat to utility business models, much the same way that Tesla hopes its electric cars will displace gas guzzlers from the roads one day. Solar-plus-storage goes even further, with Morgan Stanley and Barclays among others recognising its potential to eat into utility revenues like no other technological advancement before.

Aggregated storage assets could help utilities keep existing transmission and distribution (T&D) networks in the loop, even as we move towards ever-greater levels of distributed generation. Indeed, SolarCity chief technical officer Peter Rive has written in the company's blog that SolarCity has never targeted cutting out the grid entirely. On the contrary, Rive wrote, grid operators and utilities may be in the best position to manage batteries effectively. SunPower CEO Tom Werner has gone one step further, telling *PV Tech Power* in the journal's first volume that "grid independence" is a "naive", unrealistic and fallible scenario.

Utilities in the US are already starting to deploy energy storage, driven not only by California's famous mandate, AB2514, but also to protect grids, prevent the need for infrastructure upgrades and provide capacity lost with the decommissioning of ageing nuclear plants.

Southern California Edison (SCE), one of California's three main utilities, is also one of Tesla's partners on energy storage, trialling the deployment of Powerwalls to existing rooftop solar customers. SCE says it wants to "help create a market" for energy storage, demonstrating the use of customer-sited batteries in providing demand response. Customers who participate in the SCE demonstration may be given rebates on their electricity bills, while the trial's findings may help bring down costs and open new revenue streams. Details of the demonstration have not yet been given, but this is likely to be an extension of the type of 'virtual power plant' being deployed in the commercial space for SCE by Stem

Case study 1

Stem Inc for Southern California Edison

Residential aggregation trials in the US could build on examples from recent work in related fields. The 'virtual power plant' has been an established term for some time in managing demand response, where an aggregator will contract heavy industrial users of electricity to lower consumption to manage supply and demand balances.

Another recent example where cues could be found is with Stem, another company that, like Tesla, is working with Southern California Edison (SCE) on deploying storage. Stem operates in the commercial segment and last November was awarded a whopping 85MW contract by SCE to use customer-sited storage in the Western Los Angeles Basin to act as "dispatchable capacity to enhance the local reliability of the region".

Stem vice president Ben Kearns explains some of the advantages offered by a number aggregated small-scale storage plants.

"[One of] the pros for a large-scale system is that you have a single point of communication to it [but] you have a single point of failure as well. One of the challenges that the utilities have is they're not really used to dealing with power in very large chunks, like 100GW, 200GW, 400GW.

"So their systems are designed to dispatch power in a very large manner. Through aggregation you can make small assets look like large assets but it requires a coordinator in order to do that. That's what distributed energy storage is good for."

Source: Stem.

Stem is installing commercial-scale battery storage units under a contract with Southern California Edison.

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Chris Edgette of CESA says the best practice principles of aggregation would allow utilities to retain a stake in future distributed network models. Edgette says that among the leading lights in this area is New York's Reforming the Energy Vision (REV) programme, currently adapting that state's T&D networks for distributed generation (DG), while determining who can own what and who can get paid for what. The danger is to avoid giving utilities a reason to stifle progress in the interests of the incumbent energy industry or to exploit the unique monopoly position conferred on them as guardians of the network, Edgette says.

"That's the balance in every given region: how to understand what the utilities or system operators should be incentivised to do, what they should be allowed to earn a rate of return on," Edgette says, giving the example of EV charging networks in California, where utilities have asked for the right to rate-base an asset by levying fixed fees to all ratepayers.

"Which sounds great, more EV charging stations," Edgette says, "but it means that any other companies doing EV charging and market participation are competitors to the utility and the utility has the monopoly power…Meanwhile the utility customers are all paying five bucks extra a month for this charging infrastructure that isn't providing them with any value."

Building scale

Aside too, from the pitfalls of equating scale with monopoly power, not everyone is convinced that aggregation is a realistic near-future prospect as a business model for solar storage. Logan Goldie-Scot, energy storage analyst with Bloomberg New Energy Finance (BNEF), believes that while it remains a possibility, it is still early days.

First, he says, while some of the more forward-thinking parts of the US may act out of pragmatic concerns for the reliability of the grid, this is not yet the case in many regions of the world.

"There is less of an incentive to change systems which are currently meeting [required] criteria in providing some reliable balancing. Grid operators often in many markets do not have an incentive to overhaul the existing market structure," Goldie-Scot says.

"Having said that, the early indications suggest that deploying storage or other fast-responding regulation can reduce the amount of regulation required in a market and also lead to fewer emissions. There you start seeing incentives for grid operators to at least look at this."

While grid networks could ultimately benefit, for the time being the onus is on storage providers to prove a compelling case for the storage-led virtual power plant, Goldie-Scot says: "If you can reduce the payback for one of these residential storage systems by adding in additional revenue streams such as the revenue for balancing then that will create a bigger market for residential energy storage systems because they will be more attractive."

It is true also that building scale will be difficult to achieve for some time without the support of network operators and regulators with the jurisdiction and resources to oversee meaningful pilots, with the data these pilot programmes collect essential at this stage. Additionally, as we have seen for some time, technologies to enable so-called 'Smart Homes' and 'Smart Communities' exist, but so far have not been supported by the kind of widespread storage and solar deployment to live up to their promise.

Another analyst, Cosmin Laslau of Lux Research, says aggregation is already a "legitimate business model" but agrees with Goldie-Scot that scale is a pre-requisite.

"Critical mass will be key in making these aggregates large and more useful, so the more sales Tesla and SolarCity can generate for stationary energy storage, the better its chances to make a difference with this business model."

In an article which began with mention of Tesla we have not even touched on what it means for the growth of grid-connected electric vehicles. Adoption of one technology at home may yet spur on the adoption of the other.

Although for now it remains the realm of those that can afford it, the interest of third-party leasing companies from solar, other innovative financing models to get the kit deployed and new business models to open up revenue streams mean we could really start to see the dots begin to join up on a distributed generation-powered future network. With solar, storage and an EV in the garage, the average residence could become a critical component that benefits the individual, the grid and the economy. ■

Case study 2

Moixa Technology for the UK Department of Energy and Climate Change

Stem is focusing for the most part on commercial customers because demand charges applied to their bills make energy storage economically viable already. It is on the shoulders of Tesla and its partners, and other aggregation frontrunners like Moixa and Sonnenbatterie, to prove the case for scaling up its residential counterpart. Meanwhile, third-party management of a distributed resource as seen in demand response could be an interesting way to finance an aggregated storage virtual power plant, especially with companies like SolarCity that are already familiar with leasing models for solar.

Source: Moixa Technology.

A trial to aggregate 250 mainly residential storage systems is underway in the UK.

Among the other trials aggregating customer-sited storage is one by UK company, Moixa, in which 250 systems are being deployed across houses and a few community buildings and businesses. Totalling around 0.5MWh of storage, the company was awarded the contract by the UK Department for Energy and Climate Change. The pilot project, awarded in late 2013 and currently ongoing, will demonstrate residential peak shifting, solar self-consumption and back-up, together with "aggregate storage as service for network and grid benefits", according to the original description of the project.

According to Simon Daniel, Moixa's CEO, the government department has "seen the international examples, but they need some examples of what could work in the UK in order to create evidence for policy". Part of the reason for needing a UK-specific example is again in market design. The UK's electricity infrastructure is overseen by a number of distribution network operators, which manage networks separately from utilities, which are primarily responsible for electricity sales.

The project was awarded in late 2013 and is currently in a "data phase", Daniel says. The trial tests the capabilities of connected storage to mitigate solar and wind and other network constraints. Ultimately, Daniel says, Moixa aims to prove that "if you aggregate lots of storage it can make available that storage to other participants in the system for when the location doesn't need it, or for when the other locations have greater economic value from that asset".