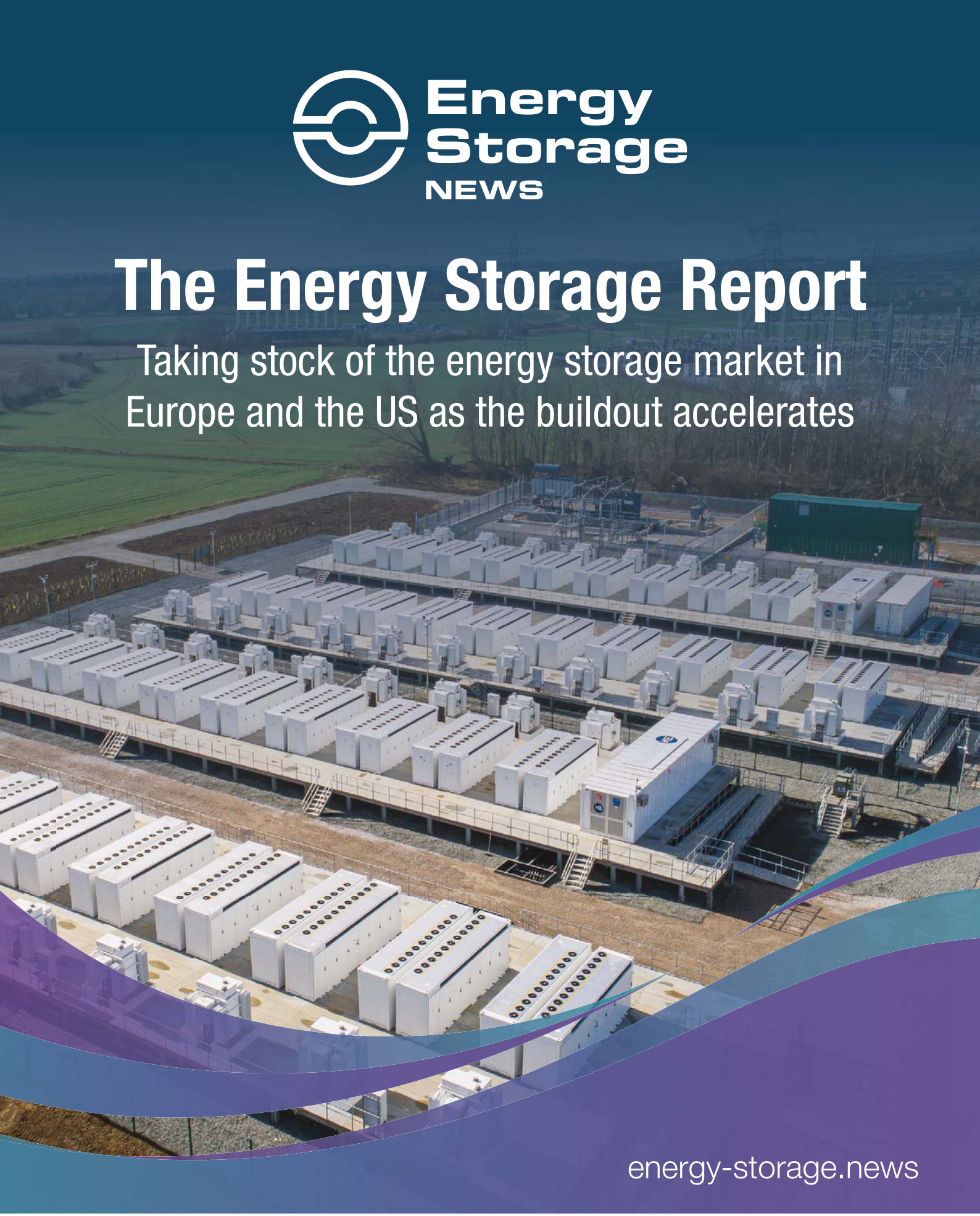
Energy Storage NEWS

The Energy Storage Report

Taking stock of the energy storage market in Europe and the US as the buildout accelerates



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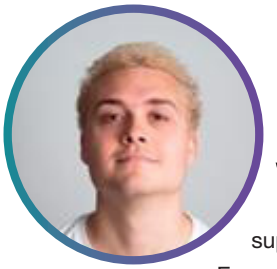
Introduction



Welcome to the first edition of *The Energy Storage Report*, the supplemental publication for Solar Media's Energy Storage Summit EU and USA events.

In it, you'll find the best of our energy storage coverage from *Energy-Storage.news* Premium and *PV Tech Power* over the past few months, as well as new articles produced for this publication, including an overview of where we are up to with battery storage deployments in the UK and continental Europe.

Energy storage continues to go from strength to strength as a sector, with the UK and California/Texas continuing to lead on either side of the Atlantic but neighbouring markets close behind.

The booming UK grid-scale market shows no sign of slowing down as you can see in an overview on page 8, using the latest UK figures from Solar Media's Market Research team.

For the next year or two, Italy is a particular one to watch in Europe. See how grid-scale deployments there will soar in 2024 in a feature on pages 10 and 11 looking at continental Europe's seven key markets, drawing on data from LCP Delta.

For UK-focused readers, see interviews and analysis on the implications of falling BESS revenues (page 12), the governments' long-duration energy storage (LDES) consultation (page 16), grid interconnection and new market mechanisms (page 18) and BESS' role in a major frequency event (page 21).

The German grid-scale market also continues to rebound after a quiet few years - read our coverage of the release of its Energy Storage Strategy on page 20.

More interested in engineering? From pages 33 to 41 you can read technical articles from Wärtsilä, Burns & McDonnell and Italian engineering firm Benny Energia on augmentation, energy density and a 200MW/800MWh BESS project they designed, respectively.

For our US audience, see deep-dives into the recent project "M&A mania" (page 27), virtual power plants (page 43), local planning for storage projects (page 14), long-term project upgrades and retrofits (page 42) and a lawyer's digest on everything you need to know about the Inflation Reduction Act and tax equity (page 23).

And finally on the upstream side, we hear from BloombergNEF on its recently-launched Tier 1 BESS provider list and talk to Freyr's CEO about how Europe's nascent lithium-ion gigafactory ecosystem is at risk from competition elsewhere.

So, from myself, *Energy-Storage.news* editor Andy Colthorpe and the whole team at Solar Media, thank you for reading our content, supporting our events and most of all for being part of this exciting, game-changing industry.

Cameron Murray, senior reporter

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Saving Millions By Self-Procurement

By: Daniel Crotzer, Fractal EMS Inc.

In the beginning, traditional integrators played an important role in the supply, installation and operations of battery systems. The supply chain was confusing and fragmented. Traditional integrators provided a one-stop-shop with proprietary equipment, software and services. Over time the supply chain for equipment became easier to navigate. Similar to solar, the role of a traditional integrator has diminished because savvy buyers now purchase equipment direct from the OEMs (self-procurement). Along with the emergence of third-party Energy Management System (EMS) companies, a massive shift towards self-procurement has unfolded.

Reasons for Self-Procurement

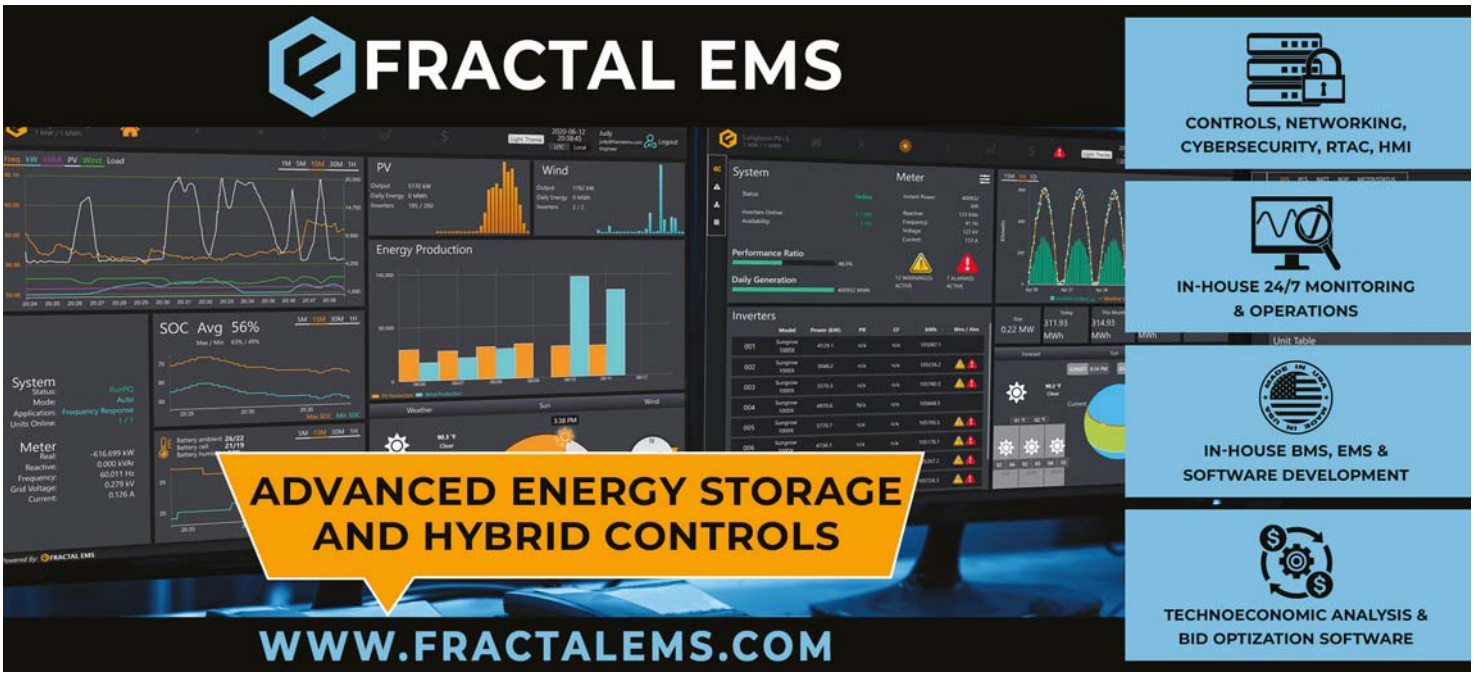
1. Cost: Traditional integrators add a sizeable margin to the equipment and EPC cost. On a 100 MW / 400 MWh project, integrators add 15% margin (up to 25% margin on smaller projects).
2. Supply Chain and Price Fluctuations: Buyers should have the ability to purchase cost-competitive equipment on a project-by-project basis as pricing and supply fluctuate.
3. Visibility into Risk Exposure: Traditional integrators just pass through the OEM warranties and guarantees. Once LD caps are hit, many integrators reduce support or walk away altogether.
4. Availability: Buyers have become aware that most downtime is caused by inverters and battery thermal management. Instead of purchasing expensive performance guarantees (based on total equipment cost), it is more cost efficient to mitigate this risk by oversizing or purchasing spare parts.
5. Future Flexibility: Integrators that install proprietary equipment and controls can hinder (or even prohibit) the ability to retrofit the EMS. Buyers prefer equipment that can be repurposed and retrofitted in case the original EMS underperforms or becomes insolvent.

Challenges of Self-Procurement

1. Multiple Negotiations and Agreements: Buyers need to separately procure, negotiate and contract the equipment, EPC, EMS and operations. This requires staffing and experience.

How Fractal EMS Enables Self-Procurement

1. Competitive Procurement and Contract Support: Fractal consultants can assist Buyers with sizing the equipment, technoeconomic analysis and procurement via RFPs.
2. Universal Controls: There is an ever-growing list of new batteries vendors, Fractal EMS can provide universal controls, reporting and HMI to monitor and operate a fleet of different equipment.
3. Equipment Deficiencies: Some battery OEMs may have excellent pricing, but they may have deficiencies in protections, BMS capabilities (SOC accuracy, p-limiting, etc.), balancing algorithms, and cybersecurity (easy to hack). Fractal provides industry leading controls that compensate for these deficiencies.
4. Warranty Protection: Each OEM has stringent requirements for data to facilitate warranty claims. Fractal EMS provides databases, dashboards, KPIs and alerts to track warranty and off-taker requirements.
5. Technology Expertise: Fractal EMS has deep experience from integrating over ten batteries OEMs and over ten inverter OEMs.
6. Cybersecurity: Fractal EMS implements best practices from NERC/CIP, NIST 800 and ISO 27001.
7. Ongoing Technical Support: Fractal's 24x7 Remote Operations Center is just a phone call away for inquiries, issues, or trouble-shooting of all BESS equipment (inverters, batteries, thermal management, etc.).
8. Features and Customization: Fractal can fulfill owners' requests for custom features, dashboards and KPIs that may not be available through a traditional integrator's HMI.
9. Future Augmentations: Fractal EMS is built to facilitate augmentations (AC or DC) by integrating new equipment with the existing equipment.



California solar-plus-storage project with world's largest BESS fully online

The Edwards & Sanborn solar-plus-storage project in California is now fully online, with 875MWdc of solar PV and 3,287MWh of battery energy storage system (BESS) capacity, the world's largest.

The 4,600-acre project in Kern County is made up of 1.9 million PV modules from First Solar and BESS units from LG Chem, Samsung and BYD totaling 3,287MWh of energy storage capacity.

That makes it bigger than the current largest BESS in the world, Vistra's 750MW/3,000MWh facility at Moss Landing, also in California, which also came online in two phases.

Engineering, procurement and construction (EPC) contractor Mortenson started construction around three years ago and the first phase, comprising about half of the total capacity, came online in late 2021.

The project has an interconnection capacity of 1,300MW. Its offtakers include the city of San Jose, utilities Southern California Edison (SCE) and Pacific Gas & Electric (PG&E), community choice aggregator (CCA) Clean Power Alliance, and coffee chain shop Starbucks.

Credit: Mortenson/Terra-Gen

The Edwards Sanborn solar-plus-storage project in California

LFP cell average falls below US$100/kWh as battery pack prices drop to record low in 2023

After a difficult couple of years which saw the trend of falling lithium battery prices temporarily reverse, a 14% drop in lithium-ion (Li-ion) battery pack cost from 2022-2023 has been recorded by BloombergNEF.

On average, pack prices fell 14% from 2022 levels to a record low of US$139/kWh this year. This reduction was driven by the dynamics of falling raw material and component prices, and increases in production capacity.

However, despite the good news, BloombergNEF (BNEF) no longer expects to find average pack prices fall below US$100/kWh by 2024 (as it predicted in 2020), nor by 2026 (as it predicted last year). It will however be likely to happen before the end of this decade, with BNEF forecasting that the average pack will cost about US$113/kWh in 2025, and decline in cost sharply to around US$80/kWh by 2030.

EU approves Italy's €17.7 billion state aid for large-scale energy storage rollout

The European Union (EU) Commission has approved a state aid scheme aiming to fund the rollout of over 9GW/71GWh of energy storage in Italy.

The scheme totalling €17.7 billion (US$19.5 billion) will provide annual payments covering investment and operating costs for those developing, building and operating large-scale energy storage in Italy. It will be alloted via a competitive bidding process where developers with the lowest offer win out.

Transmission system operator (TSO) Terna estimates Italy will need 9GW/71GWh of new energy storage to integrate its growing renewables pipeline, an average duration of just under eight hours.

Terna and its regulators have been busy updating the electricity market in Italy to facilitate the rollout of energy storage and developers and operators have been announcing gigawatt-scale pipelines of projects throughout 2023.

CATL battery storage unit disconnected at Marine Corps installation amid 'concerns' about project

Battery storage equipment manufactured by CATL and recently installed at a US Marine Corps facility has been disconnected after the raising of security concerns about the China-headquartered maker.

Reuters reported on 7 December that BESS equipment at a solar-powered microgrid on Camp Lejeune Marine Corps Base (MCB) had been switched off by Duke Energy, the energy company tasked with building the project.

Duke Energy confirmed the accuracy of the report in a statement given to *Energy-Storage.news* by company director of communications and public affairs Kaitlin Kirshner, who said Duke Energy did not believe the equipment itself posed a threat but that the system has been switched off until the matter is resolved.

According to Reuters, the decision was made following high-profile accusations by US lawmakers that CATL – the world's largest manufacturer and supplier of lithium-ion batteries – is directly funded and enjoys support from the Chinese Communist Party.

CATL, for its part, strongly refuted the allegations, publishing a statement in early December 2023. It described the accusations that its batteries posed security threats as "false and misleading".

Northvolt and Altris develop 'breakthrough' 160 Wh/kg sodium-ion battery for energy storage

Gigafactory company Northvolt and sodium-ion battery technology firm Altris have together revealed a battery with an energy density of 160 Wh/kg, designed for energy storage systems.

The firms revealed the battery's energy density following a research partnership and Northvolt's investment in Altris in May 2022.

Sodium-ion battery technology is widely seen to be the most commercially mature electrochemical-based alternative to lithium-ion. For comparison, lithium-ion technology generally has a Wh/kg energy density of between 120 and 260, according to the International Energy Agency (IEA) in its Global EV Outlook 2023.

The firms said the battery they have developed together will provide the foundation for Northvolt's next-generation energy storage solutions.

Gotion's first 'Made in USA' ESS battery packs roll off Silicon Valley production line

China-headquartered lithium-ion battery maker Gotion High-Tech has produced the first battery pack at its new factory in California's Silicon Valley.

The company said that the first pack came off the production line at its plant in Fremont – which is also home to Tesla's main US automobile production plant and HQ – on 21 December.

The factory is dedicated to products for the portable and residential energy storage system (ESS) markets ranging from 3kWh to 30kWh. It has a planned 1GWh annual production capacity, although the company did not mention in an announcement when it aims to ramp to this figure.

Calpine Corporation closes US$1 billion financing for 680MW California BESS

Gas and geothermal plant developer and operator Calpine Corporation has closed a syndicated financing for what could be one of the largest BESS projects in the US.

The credit facilities totalling over US$1 billion will finance the development and construction of a 680MW BESS project in Menifee, Riverside County, California, law firm and advisor to Calpine on the financing White & Case said in early January 2024.

It will be built in five phases with construction already underway, Calpine announced in December 2023 calling the project the 680MW 'Nova BESS'. When completed it will be one of the largest BESS in the US.

The plan is to interconnect the project with the grid at a substation owned by Southern California Edison (SCE). It will utilise battery storage technology (either lithium-ion, flow batteries or other technology) to store energy from the grid to be discharged when customer demand is high.

Giga Storage to start building 2,400MWh BESS in Belgium in 2024

Netherlands-based BESS developer Giga Storage has unveiled a 600MW/2,400MWh project it is developing in neighbouring Belgium, one of the largest planned projects in Europe.

Called 'Green Turtle', it would be located in Dilsen-Stokkem adjacent to a new 380kV high-voltage substation run by transmission system operator (TSO) Elia. The location is along a high-voltage line from Van Eyck to Gramme while also being connected to the grid of the Netherlands.

In the announcement, Joeri Siborgs, general manager GIGA Storage Belgium, said: "This project is being developed on an industrial site where there was a previous initiative to develop a battery. The permit application has been submitted, and we expect to commence construction in 2024. GIGA Storage aims to achieve the realisation of 3GW of battery storage in Belgium by 2030."

Credit: Giga Storage

A render of the Giga Storage's 'Green Turtle' project being developed in Dilsen-Stokkem, Belgium

Spain awards contracts to 1.9GWh energy storage in first PERTE tender

The government of Spain, through the Institution for the diversification and energy savings (IDAE) has awarded 880MW/1,809MWh in its first tender for energy storage to be co-located with renewables.

Among the companies awarded from the Spanish strategic projects for the economic recovery and transition (PERTE in Spanish) programme are utilities Iberdrola, Naturgy, Enel Green Power but also renewables developer Fotowatio Renewable Ventures (FRV) among others.

Results were published in mid-November with in total 34 projects awarded capacity in the auction across the entire territory.

Grants will cover 40-65% of the project cost depending on the size of the company applying, while nearly €160 million ended up being allocated to the awarded projects. All the projects but one are targeted to be completed in 2025.

Startup Form Energy's '100-hour' iron-air battery tech attracts another US utility's attention

Another utility agreement has been signed by Form Energy, the US startup which claims its iron-air battery can provide sufficient stored energy to ride through multiple days of low solar or wind production.

Puget Sound Energy, an electric and gas utility serving 1.2 million electric customers in the Washington State region of the same name, said on Friday (5 December) that it has signed a memorandum of understanding (MoU) around Form Energy's technology.

With Puget Sound Energy considering deploying a pilot project in its service area, the pair's new partnership could see them jointly develop one, which would be a 10MW system with 1,000MWh capacity – equivalent to 100-hour duration.

The key ingredients of Form Energy's proprietary battery tech are iron and air. Basically, iron inside the battery is rusted (oxidised) as the system charges with electricity, and then de-oxidised as the battery discharges. ■

Utility-scale energy storage systems in the UK remain on strong growth trajectory

Mollie McCorkindale tracks the latest trends in the pipeline and deployment of energy storage in the UK tracked in the 'UK Battery Storage Project Report'

The UK energy storage market is now on a promising upward growth trajectory, with the total operational capacity expected to reach 7.3GW/11.6GWh by the end of 2024, potentially increasing further to 14GW/25.9GWh by 2026-2027. The built capacity is consistently growing year on year, following a substantial rise in submitted and approved planning applications.

Energy storage deployment rates

In 2023, the UK added a record-breaking 1.3GW/1.9GWh of utility battery storage. This brought the total operational capacity to 4GW/4.9GWh. As widely expected for some time now, the built capacity is increasing every year. Furthermore, the operational megawatt-hour capacity is outpacing megawatt capacity due to the increasing duration of battery storage systems.

Figure 1 displays the amount of built capacity in megawatts and megawatt-hours for each year, going back to 2014.

In 2023, a total of 33 utility-scale energy storage projects were brought online. Two of them were 100MW each and had a duration of one hour, while 16 were 50MW each. Among these projects, seven had a duration of one hour, while the remaining nine had a duration of two hours. Interestingly, over 50% of these 33 projects had a duration of more than one hour, a significant increase compared to the previous two years (2021 and 2022), when only 20% of the projects had a duration of more than one hour.

Credit: Pacific Green / National Grid.

Sosteneo Infrastructure Partners' 100MW/100MWh Richborough BESS project in Kent, which came online in December 2023

The majority of projects in the development pipeline are being planned to have at least two hours duration, as this now appears to offer better value for operators.

The significant rise of the energy storage pipeline

Over the course of one year, the total pipeline for battery storage in the UK has more than doubled. A year ago, the pipeline was at 61.5GW, but has since grown to 125GW. This figure is expected to continue increasing due to the ongoing planning of transmission projects for 2030 completion (and beyond).

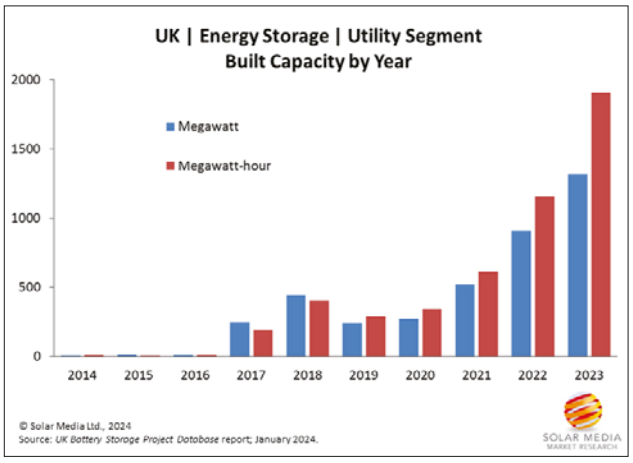


Figure 1. In 2023, the amount of energy storage capacity added to the grid in the UK reached a record-breaking level of 1.3GW/1.9GWh

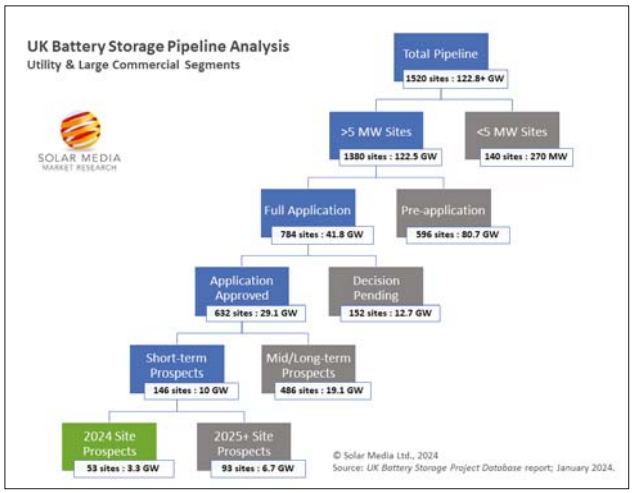


Figure 2. There is currently 3.3GW/6.7GWh across 53 sites slated for completion in 2024

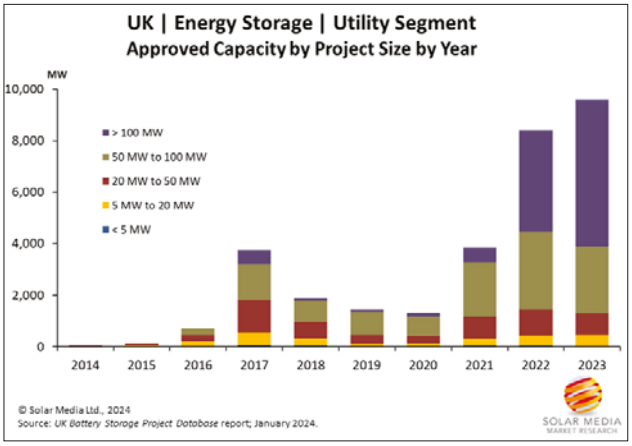


Figure 3. A record-breaking 9.6GW of capacity was approved in planning in 2023

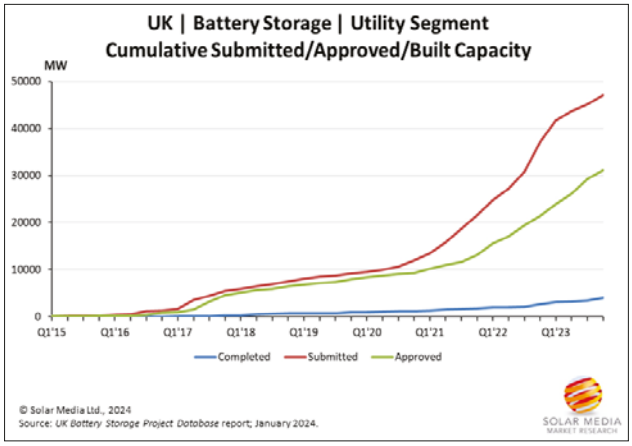


Figure 4. Built capacity is likely to rise substantially in the near future

Figure 2 is a visual representation of the project pipeline analysis with a focus on projects scheduled for completion in 2024.

With reference to Figure 2: initially, we filtered out small sites with a capacity of less than 5MW. Then, we removed any projects that have not yet submitted a full application. After this, we only considered the projects that have obtained planning approval, and among those, we filtered out the ones that have not yet been awarded a capacity agreement; this gives all the Short-Term Prospects.

The Short-term Prospects are any projects that have an application approved and have also been awarded a capacity agreement. The 2024 site prospects are already under construction and are expected to be completed during this year.

By the end of 2024, the operational capacity of energy storage is likely to increase by 3.3GW/6.7GWh, bringing the total capacity to 7.3GW/11.6GWh. By 2026/2027, this figure has the potential to reach up to 14GW/25.9GWh. This includes 11 projects of size 100MW and larger – including one as big as 500MW – with a duration of at least two hours.

How much capacity was approved in planning last year?

Last year (2023), a remarkable 9.6GW capacity was granted approval in planning, out of which more than 50% was from projects exceeding 100MW in size. It is worth noting that such projects of this magnitude have only recently been initiated. Only since 2022 have projects of this size really started to come into play.

Figure 3 shows the approved capacity of battery storage, by project size and by year.

The first surge in 2017 was due to a significant increase in the number of applications submitted for battery storage that year. The success of some projects in the Enhanced Frequency Response (EFR) auction in 2016 motivated many developers to submit more applications. However, after this surge, the rate of submitted capacity slowed down, resulting in a similar trend in the yearly approved capacity.

The submitted capacity started to increase again in 2021 and, therefore, so did the approved capacity; partly due to the increase in the 50MW planning threshold, and because developers gained more experience in the services available, leading to more attractive revenue streams.

In 2022, the total capacity of newly submitted projects reached a record high of 23GW. These projects were approved in 2022 and 2023, with most of the capacity given the green light in 2023. This is because there are more large-scale projects and these generally have a longer planning process.

The total amount of capacity that has now been approved in planning, since the market began, is at 32.9GW across 957 sites.

The pattern of submitted, approved and built capacities

Looking at the rise of submitted, approved and built capacities, there is a clear (linear) relationship between submitted and approved capacity. This is evident from the data presented in Figure 4.

Although the build-out of these projects started slowly, there is still some linearity between the approved and built capacity, but it is not immediately obvious. However, in the previous graphs in this article, there is a similar pattern between the two. Therefore, the built capacity is likely to soar in the very near future.

In conclusion, everything points to a rapid increase in the operational capacity of energy storage in the UK going forward. This is evident from the year-on-year increase in built capacities, the upcoming short-term prospect sites that are expected to be completed in the next few years, the increasing amount of capacity approved in planning, and the linear relationship between submitted, approved and built capacities. ■

All data and analysis shown in this article comes from our in-house market research at Solar Media Ltd. Full details on how to subscribe to our 'UK Battery Storage Project Database Report' can be found at bit.ly/ukstorage

Grid-scale energy storage set to soar in Europe in the coming years

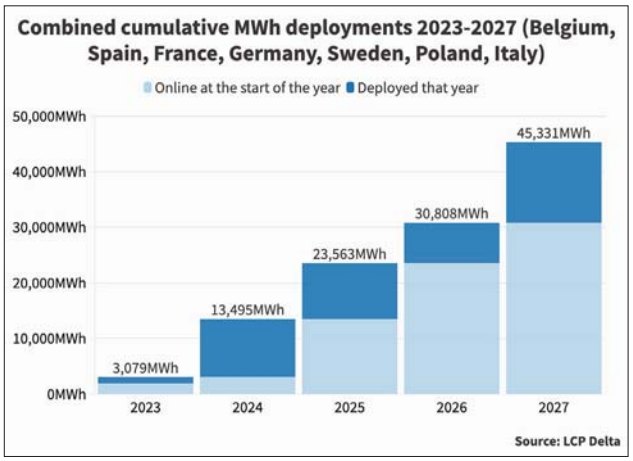
Although still some way behind the UK, several other European storage markets are starting to show serious growth. Cameron Murray reports on continental Europe's leaders, drawing on figures supplied by consultancy LCP Delta

While the UK has been the early mover in deploying short-duration energy storage resources, other major economies in Europe are also set to ramp up their deployments over the coming few years.

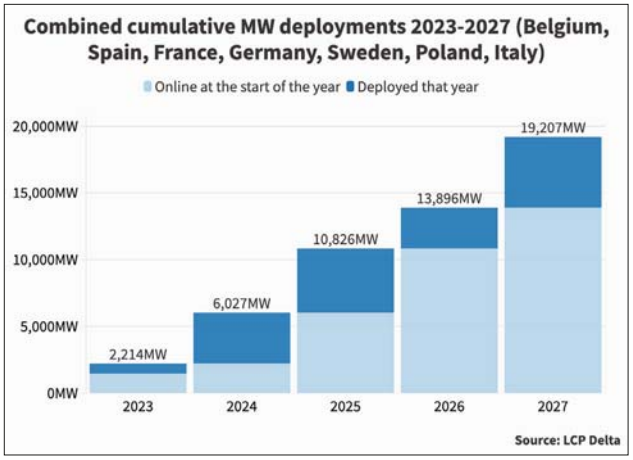
France, Italy, Spain, Sweden, Germany, Belgium and Poland together had 2.2GW/3.1GWh of BESS online by the end of 2023, according to data from LCP Delta, with 750MW/1.15GWh of that coming online over the past year.

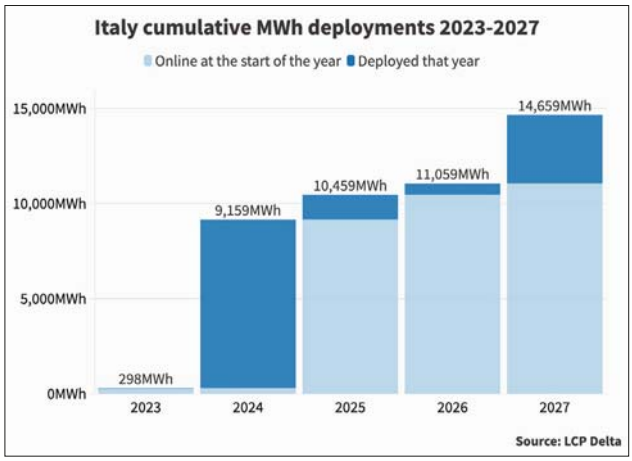
Both of those figures are a little over half of the UK data cited in the previous article, but deployments on the continent in both megawatts and megawatt-hours will be outpacing those in the UK from 2024 onwards.

This is largely being driven by increased renewable energy deployment targets in line with RePowerEU, the move by the EU to end reliance on Russian fossil fuels by increasing domestic renewable production. The aims have been codified by member states' revised national energy and climate plans (NECPs), released over the last 1-2 years.



Note: all data refers to the grid-scale segment





Italy

As readers of *Energy-Storage.news* will know, Italy is set to become one of the busiest grid-scale BESS markets in the coming years.

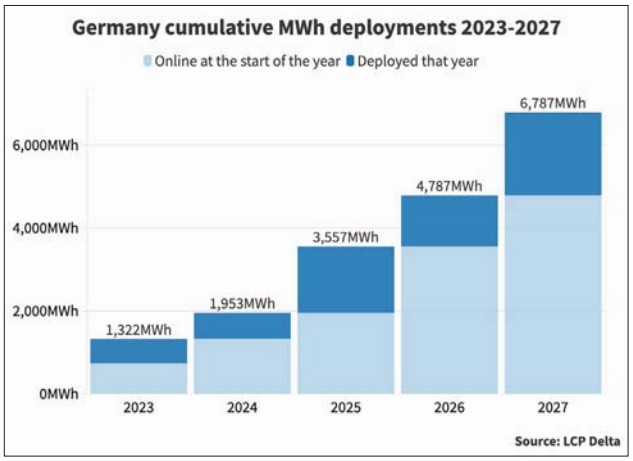
Following growth in its renewable energy goals and deployment pipeline, transmission system operator (TSO) Terna has spent the last few years consulting with the industry on how to facilitate energy storage on its grid, projecting that 9GW/71GWh needs to come online by 2030.

The business case for storage will be built around the capacity market and energy arbitrage, including through a new dedicated platform launched by Terna where storage owners will be able to sell 'time-shifting' of energy to renewable energy owners, plus ancillary services. Projects will generally be four hours-plus.

All this will be supported by a €17.7 billion (US$19.1 billion) EU-backed grant support scheme to cover part of the investment and operating costs for grid-scale storage, approved by the EU Commission in December 2023.

A whopping 2.6GW/8.9GWh is set to come online in 2024 with an average duration of around 3.4 hours, LCP Delta said. A big chunk of that is around 1GW that utility and independent power producer (IPP) Enel is building, much of which it won long-term capacity market contracts for in 2022.

Deployments will continue at a slower pace thereafter, and by the end of 2027, 4.8GW/14.7GWh should be online.



Germany

Germany was at one time the leading market for grid-scale BESS in Europe, even ahead of the UK, before the ancillary service markets which supported that growth were saturated in 2018.

Starting in 2021 and 2022, ancillary service and energy trading opportunities have come back, and BESS deployments have subsequently picked up. 'Innovation Tender' grants for co-located projects have also given a boost to the market.

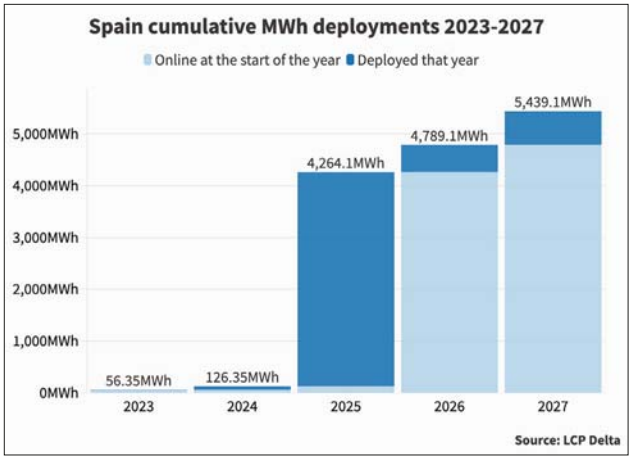
The government released its Electricity Storage Strategy in December 2023, aimed at supporting the scale-up and integration of energy storage on its grid, putting the technology on the political agenda for the first time.

By the end of 2023, there was 937MW/1,322MWh online in Germany and another 485MW/681MWh is set to come online this year.

Spain

The Spanish market has been a challenging one, with anecdotal evidence of 'over-development' of solar PV projects and other challenges perhaps explaining why just 5MW/10MWh came online last year.

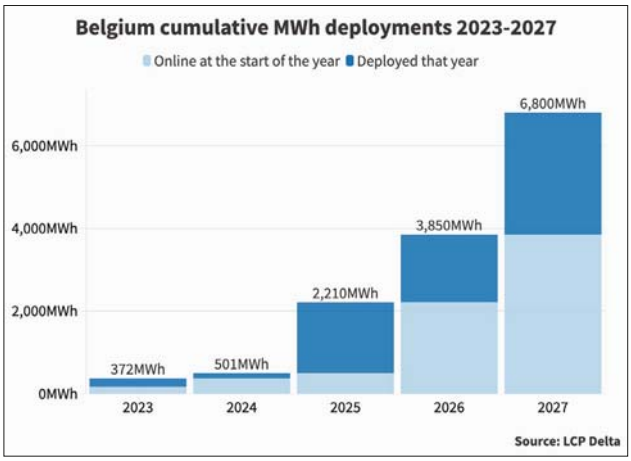
Deployments are set to pick up, however, with a new energy storage deployment target of 22GW by 2030 as part of its revised NECP (which also includes 76GW of PV by that year).



The business case will primarily be around shifting solar PV generation into the evening hours, and a recent grant scheme from the government through its Spanish strategic projects for the economic recovery and transition programme (PERTE in Spanish) will help kickstart the market.

Some 880MW/1,809MWh of energy storage projects were granted contracts in the PERTE tender in December 2023. The bulk will come online in 2025, reflected in LCP's data, which shows 1.7GW/4.1GWh coming online that year.

Belgium



Although Belgium has less BESS online today than larger neighbours France and Germany, it is notable for having already seen some large-scale, multi-hour-duration deployments.

Two 25MW/100MWh projects were deployed in the last few years (by Nippon Koei Energy Europe and Nala Renewables respectively) and January saw Dutch developer Giga Storage claim it would start construction on a 600MW/2,400MWh project there, one of the biggest in Europe, in 2024.

A big driver of the multiple hours' duration and scale of these projects is the country's capacity market, through the Capacity Remuneration Mechanism (CRM), which can be stacked with ancillary service opportunities to create a strong business case.

Poland, Sweden and France

Poland is another market due to soar from a negligible starting base today, with capacity market contracts again playing a huge part. Deployments are really set to kick off in 2026 and 2027, with 600MW/2,282MWh and 1,300MW/4,550MWh coming online respectively, with 2027 the start of obligations for the first capacity markets that awarded BESS contracts (in late 2022).

The 2024-27 trajectory for Sweden and France would more aptly be described as 'slow and steady', with 300-400MW coming online each year with durations between one and two hours, with business cases built around a mix of energy arbitrage, capacity and ancillary services.

UK BESS project premiums, valuations down as revenue expectations drop

Rising financing costs and falling revenues have prompted a drop in company valuations and developer premiums in the UK battery storage market, reports Cameron Murray

Company valuations and developer premiums for project sales have come down in the UK battery storage market amidst rising financing costs and plummeting revenues.

Project premiums have fallen 15% in the last few months, a source told *Energy-Storage.news*, while the share prices of the three big listed energy storage funds have fallen 40-50% since the start of the year.

Falling revenue expectations and higher financing costs

The UK market for short-duration battery energy storage system (BESS) projects has boomed in recent years to become the largest in Europe with over 3.5GW now online, with projects benefiting from high ancillary service market prices, particularly in 2022.

Saturation of those markets was always expected for 2023 but revenues may have fallen more sharply than expected as the wholesale energy trading opportunities, such as in the balancing mechanism (BM), haven't materialised to make up the difference.

This has led to a fall in both the valuations of those companies developing and operating projects, and the prices that purchasers are willing to pay for early-stage or ready-to-build (RTB) projects.

"Development premiums have come down 15% in the last few months as revenue expectations have fallen," a BESS finance source told *Energy-Storage.news*, speaking anonymously.

This is also partially to do with the rising cost of capital. The effect of rising interest rates is felt in the debt space instantly, but with debt typically 20-40% of BESS financing at most the effect on the cost of equity, which takes longer to be felt, is more significant.

Both of these factors have been partially offset by falls in the cost of BESS equipment seen this year as the supply-demand imbalance closed after 2022's supply chain shock, which saw BESS costs rise by 25% and led to the untimely fall of some firms in the engineering, procurement and construction (EPC) sector.

"Because the cost of raising these investment funds has gone up, people will want to make more return on their equity. So, if I was happy to invest in this and get 9% return before, now I want an 11% return. So the price they will be willing to pay is going to drop," a separate source said.

In the Spring, ready-to-build (RTB) projects were still selling for north of £100,000/MW (US$121,000) in the UK market but that has now come down.

A separate way to take the temperature of the market is to look at the share prices of the listed vehicles investing in and operating energy storage projects, of which there are three main ones in the UK: Gresham House Energy Storage Fund (listed under the ticker GRID), Gore Street Energy Storage Fund (GSF) and Harmony Energy Income Trust (HEIT).

Credit: Harmony Energy

Harmony Energy's 99MW Bumpers BESS in Buckinghamshire, UK, which came online in October 2023

Since the start of the year to the time of writing, HEIT is down 40% to 75p, GSF is also down 40% to 68.06p while GRID is down nearly 50% to 88p. The FTSE 100 meanwhile is up 1-2% in the same period.

All three are diversifying internationally to mitigate against an increasingly saturated UK market, with GSF buying projects in the US and Germany, HEIT's manager Harmony Energy targeting various European markets and GRID acquiring in California.

In a recent LinkedIn post, Gore Street Capital wrote: "As the #GreatBritain (GB) market suffers from market saturation and the lack of wholesale #trading as a material revenue in place of ancillary services, our diversification strategy continues to deliver for shareholders."

"Our international fleet under management now accounts for over 62% of the Company's operational capacity and drove estimated weighted average revenue of £18.9/MW/hr during the September-end quarter. This is against the £6.6/MW/hr estimated average accrued by the GB portfolio."

Perhaps not coincidentally, this period of falling revenues, falling revenue expectations and falling valuations has coincided with a flurry of acquisitions of both listed and privately held BESS developer-operators in the UK by global asset managers.

Global infrastructure investor Brookfield bought Banks Renewables last week, private equity firm KKR acquired Zenobe in September while asset manager Searchlight acquired Gresham House, the manager of GRID and other clean energy vehicles, in July 2023. *Energy-Storage.news* has been told that more deals are coming. ■

Advancing Resilience: The Shift Toward Prolonged Energy Storage in Texas

By: Rahul Verma, Fractal Energy Storage Consultants

The Energy Reliability Council of Texas (ERCOT) is a formidable player in the energy storage arena, boasting a capacity of around 4,000 MW - one of the highest in the U.S. Historically, ERCOT has leveraged this capacity to provide critical ancillary services like Frequency Regulation and Responsive Reserve Services (RRS), while also capitalizing on the differential between off-peak and peak pricing periods.

A Shift in Market Dynamics

Despite ERCOT's significant power capacity, its energy storage duration falls short compared to other regions. A whopping 77% of its operational capacity can only sustain up to 2 hours of continuous power, contrasting sharply with areas like California and New York, where energy storage systems typically offer a minimum of 4 hours of capacity.

Most of the currently planned capacity in ERCOT will also sustain less than 2 hours of output at their maximum output capacity. Project developers planning for less than 2 hours of storage capacity can future proof their assets by designing projects capable of expanding storage capacity in the future.

Shorter Duration Batteries To Date

Three core factors shape Texas's inclination toward shorter-duration energy storage:

1. Absence of a Capacity Market: ERCOT doesn't operate a capacity market, which in other markets often necessitates longer-duration storage.
2. Dynamic Ancillary Services Market: The lucrative quick-response services and the efficient management of charge states during downtimes favor shorter-duration solutions.
3. Complementary Renewable Profiles: The robust wind energy infrastructure in ERCOT effectively balances the load after the decline in solar production, mitigating the need for prolonged peak-time energy supply.

Transitioning to Longer Duration

Market forces are increasingly favoring storage solutions with minimum 2-hour capacities, driven by regulatory initiatives for greater resilience and the diminishing returns of short-duration ancillary services due to market saturation.

Significant Market Rule Changes

NPRR 1096 mandates sustained two-hour and four-hour capabilities for ERCOT Contingency Reserve Service (ECRS) and Non-Spin, respectively, influencing procurement strategies and revealing a trend toward more lucrative revenue models compared to RRS. Prescribed rules for the newly added Dispatchable Reliability Reserve Service (DDRS) similiarly requires that an asset can operate at its High Sustained Limit (HSL) for at least four consecutive hours.

Shifting Focus to Energy Arbitrage

As the ancillary service markets approach saturation, the focus is pivoting to energy arbitrage. If the future holds many more seasons like the 2023 summer, energy storage resources can provide immense value by arbitraging between frequent peaks and troughs in the energy markets.

The Influence of Decreasing Storage Costs

The dominance of 1 to 1.5-hour duration storage was largely because the benefits of longer duration storage did not exceed its cost in the past. However, as markets outside Texas have highly skewed the demand for 2-hr and 4-hr batteries, the suppliers of 2-hr and 4-hr batteries have achieved better economies of scale. These suppliers can offer lower cost per hour of energy storage capacity as compared to battery suppliers that offer shorter duration battery chemistries. The difference in per hour cost of storage capacity leads to a disproportional increase in revenue as compared to the increase in cost.

Conclusion

The transformation of ERCOT's energy market is a complex interplay of supply, demand, regulatory influences, and market dynamics. The anticipated shift in energy storage within ERCOT points to a blend of responsive and long-term energy solutions, underpinned by a strategic pivot to energy arbitrage and prolonged storage capacities. This evolution is set to redefine Texas's energy landscape, paving the way for a new chapter in sustainable energy solutions.

Making local planners comfortable with energy storage in their communities

Andy Colthorpe speaks with Pacific Northwest National Laboratory analyst Jeremy Twitchell, one of the authors of a report on how communities can evaluate energy storage project proposals

The enormous and rapid growth of the US energy storage market is there for all to see, but what the industry is quickly realising is that storage adoption is not always going so smoothly at the local level.

Storage deployments have multiplied seven times over since 2020, with recent figures from S&P finding the US closing in on 15GW of utility-scale battery energy storage system (BESS) projects and rival research firm Wood Mackenzie forecasting 55GW of new grid-scale storage deployments from this year through 2027.

Yet there are many cases of battery storage projects failing to find support from the authorities having jurisdiction (AHJ) – public bodies such as fire departments and town planners – that ultimately have the final say on behalf of their communities if a project goes ahead.

Some towns have enacted moratoria on the development of new storage facilities, most prominently in New York. That is perhaps understandable to an extent, given that the state has seen several high-profile fire incidents this year, though thankfully no injuries have been reported and property damage (including to the BESS themselves) limited.

Concerns over fire safety and explosion risk appear to be the most commonly cited concern. While it is perhaps tempting for the industry to try and swat away those concerns with statistics around the rareness of large-scale battery fires and explanations of the safeguards in place to prevent escalation of incidents, the messages filtering down to the public are affecting real projects and ultimately slowing the adoption of renewable energy.

"We have tried to provide an objective and factual reference for local planners and zoners for local communities, and hopefully, they will find it useful as they navigate these challenging processes," says Jeremy Twitchell, PNNL energy research analyst.

It is not fair, PNNL's report concluded, that local authorities and planners are increasingly having to put themselves in the position of being energy experts as well as handling their already complex workloads.

Together with PNNL colleagues Devyn Powell, an energy policy research analyst, and Matthew Paiss, a technical advisor on battery materials and systems who is well known in energy storage circles as a former firefighter turned subject matter expert, Twitchell authored 'Energy storage in local zoning ordinances'. Prepared for the Department of Energy (DOE) and funded by the department's Office of Electricity, it aims to provide technical assistance to states, including state utility commissions and energy offices as they wrestle with new questions and demands around battery storage.

Credit: Andrea Starr/Pacific Northwest National Laboratory

PNNL fire safety expert Matt Paiss explains operations and safety aspects of large-scale Li-ion battery storage facilities

"A couple of years ago, we were doing some work with several states, and kind of all at once, several states started to point out that this was an issue that they were encountering: that there were energy storage projects that developers wanted to build but were running into significant challenges at the local level, at the state level in the siting and permitting process," Twitchell says.

Quickly recognising it as a growing issue, PNNL found that while on a big picture level, storage is gaining traction, with gigawatts of storage in utility planning processes and interconnection queues, the local zoning and planning officials that ultimately make the decisions sometimes don't have enough information to act.

"They live in a complex world of planning and zoning and ordinances and conditions and legal requirements, and now a storage project comes along, and we're asking that they'll be energy experts as well. That's not really fair."

Filling information gaps for communities

The report seeks to fill information gaps for the likes of local, municipal and county-level planners who might suddenly find

themselves looking over proposals for a 200MW BESS plant that might, for example, be planned next to a commercial or residential district.

Due to the perhaps unique modular nature of battery storage, there's a lot more flexibility in terms of where a facility can be sited versus traditional power plants, but that sometimes also leads to what Jeremy Twitchell refers to as "a level of potential conflict with energy storage that we haven't necessarily seen with other energy infrastructure".

One thing that stands out from the dozens of news reports about local opposition to battery storage projects is that the members of communities that speak to the press very often mention that they are in favour of renewable energy and in favour of energy storage to enable its growth.

But at the same time, a typical quote will then go on to ask why the storage system could not be sited somewhere else, where it will not present a potential eyesore or even a fire or explosion risk.

Developers are not choosing energy storage sites at random, nor are they choosing sites just because land is available. Mostly, it is about proximity to grid infrastructure, which can dictate how strategically useful to the network a BESS asset can be, as well as mitigate the need to build out more and more transmission and distribution (T&D) lines, which in themselves can present development challenges.

"If you are close to a substation, you've got a lot of lines coming out of a substation. If you can tap into that substation, you can provide service and support over a lot of lines, you can support a larger segment of the utility system. If you're out at the end of a particular line, a distribution line or transmission line, you don't have that same level of visibility, you don't have that same level of support to the utility system," Twitchell says.

"Substations are like the hubs of the electric grid, and the closer you can be to a hub, the more benefit you can provide, the better value of the services that you can provide."

Elephant in the room

Still, while the technical and economic benefits of certain sites may be explainable in this way, it might not be enough to eliminate other concerns.

There will always be NIMBYs, who simply do not want anything built near them or built in a particular area. That is one (possibly small) set of people, but frankly, the elephant in the room is safety and the public need to be reassured as well as educated.

Many learnings have been made on safety and incorporated into industry best practices and standards. Incidents like the 2017 fire and explosion at AES' McMicken BESS project in Arizona and the handful of more recent incidents in the US will be thoroughly investigated for their root causes, providing valuable feedback to the industry.

"One of the things we tried to do in the report is point out how the industry has learned from those incidents, how codes and standards have evolved to specifically address the safety risks of energy storage," Jeremy Twitchell says.

"You cannot build a battery that is guaranteed to never enter thermal runaway. Some thermal runaway is going to happen, although those incidents are fairly rare. What you can do is engineer a battery that will not explode, that will not spread to other batteries."

Codes and standards that are now in place that mean even in the worst-case scenarios where thermal runaway occurs, systems are designed and engineered to limit the failure to just one unit.

So again, while local officials shouldn't have to be experts in battery fire safety, what they can do, with PNNL's new paper as a basis, is ask questions about which codes and standards an energy storage system is certified to.

Entering new zones

A lot of the local authority acceptance issues come back to just how new grid-connected energy storage is as a concept. For example, zoning ordinances often don't have BESS developments as a consideration when it comes to determining whether a storage site can be classified as an industrial use of land.

PNNL's researchers investigated where in the country, and to what extent, local zoning ordinances included consideration of storage, which Twitchell said was not an easy task given that there are no central repositories of those ordinances to reference against.

"What we found is that very few municipalities had an ordinance in place. We identified a few different kinds of ordinances. The most common version is a municipality had a zoning ordinance in place for solar energy and they modified it to just say, 'solar and storage'."

"Obviously storage is a different resource with different characteristics and a different risk profile. We also identified a handful of ordinances that are more proactive [and] provide specific guidance and regulations around how and where storage can be built," Twitchell says.

However, PNNL was only able to identify "about a dozen such ordinances around the country", and many of those were created in response to a specific project proposal, meaning that finding municipalities that have proactively addressed the issue is rare, although there are some.

Again, asking municipalities to set aside the time and resources to do that legwork is a big ask, and so PNNL hopes its report will provide guidance on that. The PNNL energy storage team the authors are part of will next be working on a follow-up report specifically around "the anatomy of a zoning ordinance," Twitchell says.

"What are the components of it? What are the things that it should address? And what are some of the options in terms of how you construct it and some of the requirements? We'll be drilling down into those topics at a level deeper than we did in the latest report." ■

The report 'Energy storage in local zoning ordinances' can be downloaded from the PNNL website, ***www.pnnl.gov***

UK: Developers welcome LDES cap and floor but caution against 'gaming' and lithium-ion exclusion

Cameron Murray hears from UK battery storage developer-operators and long-duration energy storage (LDES) technology firms on the government's recently released LDES consultation, which has proposed a cap and floor scheme to kickstart investment

The long-duration energy storage (LDES) consultation, which was launched in mid-January 2024, followed months of discussions with the industry on creating a mechanism to incentivise investment into LDES technology, defined as six-hour-plus duration, which most agree is needed for the UK to get to net zero.

The chief proposal is a cap and floor mechanism for LDES projects which would guarantee a minimum and maximum revenue for projects, with the government funding any shortfall and receiving any money back above the cap.

"The cap and floor mechanism for LDES is a sensible evolution from the simpler strike price model of a Contract for Difference (CfD), which has proven to help get less mature technologies off the ground," developer and operator Balance Power's commercial manager Nick Provost told *Energy-Storage.news.*

"It's likely to benefit consumers as asset operators will be able to gain more revenue before breaching the cap, compelling them to pay this extra revenue to the government. This should help provide downward pressure on the cost of the floor which is good for electricity consumers."

Luke Gibson, COO at another developer-operator Field, similarly told us: "We welcome the launch of this consultation. It's reassuring to see the recommendation for a cap and floor mechanism that – price dependent – should give greater revenue certainty, which will in turn help to secure financing for these assets."

Credit: Drax Power

Cruachan Dam, Scotland, an existing 440MW pumped hydro energy storage (PHES) facility, one of only four in the UK. PHES is the most commercially mature LDES technology, with a duration typically between four and 20 hours

Provost also said that a cap and floor for LDES would complement existing shorter-duration assets. The UK already has 3.9GW/4.8GWh of operational battery energy storage systems (BESS) and the near-term pipeline is 60GW/92GWh pipeline (figures from Solar Media's UK Battery Storage Project Database Report).

"A cap will discourage LDES assets from seeking the absolute peaks and troughs in the wholesale market which unsupported assets can chase and a floor will encourage LDES assets to provide energy security during periods of lower wholesale volatility," Provost said.

Lithium-ion exclusion 'should be reconsidered' for LDES

The aspect of the consultation that has been most widely opposed by industry figureheads is the proposed exclusion of lithium-ion as an eligible LDES technology for the cap and floor scheme. The government said this is because it is already commercially viable and being deployed at scale without any subsidies. Indeed, lithium-ion technology is being used for the vast majority of energy storage projects being deployed in the UK.

However, Field's Gibson said: "The exclusion of existing lithium-ion technology at six-hour duration should potentially be reconsidered if the goal is consumer savings. LFP (lithium iron phosphate) batteries remain cost competitive at this duration."

Analytics firm Modo Energy's Ed Porter has also opposed excluding lithium-ion but for the opposite reason – that it is not currently commercially feasible at a six-hour duration.

'Absolutely crucial to police gaming as a priority'

Balance Power's Provost also discussed the risks of 'gaming' and operators exploiting the system for financial gain. Other industry sources have previously opposed cap and floor regimes for energy storage.

Provost: "It's absolutely crucial that the policing of gaming is prioritised in the final design of any LDES support and we are happy this is considered within the consultation. This is for a couple of key reasons."

"The myriad of trading opportunities available with storage will provide differentiation between competitors and will provide consumer benefits through innovation. However, this will make transparency harder to achieve and increase the potential for operators to exploit the system for financial gain."

"The ultimate requirement for LDES is driven by the technical need for energy security during periods of low renewable energy generation [i.e., as coined in the German language expression *dunkelflaute*/'dark lull']. Therefore, there should be a mechanism to compel LDES-supported projects to deliver power during periods of *dunkelflaute*. Intuitively market signals should be enough but may not be sufficient under all circumstances."

"However, gaming concerns are not unique to the proposed cap and floor model and will exist in any subsidy regime for storage as revenue is dependent on multiple components within a volatile market."

LDES technology firms react positively

LDES technology firms have generally reacted positively to the government proposal. Stephen Crosher, CEO of proprietary 'high-density' pumped hydro energy storage (PHES) technology firm RheEnergise, said:

"We welcome the commitment to long-duration energy storage from the UK government and the recognition that support mechanisms to initiate the LDES market are needed. In principle, we agree with the proposal for the cap and floor mechanism. We are keen to ensure that the mechanism is applicable for all LDES technologies and at the various scales needed to support the overall, increasingly distributed, energy system. We will be responding to the consultation in due course."

"We are keen to ensure that the mechanism is applicable for all LDES technologies and at the various scales needed to support the overall, increasingly distributed, energy system"

Scott Bolton, executive VP global policy & regulatory affairs for advanced compressed air energy storage (A-CAES) technology firm Hydrostor added: "We're pleased to see this proposal from the UK government, which will go a long way to support the decarbonisation of UK electricity markets while also adding flexible firming capacity. We look forward to reviewing the proposal in further detail." ■

UK developer Field on grid and market mechanisms: 'totally different picture to a year ago'

Cameron Murray speaks to Chris Wickins, technical director at UK-based battery storage developer-operator Field, about how the grid interconnection question and market mechanisms are developing in Europe's most advanced energy storage market

Credit: National Grid

National Grid's Lovedean substation

Field was founded in 2020 by CEO Amit Gudka, previously head of retail utility Bulb which collapsed and was acquired by Octopus Energy in 2022 (it was the largest utility in the UK to tumble in the face of soaring natural gas prices).

Field primarily operates in the UK where it has a 20MWh battery energy storage system (BESS) project online in Oldham, northern England, and several more under construction across the country. It is also targeting Spain, Germany and Italy.

In this interview, Wickins discusses two important parts of how the UK market and the approach of transmission system operator (TSO) National Grid are developing: grid interconnection and market mechanisms for energy storage.

"There's lots of appetite in the UK market and the conversation has moved on, rightly so, to how we facilitate getting to our deployment goals as a country. Particularly questions around how can we connect all these new assets to the grid and how can we maximise their usefulness. Across Europe it's definitely an earlier picture," Wickins says, with the firm's experience in Italy so far providing a useful comparison.

Grid: backlogs, queue management and smart planning

As *Energy-Storage.news'* sister site *Current* has written extensively, one of the big challenges in the UK market is long wait times to connect projects to the electricity grid. There are more BESS projects being developed and put into the queue than grid connections, network capacity or engineers to integrate them, Wickins says.

"This overflowing queue has been born out of a couple of things. It's been very cheap to apply to connect to the network, you've really had to do nothing in advance of that – the developer approach has been to secure a grid connection then do everything else," he says.

"In Italy, it's different – you can't apply for a grid connection until you have some land secured for your project. That's more onerous and might take you three to six months to secure that so it turns the development process the other way around, but it slows down the connections being applied for as you won't get people applying without adequate land."

"National Grid is now changing the rules and you'll need a short letter from a landowner saying they are in discussions with you about a project on their land, though we at Field think it should go further. Something like a legally binding option agreement for the land or at least exclusivity terms having been agreed, for example."

The other aspect of getting projects into the ground more quickly is around queue management; ensuring projects within the interconnection queue are assessed based on how likely they are to be built and not just who joined the queue first.

"There's been positive movement recently in the direction of queue management too, in terms of telling projects that aren't moving forward to get out of the queue and to let those behind them that are moving forward to come forward. Queue management is really important and we at Field are very supportive of what's been done in the last few years."

A final aspect of the solution is called 'construction planning assumptions', which is about not treating energy storage like it is always exporting when modelling its effect on the grid.

"National Grid is changing these assumptions to treat batteries in their analysis more in line with how they will operate, and that should free up the potential to connect batteries earlier," Wickins adds. "These things mean it's now a totally different picture to if we had had this conversation around grid a year ago. Lots of good work has been done over 2023 on this."

National Grid recently appointed global assurance and risk management provider DNV to assess the potential of taking out energy projects in the interconnection queue it has deemed "high-risk", totalling 29GW. DNV will assess projects and how likely they are to get built, which will involve asking developers if they have achieved certain milestones.

Wickins says: "It will be interesting to see how that works in practice. You can imagine National Grid liking the idea that someone independent will make the judgement. And if you are a developer trying to cling on to your project you'll argue tooth and nail that you are nearly there on X, Y and Z. It's going to be a hard job, but DNV is used to doing this sort of thing."

Market mechanisms: frequency, reactive power, BM, inertia and Grid Boosters

The discussion moves on to how market mechanisms need to be further developed in the UK to facilitate the deployment of the energy storage the country needs.

"Generally speaking, we're in a very good position when it comes to providing frequency services. There's been a big overhaul of that market and it seems to be working well, National Grid has driven down prices quite successfully," Wickins says, adding there is good work being done in some areas and work still to do in others.

One area where Wickins says National Grid is leading the world on with BESS is inertia, through its Stability Pathfinders tender.

Other areas need more work. After complaints earlier in 2023 about BESS' treatment in the Balancing Mechanism, a revenue stream many hoped would make up for falls in frequency service prices, Wickins says there is "good visibility of progress" there as well as the introduction of the Open Balancing Platform.

One current problem is that National Grid doesn't have a signal telling it the state-of-charge (SOC) of a BESS or how long it can be used for, and if this was rectified the TSO would be using BESS with a lot more confidence.

"Generally speaking, we're in a very good position when it comes to providing frequency services. There's been a big overhaul of that market and it seems to be working well"

Reactive power, which means providing power to help manage voltage, is a market which exists at the transmission level but not at the distribution level, something Wickins calls a "missed opportunity" as there are BESS which could provide that service.

A 100MW, transmission-connected project from developer-operator Zenobe Energy claimed to be the first to do this.

A market mechanism for large-scale BESS seen elsewhere that has caught Wickins' eye is so-called Grid Boosters in Germany, Lithuania and elsewhere. The basic principle of this idea is setting up large BESS either side of a high-voltage transmission line to mimic the power flow of the line if it ever goes down, reducing the need for a second, expensive backup line.

"It's an exciting idea that is not really being talked about in Great Britain (GB). It's complicated and there's some really detailed power system engineering that's gone behind it because things happen on a very short timeframe, and what they are doing in Germany is quite impressive," Wickins says.

"It may be possible that if we had 2.6GW of batteries in Scotland and 2.6GW in England maybe National Grid wouldn't be turning off 2.6GW of wind today, which is happening as we speak.

"These wouldn't even need to be dedicated BESS but they would need to be the right type of very fast-acting batteries."

Wickins adds that he wouldn't see a contract for difference (CfD), or other cap-and-floor, or feed-in tariff as appropriate market mechanisms for energy storage. ■

Germany's Electricity Storage Strategy 'puts storage on political agenda for the first time'

The world's first significant solar market, Germany, has been slower to embrace storage. But a strategy published in late 2023 shows encouraging signs that storage is firmly on the political map, writes Andy Colthorpe

Germany's Federal Ministry for Economic Affairs and Climate Action (BMWK) published a strategy for electricity storage in at the end of 2023, aimed at supporting the ramp-up of electricity storage and achieving "optimal integration" of storage into the electricity system.

BMWK said higher shares of electricity storage will be needed to integrate the German renewable energy targets comprising 215GW of solar PV and 145GW of combined offshore and onshore wind by 2030. The ministry identified 18 separate areas it considered appropriate for promoting storage deployment.

Those include electricity storage's role in the context of the national Renewable Energy Sources Act (EEG), acceleration of network connections, promoting the production of battery cells and system components, identifying obstacles to the development of pumped hydro energy storage (PHES) and network charging schemes.

While the strategy doesn't yet spell out specific actions, its release puts electricity storage on the German political agenda for the first time, said Lars Stephan, senior manager of policy and market development for Fluence on LinkedIn.

Fluence and four other energy storage-related companies active in the German market recently commissioned a report analysing the projected need for energy storage on the country's grid. Authored by consultancy Frontier Economics, it found that with a supportive policy framework in place, Germany's capacity of deployed storage will rise to 15GW/57GWh by 2030 and to 60GW/271GW by 2050.

Frontier Economics also found that those levels of storage deployment could provide around €12 billion (US$13.04 billion) in economic benefit by the mid-century and lower wholesale electricity prices by, on average, €1/MWh between 2030 and 2050.

"Without the flexibility provided by storage, the country will face higher economic costs caused by increasing gas imports and expensive curtailment of renewable generation" Frontier Economics director Dr Christopher Gatzen said.

Frontier Economics and the companies which funded the study (Fluence, developers Baywa r.e., Kyon Energy, ECO STOR and optimiser/trader enspired, recommended two main actions to be taken including a national deployment target for storage and setting aside "corridors" for energy storage facilities.

The German battery storage market is already on an upward trajectory, but not at anything like the levels believed needed.

Credit: Fluence.

Rendering of a 250MW transmission-connected BESS supporting the German transmission network, currently under construction.

According to recent analysis from the Fraunhofer Institute for Solar Energy (Fraunhofer ISE), the installed base of battery storage close to doubled last year, going from 4.4GW/6.5GWh of cumulative installs by the end of 2022 to 7.6GW/11.2GWh by the end of 2023. Pumped hydro connected to the grid, totalling 6GW, remained unchanged.

Frontier Economics said it expects the growth of energy storage in Germany to mirror the success of solar, and it and BMWK both pointed out that, unlike the early days of the solar boom, storage systems are being deployed on an unsubsidised basis. The market could go much further, the consultancy said, but with measures including the storage strategy, Germany needs the right framework in place.

Fluence's general counsel EMEA and managing director Markus Mayer said far fewer large-scale storage systems are being built than in other markets such as the UK, US or Australia.

There is a "great potential" for increasing the uptake of utility-scale storage, but uncertainties in the regulatory and political space "cause unnecessary delays for our customers and their projects, for example, during the approval processes or obtaining network access", Mayer said.

"The flexibility provided by storage is fundamental to the success of the energy transition and must become an urgent point on the political agenda... The energy storage strategy ... gives us hope for positive regulatory changes." ■

‘Let batteries help’ says Arenko CTO after frequency event threatens Britain’s grid stability

Credit: National Grid. id

One of National Grid’s IFA Interconnectors with France tripped to cause the incident

Roger Hollies, CTO of UK-based Arenko, tells Andy Colthorpe why a frequency event on Britain’s power network highlights the need for batteries to play a bigger role in helping stabilise the grid

A frequency event that nearly caused major disruption of the electricity grid in Britain could have been more effectively dealt with had network dispatchers called on more of the country’s battery storage.

That’s the view of Roger Hollies, CTO at UK-based energy storage optimiser and trader Arenko, who spoke to *Energy-Storage.news* about the event in late December 2023 in which the operating frequency of the Great Britain (GB) grid dropped to 49.2Hz.

Had it dropped any further, the results could have been serious, with blackouts and other disruptions to supply as well as potential damage to infrastructure. While it isn’t yet clear exactly what happened in the chain of events, it was precipitated by a loss of 1GW of load from the IFA Interconnector between the UK and France.

It came during a couple of days of high renewable generation, with a record-breaking 21GW of wind on the system; the previous day, there was around 19GW of wind – well over 50% of the 30GW to 35GW of total generation on Great Britain’s grid (GB – the UK would include Northern Ireland, which shares its grid with the Republic of Ireland).

The interconnector trip therefore took about 3% of total power off the network in one go.

“This is a reality of the new interconnected grid that we’re operating. With traditional power stations, big loads do not tend to drop off instantaneously, whereas interconnectors do. A big generator will wind down very slowly unless there’s a catastrophic event, but the interconnectors quite often seem to trip very large loads off of the system,” Hollies told *Energy-Storage.news.*

“So, you’ve got this situation where you’ve got high renewables and then a good really big chunk of the system got lost instantaneously.”

The UK has two arms to its electricity network operation. One is National Grid, which is the transmission system operator (TSO), physically operating and managing the grid infrastruc-

ture, while the other is National Grid Electricity System Operator (National Grid ESO), managing and coordinating supply of electricity in real-time.

In that context, it's the ESO that offers markets for grid-balancing services such as frequency response and it is currently reforming the balancing reserve products available. The rollout of its dynamic frequency services as part of this, includes Dynamic Containment, the ancillary service which Hollies said is the post-fault service, and "the thing that's supposed to really catch these big incidents, when there's a huge, quick frequency deviation".

"And it looked like it worked. In the first instance, the 1GW dropped off, you saw the initial frequency response dropped to about 49.5Hz. But then something else happened – we had this really deep, deep dip to 49.2Hz."

The fact that disaster was averted and the frequency was kept within the boundary of 49.2Hz means that the safeguards in place ultimately worked. A serious blackout event did happen in 2019 after a frequency drop to 49.55Hz that happened in fewer seconds than was the case this time. It's a good news story in that respect but Roger Hollies said it was, "really, really close, probably a lot closer than they were expecting", in the ESO control room.

'Batteries do it cheaper, and better'

The GB grid experiences high levels of volatility in its frequency, due to the high penetration of renewables and its islanded situation.

Battery storage has been able to compete widely in its ancillary services markets since 2016, when National Grid (prior to a split into two separate entities) launched a world-first competitive tender for 200MW of enhanced frequency response (EFR).

Since then, the UK has raced into a leading position for battery storage deployment ahead of its continental European neighbours and an installed base of more than 4GW of large-scale battery energy storage system (BESS) assets.

Hollies said in a post to LinkedIn prior to our conversation that due to the reduced value of frequency response markets, only about 80MW, or a third, of a portfolio of assets the company manages on its Nimbus software platform was contracted to deliver the grid services needed.

More importantly perhaps, Hollies noted that the post-fault correction which was dispatched through the Balancing Mechanism – through which the ESO matches supply and demand in real-time – featured little to no instructions for batteries to step in.

In other words, there has been enormous investment into BESS in the UK (including Northern Ireland) since 2016 and much of that has directed resources into providing frequency regulation.

While that investment enables batteries to participate in maintaining the frequency day-to-day, much less regard has been paid to what batteries can do during more critical events and in post-fault correction such as following what happened at lunchtime on 22 December.

> "What we have to do as an alternative industry is to replace and provide the services that fossil fuel companies provide, better and cheaper. We're seeing that with frequency response, that's been done, batteries now dominate the market"

Roger Hollies said the UK is leading on a lot of energy transition issues, and he acknowledged that the ESO has a difficult job to do and is taking steps in the right direction, such as the recent launch of the Open Balancing Platform for dispatching the Balancing Mechanism and other services.

Indeed, National Grid ESO is doing "really good work", according to the Arenko CTO, faced with the intertwined duties of keeping the electricity grid online and reforming the grid's balancing services simultaneously.

However, the ESO needs to communicate their problems to the industry and the industry to apply its "incredible minds, incredible resources" to figuring out the wider role or roles that BESS can play in keeping the lights on.

'Gas' contribution to reserve will erode this year'

Batteries are gradually coming in and replacing the grid's traditional support systems, and Hollies points to various studies that show they can do so considerably more cheaply than those legacy technologies. That's already been seen with frequency response: eight years ago, there were no batteries providing frequency services to the GB grid, now they dominate. The groundwork now needs to be done for that to extend into reserve and other services, Hollies argued.

"There's a really positive message of batteries coming in replacing traditional fossil fuel generation," he said, noting that he and Arenko recently attended COP28, where his main conclusion was that "fossil fuel companies are not going to move quickly enough [on climate], because they just won't".

"It's their business. So, what we have to do as an alternative industry is to replace and provide the services that they provide, better and cheaper. We're seeing that with frequency response, that's been done, batteries now dominate the market.

"Reserve is a huge volume of market and I think we're going to slowly see this year particularly, batteries are just going to erode gas' contribution to reserve massively and that'll hopefully trigger another investment push into batteries in the UK."

An open transparency forum was due to be held after the time of writing, which Hollies said would hopefully shed some light and give the industry food for thought in how it could put its ideas forward. ■

What you need to know about the IRA and tax equity

The Inflation Reduction Act brought a sense of confidence and certainty to the business of clean energy. Lawyers Adam Schurle and Morten Lund at Foley Lardner take a closer look at what that means for tax equity financing of energy storage, while exploring some of the questions still to be answered

The Inflation Reduction Act of 2022 (IRA), enacted in August 2022, had the potential to flip on its head the manner in which solar and battery energy storage system (BESS) projects were developed and financed, in particular how tax equity financing is utilised in the industry.

Now that we're over a year removed from the passage of the IRA, it's a good time to revisit whether some of the predictions, hopes and fears attendant to tax equity financing and the IRA have been realised.

Double-edged sword

The investment tax credit (ITC) is a one-time US federal income tax credit based on the cost basis of certain eligible property, including solar energy systems and BESS. As a general rule, the ITC is claimed by the owner of the property for the taxable year in which the property is placed in service. Prior to enactment of the IRA, the ITC for solar energy systems was subject to a phase-down from 30% of eligible basis to 10% over the course of several years, and standalone BESS was not eligible for the ITC.

Solar projects and BESS also benefit from bonus depreciation. The owner of a project placed in service in 2023 is permitted to deduct 80% of the cost (after reduction for one-half of the ITC) currently, rather than over five to 12 years. Bonus depreciation is set to phase down over the next few years, but it still offers a significant financing enticement.

The ITC has always been something of a double-edged sword. On the one hand, the ITC has without a doubt been the most significant financial incentive for solar energy in the US and has attracted immense amounts of capital investment. On the other hand, the nature of the ITC as a tax credit has excluded many funding sources and introduced potentially detrimental artificial incentives to the industry.

Between the ITC and depreciation, the tax incentives have always been too big to ignore. The basic 30% ITC, plus bonus depreciation returning almost 20% of project costs as immedi-

President Biden signed the Inflation Reduction Act on 16 August 2022

Credit: The White House

ate deductions, means that roughly half of the project value lies in tax benefits. Building a project without considering the ITC is not a viable strategy. At the same time, the ITC and the depreciation together create a tax benefit so large that it is essentially impossible for a project to generate enough taxable income to fully utilise its own tax benefits.

Nothing is certain, except taxes

To utilise the ITC, a significant amount of income subject to US Federal income tax is required, and the claimant generally must be a US taxpayer. Except under unique circumstances, the 'US taxpayer' requirement excludes many potential investors and customers: foreign companies, government entities, and tax-exempt entities – including most universities, schools and hospitals. Due to other (more complex) requirements, individuals are in most cases also excluded from claiming the ITC.

Prior to the IRA, the ITC was not transferable. Depreciation is not transferable. As a result, and because project developers typically can't absorb all the tax benefits themselves, outside financing is generally required to realise the value of the ITC and depreciation.

The structures used to monetise the ITC are complex. The most common are partnership flip and sale-leaseback structures; some tax equity participants use inverted lease structures, but those are less common. These complex structures come with high transaction costs. Transaction costs for a single tax equity financing frequently exceed a million dollars. Even for a simplified and streamlined transaction, the total transaction cost will almost certainly exceed US$250,000.

Solar and storage markets shaped by tax credits

These requirements combine to create a set of circumstances where there is a fairly small pool of possible ITC investors. In practice, most tax equity investors are banks and insurance companies.

This has impacted the shape of the solar energy industry in the US. Third-party ownership structures are common. Small commercial projects (less than ~300kW) are very difficult to finance, and therefore are quite rare. Generally speaking, larger projects are favoured. Bundled financings are favoured – combining multiple projects into single financings. This effectively requires a developer to have multiple projects ready for financing in the same year, which can be difficult for smaller developers.

Solar has to be structured and financed separately from other assets, even if part of a larger project. This complicates and discourages including solar as part of general developments. Most large solar manufacturers are generally unable to own projects, as most are not US companies and do not have significant US taxable income. This removes vendor finance as an option for manufacturers to encourage adoption of their products, which in turn makes it more difficult for new competitors to enter the US market.

For energy storage, the impacts have been more severe. Pre-IRA, BESS were not eligible for the ITC on a standalone basis. Instead, BESS were eligible for the ITC only if paired with other ITC-eligible electricity-producing property, such as a solar energy system. There were also significant limitations on how the BESS could be used. To qualify for the full ITC, under what are known as the dual-use equipment rules, BESS had to be charged only by the associated solar energy system or other ITC eligible property through at least the first five years after the BESS was placed in service.

Any charging from the grid or other ineligible property, and the ITC was subject to reduction; and if the total energy input for the BESS from non-ITC eligible property was greater than 25% then no ITC was permitted with respect to the BESS.

These restrictions made standalone BESS much less attractive, and most storage systems installed pre-IRA were part of hybrid systems – i.e., combined solar and storage projects, or wind and storage projects. BESS within hybrid systems are inherently limited in functionality, and do not utilise the full potential of the storage technology.

The IRA significantly changed this landscape, for both solar and storage. The full ITC rate was reinstated to 30%, and standalone BESS were added to the list of facilities that are eligible for the ITC, meaning that BESS now no longer need to be paired with other ITC-eligible generating property. The IRA extended the window for ITC eligibility for projects that begin construction no later than 2033, and possibly longer.

The IRA also introduced several ITC adders, such as a 10% adder for facilities located in certain 'energy communities', a 10% adder for facilities that satisfy certain 'domestic content' requirements, and a 10-20% adder for wind and solar (and associated BESS) facilities located in certain low-income communities, that collectively have the potential to increase the ITC to 70% of the eligible basis of a facility.

In addition to the extension, the IRA added new eligibility requirements. On a going-forward basis, any facility that is over 1MWac must satisfy certain prevailing wage and apprenticeship requirements (although projects on which construction began before January 29, 2023, will be exempt from these requirements). These prevailing wage and apprenticeship requirements generally require that in the construction, repair or alteration of a facility the taxpayer, contractors, and subcontractors must pay wages at local prevailing wage rates published by the US Department of Labor and a certain percentage threshold of such work must be performed by qualified apprentices.

If an otherwise eligible facility is subject to but does not satisfy these prevailing wage and apprenticeship requirements, the credit rate for the facility drops to 6%, rather than 30%. Further, for projects placed in service beginning in 2025 that didn't begin construction before then, a new rule will require that those projects have an anticipated greenhouse gas emissions rate of not greater than zero.

The IRA also made solar facilities eligible for the production

Prior to the act, energy storage would only be eligible for the ITC if sited with, and charged from, solar.

Credit: IHI Terrasun.

tax credit (PTC), which is a tax credit available to the owner of a facility based on electricity produced by the facility for a 10-year period beginning when the facility is placed in service. The statutory rate for the PTC for new facilities in 2023 is 2.75 cents per kWh and is subject to inflationary adjustments. As with the ITC, a taxpayer generally must satisfy the prevailing wage and apprenticeship requirements to claim the full PTC, and similar rules apply to greenhouse gas emissions rates beginning in 2025. The PTC was likewise extended through at least 2033.

Transferability, direct pay options

Aside from the extensions to the ITC and PTC, new eligibility requirements, and adders described above, the more significant two other changes had the potential to reshape how solar facilities and BESS were financed.

For the first time ITCs, PTCs, and other renewable energy credits can now be sold to taxpayers on the open market.

Second, tax-exempt entities, including many universities and hospitals, state and local governments, and tax-exempt organisations, are now entitled to claim direct cash payments from the US government for the tax credits they otherwise would have been eligible to claim (but could not use due to their tax-exempt status).

These changes – transferability and direct cash payment, respectively – left some within the renewable energy industry hoping (and others concerned) that we would soon see a day when the complexity of tax equity financing would be no more. One year on, it is clear that neither those hopes (nor the fears) have been fully realised.

There have been some changes. We have seen interest in tax credit transfers, and some transactions have already been signed up. Many direct pay transactions involving tax-exempt entities building solar and BESS projects that they will own are in the works, and more are expected as more such entities dip their toes into renewable energy investing.

Third-party tax equity financing here to stay

What we have not seen is any movement toward abandoning third-party tax equity financing. There are two principal reasons for this. First, a tax credit transfer is itself a form of tax equity financing. While these transactions have the potential to be less complex and costly than other tax equity financings, they still add significant complexity and cost to the project.

Moreover, the tax credit purchaser is subject to the same qualification requirements and general limitations as any tax equity investor, so the pool of eligible investors has not grown, although there will certainly be some tax credit buyers that would not be willing to participate in traditional tax equity. Taxpayers without experience in traditional tax equity might be hesitant to make the leap to buying credits. This reluctance could be eased by third-party brokers of tax credit purchases, which the transferability guidance expressly permits, but that is a nascent marketplace at this time.

Second, and more significantly, only the tax credits themselves – the ITC and the PTC –are transferable. The depreciation benefits cannot be sold. With a potential value of roughly 20% of project cost, this by itself is often enough

to justify a full-on tax equity financing. While smaller projects may elect to forgo the depreciation benefits (because owners don't have taxable income to utilise depreciation), this is not a realistic option for larger projects. A similar effect is in place for tax-exempt entities: the direct pay option only applies to the ITC. Depreciation benefits are forever lost if a tax-exempt entity is the tax owner of the project.

It is perhaps not surprising that what we are seeing so far is analogous to what happened during the Section 1603 cash grant programme in the wake of the 2008-2009 economic crisis. Then, as now, some small projects took the cash grant and used what they could of the depreciation without outside financing. But for larger projects (and larger bundles), tax equity financing was still an easy choice. This effect may become more pronounced as bonus depreciation phases down, but tax equity financing will continue so long as there is any additional value to be extracted.

On the storage side, the story is similar, but for different reasons. An ITC for energy storage (without solar) removed a major hurdle to widespread adoption of standalone storage projects. Other hurdles remain, however.

There are significant regulatory hurdles to standalone storage in many states, and there are only a few states with active markets for energy storage services. It is therefore no surprise that we have seen a substantial increase in standalone projects in states where standalone storage was already growing (principally California and Texas), but no apparent impact in jurisdictions where other obstacles remain.

This is where we are, and where we expect we will remain. Some projects are now financeable that were not before the IRA. Other projects can now choose to forgo outside tax equity financing. But the era of complex tax equity financings is not over. To the contrary, the IRA all but guarantees that tax equity financings will continue for at least another decade. ■

Authors

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US: Interest rate rises and longer development timelines causing project 'M&A mania'

Agilitas Energy CEO Barrett Bilotta tells Cameron Murray about the impact of higher interest rates on the economic case for renewable energy projects

Interest rate rises and longer development timelines have driven a fall in the value of early-stage projects in the US clean energy and energy storage market and a flurry of sell-offs, developer-operator Agilitas Energy has told *Energy-Storage.news.*

"Renewables as an asset class is definitely going through a rejig as interest rates increase the need for projects to have a really strong economic case," Agilitas CEO Barrett Bilotta said. "Renewables at scale has only ever lived with near-zero interest rates and a lot of what's been developed in the industry were marginal projects."

Agilitas Energy is a solar and storage developer and operator based mainly in the New England market, where the grid operator is ISO-NE, but has recently expanded into ERCOT. The trend Billotta discussed mirrors what is happening in the UK according to sources interviewed by *Energy-Storage.news.*

Higher financing costs increase the value dilution that happens between greenfield origination and commercial operation, like the interest payments on the financial assurances you need to post to keep your place in an interconnection queue, Bilotta explained.

Along with interest rates, US project development timelines have also gone up due to longer grid connection queues as grid operators' books have become flooded with interconnection requests, increasing that dilution.

"What's happened is the market as a whole has realised that development assets that were on a spreadsheet saying that it would get built in Texas in 2026 or California in 2028, a lot of the time there is no real value anymore. Or the value is diminished because the cost to get that project to NTP is so dilutive because of interest rates," Bilotta said.

"That is where we are seeing the most opportunity, where developers are looking to sell off development assets at their current condition to get capital to potentially salvage their others, and clear down their books as they can't fund all of them. That's what's leading to a lot of the M&A mania right now from a project standpoint."

"In our realm of distributed generation of 5-20MW project sizes, we're seeing values for those early-stage projects come down about 70% from their peak in mid-late 2022. It's a big move."

The peak in project valuations in mid-late 2022 came when the market was peaking anyway in the middle of the year and the passing of the Inflation Reduction Act and its increased tax credit incentives for clean energy deployments "turbo-charged" it further.

Credit: Business Wire.

An Agilitas Energy BESS project in Rhode Island being inaugurated in April 2022.

Developers that have recently been very publicly marketing project pipelines include Solvent Energy and Granite Source Power, mainly in ERCOT, Texas.

The trend has been noted by renewable energy asset buying and selling platform LevelTen Energy. In its H1 2023 M&A outlook report it said that buyers are now exhibiting a more balanced and disciplined approach as opposed to the "land grab" seen in the last few years and that the "sellers market" has abated. Projects with a firm and near-term timeline for interconnection are better placed, its report said.

Agilitas recently brought a 4.8MW/23.7MWh battery energy storage system (BESS) online in New York, a project for which it won a 10-year contract with local utility Con Edison to discharge during peak demand periods.

Bilotta added that the pricing for lithium-ion BESS project equipment is down 30% per kWh – across batteries, transformers and inverters – versus last year which he attributed to lower demand because fewer of those 'marginal' projects are going ahead, and that this offsets some of the increased costs from financing and long development timelines.

But more primarily the interest rate environment has switched the focus in the market from development shops to being a fully integrated developer and independent power producer (IPP), he claimed. Developer-IPPs in Europe have said the same thing to *Energy-Storage.news*, expressing scepticism about early-stage pipelines and the 'develop-and-flip' model.

Bilotta estimated that the current dip in valuations for projects and companies in the space is "bottoming out" and will reach a trough in Q1 2024. ■

European developer/IPPs: Sodium batteries gaining ground but big LFP upgrades expected

Cameron Murray speaks to Aquila Clean Energy EMEA, Kyon Energy and BayWa r.e, three major Europe-based developers and operators, for their 2024 energy storage technology predictions

This article follows a broader Year in Review piece at the start of January in which energy storage executives from Aquila Clean Energy EMEA, Kyon Energy and BayWa r.e looked back on the year just gone and ahead to 2024. In their responses to a question about technology, published separately here, all three highlighted sodium-ion as one to watch out for.

Kyon is primarily active in Germany where it has brought nearly 700MW of battery energy storage system (BESS) projects to the ready-to-build stage, including 195MW sold to investor Obton last year. Kyon's managing director Florian Antwerpen shares his views for this article.

Aquila was one of the first movers in the Belgian BESS market and launched its first operational project in Germany in December, a solar-plus-storage system in Lower Saxony with a 6.9MWh BESS, while actively targeting Italy and Poland and Australia. We hear from its director for energy storage Kilian Leykam.

For BayWa r.e., recent projects it has progressed include a three-hour 171MWh BESS project in the UK and a solar-plus-storage-plus-hydrogen project in France. Head of storage Julian Gerstner rounds off the trio of contributors.

Although the three companies agreed on the growing importance of sodium-ion technology, Aquila and Kyon Energy both said that upgrades to lithium iron phosphate (LFP) lithium-ion battery (LIB) cells are expected too, while BayWa said sodium-sulphur's share in the market could increase, while not getting to the scale of lithium-ion or sodium-ion.

Their answers coincide with a press release from Dongguk University in South Korea following research from a group of scientists into the recent advances in sodium-ion battery (SIB) technology.

Research leader Professor Kyung-Wan Nam said: "While the cost of SIBs might be (only) slightly lower and comparable to LIBs, the availability of sodium and the use of less toxic materials makes them a great alternative. In the long term, SIB can complement LIB technology, rather than being a competitor."

It also comes after European lithium-ion gigafactory firm Northvolt claimed a "breakthrough" in the sodium-ion battery technology development it is doing with Altris in November 2023.

Credit: Altris AB.

Altris is based in Sweden and has developed a proprietary sodium-ion battery technology.

See the technology predictions from the developers in response to *Energy-Storage.news*' question below.

***Energy-Storage.news:* What are some major trends in energy storage technologies that readers should keep an eye out for?**

Kilian Leykam, director, energy storage, Aquila Clean Energy EMEA

We are expectant about the upcoming technological enhancements for lithium-ion when it comes to degradation, efficiency, cost and longer-duration systems. We are also seeing new players entering the utility-scale market with a different technological perspective. So, there is more to come with regard to lithium-ion, and particularly LFP. In terms of other technologies, we expect that sodium-ion will continue to be rolled out by major market players, but the technology still needs to be proven in the field.

Julian Gerstner, head of storage, BayWa r.e.

Storage technologies are always evolving, so you should keep an eye out for the development of sodium-ion batteries, which can be one of the few technologies able to achieve a market share comparable to lithium batteries, in the short term. They're still largely in the research and development stage, but I expect to see them become a popular choice for battery storage systems in the near future.

There is an additional technology with sodium-sulphur batteries available. A high-temperature battery, which has been commercially available for over ten years and with a proven operational track record. I believe this technology could be a hidden champion. Not reaching the volume of Li-ion or sodium-ion (Na-ion), but I believe market share will increase.

Recycling will also be a big trend, especially in Europe where regulations require the circulator of the battery, or the OEM, to take back batteries and recycle them accordingly. Further, nearly all major battery cell manufacturers are working on recycling factories, or are partnering with the recycling industry, because everyone wants to have their raw materials back. We'll certainly see a circular economy for storage developed in the coming years, eliminating recycling issues for batteries in the future.

Florian Antwerpen, managing director, Kyon Energy

In the dynamic landscape of energy storage technologies, several key trends are poised to shape the industry's future. From the Kyon perspective, these are some noteworthy developments:

- **Higher energy density with new LFP battery cells:** It is expected that the energy density of new lithium iron phosphate battery cells will increase in the future. This progress will lead to increased performance and capacity of the storage systems, all achieved within the confines of the same footprint. The potential for improved efficiency and performance makes LFP a focal point for innovation and progress in energy storage.
- **Sodium-ion batteries as complementary technology:** The spotlight is also shifting toward sodium-ion batteries, as they are slowly becoming more marketable. As the technology of sodium-ion batteries matures, their integration into the energy storage landscape could offer a compelling supplement to existing technologies such as LFP.
- **Rise of multi-hour storage:** The relevance and viability of multi-hour storage (3, 4, 5 hours) may witness a notable increase with complementary technologies. This synergy has the potential to enhance the dependability and economic feasibility of extended-duration energy storage solutions.
- **Price dynamics of lithium-ion batteries:** The trajectory of lithium-ion battery prices is a crucial factor to monitor. As advancements continue and economies of scale come into play, there is a compelling question of whether the cost of lithium-ion batteries will continue to decline. A decreasing price point could render multi-hour storage with lithium-ion batteries increasingly attractive, opening new possibilities and applications. ■

BloombergNEF notes uptick in China-based BESS providers as it launches Tier 1 list

BloombergNEF (BNEF) has launched its Energy Storage Tier 1 list of providers, noting growth in new players from the China market. Cameron Murray reports on the latest findings

The Tier 1 ranking of battery energy storage system (BESS) providers was released earlier his month. While its names have not been disclosed publicly, *Energy-Storage.news* can reveal that Fluence, Tesla, Powin, Wärtsilä and Hithium are there, while other major players such as Sungrow, Nidec, BYD, Samsung SDI and LG Energy Solution are likely to be too.

One notable new entrant is China-based Kehua (Xiamen Kehua Digital Energy Tech), primarily a power conversion specialist but increasingly in the BESS market with its most notable project outside China being one in Brazil, the country's largest. It is the only company to officially announce its inclusion.

Its place on the list is emblematic of the trend of China-based companies increasingly gaining global market share in the BESS space, which was also recently noted by S&P Global and Wood Mackenzie, and on which Yayoi Sekine, head of energy storage for BNEF, commented to *Energy-Storage.news.*

"While there are quite a few notable incumbent suppliers in the energy storage space (e.g., Fluence, Tesla, Wärtsilä, BYD, Samsung SDI, LG Energy Solution within others), we've seen a significant uptick of lesser-known suppliers, especially from China," Sekine said.

"The Chinese domestic market has picked up and battery manufacturing competition is leading a lot of those companies to integrate systems to provide to downstream customers. Many integrators are going upstream and manufacturing their own batteries."

Another notable inclusion is vanadium redox flow battery (VRFB) provider Invinity Energy Systems, most likely the only non-lithium manufacturer on the list.

Tier lists for clean energy technology providers exist primarily for purposes of bankability of projects. Benchmark Mineral Intelligence has the most notable tier list (1-3) of lithium-ion battery cell manufacturers, while BNEF already has a Tier 1 list for PV suppliers and tier lists also exist for inverter brands.

Sekine also commented on the benefits of being fully integrated with battery cell production versus being a pure-play system integrator, since the list includes both types of companies. Hithium is vertically integrated while Powin is a pure-play system integrator, for example, and Hithium is selling battery cells to Powin, the pair announced this week.

Credit: Kehua Digital Energy

Projects that Kehua, a Chinese firm which is on the list, has worked on in Brazil (top left) and China (other three)

"The advantage of being fully integrated is that there can be cost savings with the logistics and product development," Sekine said. "Being a BESS-only system integrator is an advantage when there is oversupply in the market, allowing those companies to purchase lower-cost cells when they are abundant and likely lower than if they were to manufacture it themselves (current situation now). Investing in cell manufacturing is a high-cost and highly skilled endeavour, not all companies are willing to go that far upstream."

The current market appears to be in a state of oversupply, with the price of both BESS and battery cells coming down substantially after the spikes of 2022. In research notes by S&P Global and Wood Mackenzie mentioned earlier this was attributed primarily to growth in BESS manufacturing from China stemming from an increasingly competitive domestic market there.

Methodology

The analysis is based on BNEF's 9,000-strong database of projects. While the list is not public, BNEF has released its methodology for drawing up the Tier 1 list. To be included, companies:

- must have supplied, or be firmly contracted to supply, products to six different eligible projects in the last two years and those projects:
  - must be larger than 1MW or 1MWh (whichever is higher);
  - must be owned by companies that are not affiliated with the energy storage provider (in other words, the purchaser of the energy storage system must be a third party);
  - cannot be built to meet renewable energy project integration mandates (such as those in place in many Chinese provinces);
- cannot have filed for bankruptcy or insolvency protection or is in default of major financial obligations;
- must own a manufacturing plant. ■

Freyr CEO on minimising European gigafactory investment: 'IRA has shifted the market'

Freyr has built a lithium-ion gigafactory in Norway, where it plans to build battery cells using the SemiSolid battery platform from 24M Technologies.

Credit: Freyr Battery

Cameron Murray speaks to Birger Steen, CEO of lithium-ion gigafactory company Freyr Battery, about its recent decision to minimise European investments in light of the Inflation Reduction Act (IRA) and a potential policy response

Freyr Battery, a NYSE-listed firm, has taken the drastic decision to minimise all further investments in its flagship Giga Arctic project in Mo I Rana, Norway, as well as other European projects. Instead, it will only focus on scaling in the US for now, where it is developing a gigafactory project in Georgia. Freyr has an ambitious 200GWh 2030 production target across its gigafactory projects in Europe and the US.

The company's share price has been falling since July but tumbled some 40% after its Q3 report in which it spelled out the decision. It sits at US$1.66 at the time of writing, 90% down from a year ago.

IRA has "shifted the market"

Put simply, the IRA's 45x tax credit for battery manufacturing, which is paid directly, has made it much harder to justify investing in Europe's industry, as Steen explained to *Energy-Storage.news*.

"When you have something that costs around US$100 per kWh to make (lithium-ion battery cells) and one continent is giving a US$35 per kWh tax credit to anyone building gigafactories, you've basically shifted the market. Everyone here has been working to get their head around what it means but no government in Europe has come up with an adequate response."

"It's why you are seeing lots of projects migrating to the US or Canada; it's hard to get project-level financing for these in Europe. Those pools of capital are global. Why would they do it in Europe when you can do it in the US for 35% cheaper? For now, all our scaling will happen in the US."

We asked Steen whether, assuming the company went ahead with its European projects as planned, the electric vehicle (EV) and energy storage system (ESS) industry would be nonetheless willing to pay a premium for locally made, greener battery cells.

He responded, tersely: "If that was the case, why would

the US do the IRA (and its generous tax credit for battery manufacturing)?"

On the ground in Norway, the company is close to completing the commissioning of its customer qualification plant (CQP), a smaller-scale production facility for customers to test batteries made using the proprietary semi-solid lithium iron phosphate (LFP) technology Freyr has licensed from technology company 24M.

Alongside pausing its European investments, Freyr has begun "cost rationalisation initiatives" to halve its use of cash compared to 2023, including laying off employees and contractors especially relating to the Norwegian gigafactories. It expects to exit 2023 with US$250 million in cash with a runway of two-plus years.

"Mutually attractive policy solution needed"

The Giga Arctic gigafactory building next door will be completed but will remain a shell, ready for a "hot start" but waiting for a "mutually attractive policy solution" from Norway and Europe, the company has said.

The pause in investment in Giga Arctic will "allow for continued technology development at the CQP while FREYR continues to work with stakeholders in Norway and Europe to establish competitive regulatory framework conditions for scaling battery manufacturing".

When asked what those competitive conditions and policy solutions would look like, Steen pointed to the example of the EU's Temporary Crisis and Transition Framework (TCTF), adopted by the bloc in March this year to foster support measures for sectors key to the energy transition. *Energy-Storage.news* has reported on substantial grant schemes for ESS deployments using it in Slovenia and Hungary.

Though note that Norway is not in the EU but is closely linked through the European Economic Area (EEA).

"World trade has been seen as a good thing and trade barriers have been seen as a bad thing, and there is a notion in Europe that this still needs to be the basic rule. But, the TCTF provides a loophole within those world trade rules," Steen said.

The firm has also asked for an "IRA-matching" package from the Norwegian government comprising export guarantees, loans and buybacks worth a total of NOK9.5 billion (US$870 million).

Steen added that by not matching the IRA, Europe risks remaining totally dependent on China for batteries and its battery industry going the same way as the PV module manufacturing one did.

"The PV market provides all the data and experience you need to understand what will happen to batteries and other green technologies. Is that kind of dependence and exposure in the current geopolitical realities something we want? It is the same plot, the same movie," Steen said.

"We have lithium in Finland, graphite in Norway. Developing this industry at giga scale from mining all the way to DC blocks is feasible and will drive the green transition. The question now is can we kickstart this industry."

Freyr still "very focused on ESS market"

Freyr has always been notable for targeting the stationary ESS market more than other companies building lithium-ion gigafactories and as such has featured more prominently in *Energy-Storage.news'* coverage.

Interviewing the then-CEO Tom Jensen in March 2022, he said the company could sell half of its long-term production into the ESS market.

"The PV market provides all the data and experience you need to understand what will happen to batteries and other green technologies. Is that kind of dependence and exposure in the current geopolitical realities something we want? It is the same plot, the same movie"

Recent events do not change its focus on ESS; Steen said: "We're very focused on the ESS market and building a system integration to build containerised BESS products. Given the softening EV demand and strong ESS demand, this focus has been a sensible choice. The specifics of the 24M tech also means a C-rate more amenable for ESS."

The firm's main route into the ESS market is a joint venture with system integrator Nidec ASI, finalised in December last year, whereby Freyr will build cells and modules based on Nidec's IP which Nidec will use to build the full containerised battery energy storage system (BESS) solution.

Conventional technology partnership with Sunwoda

Some have questioned Freyr's big bet on 24M's technology platform which has not yet been industrialised at giga-scale.

In June, the company announced it had entered into a heads-of-terms agreement with China-based lithium-ion battery cell manufacturer Sunwoda (a Benchmark Minerals Intelligence Tier 1 battery firm) to "expand business in the western hemisphere based on Sunwoda's conventional technology".

Steen wouldn't discuss this in any detail, but the company has said an option is to include a development track as part of its Giga America project for conventional production line equipment – i.e. building conventional lithium-ion battery cells.

The advantage of building a plant using conventional lithium-ion technology is that there is no need to build a pilot plant or CQP. ■

Augmentation strategies to manage long-term battery degradation

Giriraj Rathore of battery storage system integrator Wärtsilä Energy Storage & Optimisation explores some of the main strategies for successful battery augmentation, a key means of offsetting the impacts of system degradation

Energy storage is the backbone of the renewable energy transition, able to offset periods when the wind isn't blowing, and the sun isn't shining. With broad market recognition that energy storage is key to catalysing a future powered by zero-carbon energy sources, the sector is experiencing robust growth. Energy storage deployments in 2023 are on track to double those of the year prior. By the end of the decade, total capacity is set to expand tenfold, surpassing 400GWh.

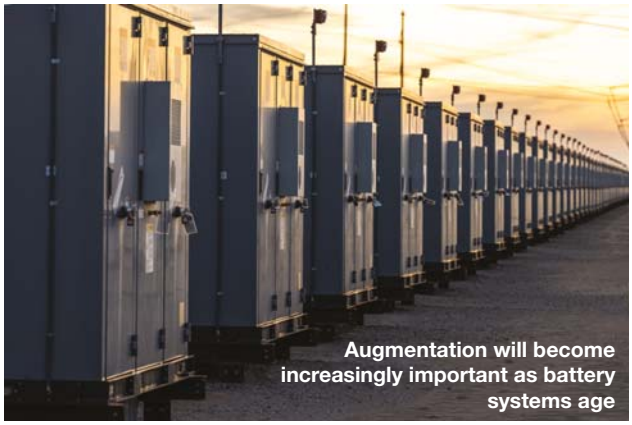
All battery-based energy storage systems degrade over time, leading to a loss of capacity. As the energy storage industry grows, it's critical that project developers proactively plan for this inevitable 'degradation curve'. Failing to do so will not only limit potential revenues but could even jeopardise the role of energy storage as a key enabler of grid stability and, by extension, the energy transition.

As the initial wave of grid-scale energy storage deployments begins to mature, managing the effects of battery degradation will emerge as a key strategy for developers looking to future-proof assets and accelerate renewable energy adoption. Many industry experts suggest that augmentation is poised to be the solution of choice, allowing developers to take advantage of declining battery costs and technological advancements.

Understanding battery degradation

Battery degradation in energy storage systems is a natural phenomenon. Just like portable electronics wear out to become less efficient over time — think of how long your old phone can hold a charge — the amount of energy that can be stored and dispatched from energy storage systems gradually declines. Whereas the average rate of battery degradation in electronics or electric vehicles is generally predictable, it's harder to calculate the decline of energy storage systems with similar accuracy. The rate of degradation and capacity loss is influenced by a variety of factors, including frequency of use, operational pattern, battery chemistry, and ambient operating environments.

Energy storage systems that engage in heavy arbitrage are particularly prone to rapid degradation. Arbitrage strategies involve purchasing and storing energy when prices are low and selling and discharging it when the demand for energy increases. Optimal charging and discharging intervals often run contrary to preferred arbitrage opportunities, meaning developers have limited visibility into the pace at which energy storage systems lose capacity. This is significant considering nearly 60% of installed energy storage systems were used for price arbitrage in 2021 — a number that is expected to continue to grow.



Augmentation will become increasingly important as battery systems age

Credit: Wärtsilä

Degradation rates also differ by battery type. There are several kinds of lithium-ion battery chemistries being used in the energy storage market today, and each comes with its respective benefits and drawbacks. Nickel manganese cobalt (NMC) had historically been the dominant chemistry for energy storage, but this is quickly changing. By 2030, lithium iron phosphate (LFP) is expected to be the dominant chemistry — growing from a market share of 10% in 2015 to more than 30% in 2030. The primary benefit of LFP battery technology is that it enables a longer lifespan compared to other lithium-ion chemistries.

Temperatures, both hot and cold, can have a significant effect on battery degradation. Higher temperatures may increase energy storage system performance in the short term, but eventually lead to higher degradation rates and a diminished lifespan. Once temperatures surpass 100 degrees Fahrenheit (approximately 38 degrees C), degradation in lithium-ion cells quickly accelerates. Prolonged exposure to extreme cold can also impact battery performance. When temperatures drop, internal battery resistance increases, which requires more effort to charge. This, in turn, lowers the system's overall capacity.

Managing degradation through oversizing or augmentation

Battery degradation in energy storage systems is inevitable. But it can be managed with careful planning and

consideration. It can even present opportunities for developers to improve the profitability and efficiency of energy storage facilities.

Traditionally, developers have accommodated battery degradation by oversizing their installations at the initial outset of the project. This approach involves installing more battery capacity upfront than needed and typically consists of site preparation, wiring, and system integration. The excess capacity enables developers to offset the expected degradation losses over the years, allowing them to maintain the contracted capacity over the project's lifetime.

A key advantage of oversizing is that it doesn't require site mobilisation, permits, additional labour, or the commissioning of new hardware down the line. By fronting the installation process, developers can keep their energy storage systems operational even as they contend with degradation. There's no need for assets to be shut down — either partially or entirely — for weeks or longer to perform retrofits.

Oversizing also enables developers to lock in capital expenditures at the project outset, mitigating future cost uncertainty and helping to improve forecasting. As the cost of lithium-ion batteries continues to fall to new lows, however, developers may lose out on significant savings by taking this approach.

Alternatively, developers may choose to offset degradation by augmenting the capacity periodically throughout the project's lifetime. In this case, there must be extra physical space with adequate electrical configuration in the initial project layout to add new hardware. Proper planning is critical to minimise downtime and risks associated with augmentation.

In 2013, one kilowatt-hour (kWh) of lithium-ion battery technology cost more than US$730. Flash forward to 2021 and that price had come down to US$141/kWh — a marked reduction of more than 80%. Had a developer opted to oversize their system back in 2013 as opposed to augmenting it years later, they would have paid almost twice as much while missing out on important technological advances that offer greater efficiency. Of course, battery prices do occasionally tick up — like in 2022 as a result of inflationary pressures and supply bottlenecks — but these can be seen as an exception to a much wider trend.

Suppliers have since rebounded from 2022's difficulties and battery prices are once again trending downward. Costs are further expected to fall as battery manufacturers ramp up production. By 2030, lithium-ion battery capacity is set to more than double, which will go a long way towards alleviating supply shortages. Furthermore, the US National Renewable Energy Laboratory suggests that the costs of lithium-ion energy storage systems could decline by up to 47% by 2030.

As prices continue to fall, augmentation is becoming an increasingly attractive way for developers to mitigate battery degradation and capacity loss. It may not be right for every situation, though, as each energy storage project is unique and different augmentation strategies depend on the appetite for potential risk and reward. Still, the likelihood of further cost reductions — especially considering the already low price of lithium-ion battery technology — makes augmentation particularly alluring.

Credit: Wärtsilä

The choice of augmentation method depends on the type of system, its grid connection and the services it provides

Choosing between augmentation strategies

There are two primary methods of augmentation — alternating current augmentation (AC) and direct current (DC) shuffling — that developers can choose between based on their system type, grid connection, and needed services.

AC augmentation focuses on improving the interplay between the energy storage system and electrical grids, enhancing system stability, and enabling grid support functions. With AC augmentation, new physical infrastructure is added to the project, including inverters and Power Conversion Systems (PCS), which are responsible for making AC electricity usable in downstream devices like energy storage.

Alongside the PCS, new protective enclosures are installed to house essential components, including the batteries themselves and associated safety, control, and monitoring equipment. The added capacity of AC augmentation can be installed without requiring significant modifications to existing equipment, minimising disruption. It also offers significant system flexibility, allows for incremental sizing, and presents an extremely low risk of technical complications.

However, there are a few drawbacks associated with AC augmentation that developers should keep in mind, particularly for grid-connected energy storage systems.

Adding new PCS equipment — while relatively straight forward from a technical standpoint — requires permitting and regulatory approval when connected to the grid. This process is cumbersome, time-consuming, and extremely complicated, slowing down the ability of developers to augment their systems. These limitations don't impact energy storage systems that are independent from the grid, however. Islanded microgrids can forgo lengthy bureaucratic approvals, making them well-suited for AC augmentation. For grid-connected energy storage systems, DC shuffling is the more suitable augmentation strategy.

DC shuffling prioritises the internal distribution of energy within battery stacks to ensure balanced charging and discharging of individual cells and modules, which is vital for prolonging battery lifespan and maximising overall system efficiency.

Whereas AC augmentation primarily focuses on external interactions between energy storage systems and the grid, DC shuffling optimises energy distribution within battery stacks, delivering greater internal efficiency and resiliency.

By reconfiguring battery enclosures from one string of batteries and transferring them equitably throughout the system, DC shuffling leads to a more balanced distribution of energy across the battery stack.

A new string of enclosures is then introduced behind the PCS from which the existing batteries were shuffled. This addition guarantees that the overall system retains its power capacity and that the number of PCS units and the nominal power of the plant remain unchanged. This allows DC shuffling augmentation to bypass permitting and regulatory approval, as there are technically no new connections being made to the grid.

DC shuffling also benefits from lower equipment costs relative to AC augmentation, as there's greater repurposing of infrastructure. DC shuffling is well suited for grid-connected ESS, though it may not always be possible due to technical limitations, from auxiliary load breaker and busbar limitations to short circuit ratings. Consequently, developers must diligently evaluate the specific technical and operational aspects of their systems before deciding whether to invest in AC or DC augmentation.

Bringing it all together

There may not be a standardised rate of battery degradation in energy storage systems, but software can provide invaluable insights, helping inform augmentation decisions. Sophisticated energy management programs, such as ES&O's GEMS Digital Energy Platform, can gather operational data over a period to inform recommendations on capacity enhancements that can result in significant monetary gains.

Energy management software is not only useful for making data-driven decisions, but it's also key to seamlessly and cost-effectively implementing augmentation strategies. Software optimises the dispatch of augmented energy storage systems and harmoniously integrates the new and existing equipment. Energy management software must be flexible and powerful enough to incorporate disparate battery technologies and capacity levels. In cases where new equipment differs significantly, a software system's ability to coordinate and control these diverse technologies is indispensable.

Developers must also consider the importance of complementary augmentation technology. Augmenting with batteries of different capacities can introduce significant complexities that need to be handled with the utmost care. LFP batteries, for instance, require different thermal management strategies compared to NMC batteries. Improperly integrating these technologies can lead to potential repercussions, including voltage imbalances that could trigger thermal runaway. Moreover, developers that incorporate battery modules from different manufacturers run the risk of software incompatibilities, which could impact monitoring and controlling processes and risk overall system performance and safety.

To mitigate these issues during augmentation — whether AC or DC shuffling — developers should look to leverage complementary technologies wherever possible. The careful selection of augmentation equipment and the utilisation of advanced software solutions can help ensure the successful and safe augmentation of energy storage systems.

Battery degradation management will remain important into the future

The energy storage landscape may be dominated by lithium-ion battery technology today, but that could very well change in the future. There are a range of emerging technologies including sodium-ion (Na-ion), hydrogen, and long-duration energy storage (LDES) that have significant potential.

Na-ion batteries, for instance, offer a reduced environmental impact and safety benefits relative to lithium. Hydrogen, lauded for its high energy density and versatility, also holds great promise as a clean and flexible storage solution. Meanwhile, LDES technologies offer extended discharge periods, addressing the need for sustained power during prolonged lulls in renewable energy production.

These technologies, while promising, have not yet been deployed at scale. They will have to prove themselves individually at the grid level before developers have enough faith in being able to use them for augmentation. But as these up-and-coming storage technologies mature, they have the potential to reshape the augmentation landscape, providing developers with an array of options that can enhance the resiliency, efficiency, and sustainability of their energy storage systems.

With hundreds of gigawatts worth of battery-based energy storage systems operating at a global scale, mitigating capacity losses will become a central part of managing projects for developers and integrators in the years to come. Careful battery degradation management practices including augmentation will enable developers to drive greater performance, lower lifetime costs, and keep the renewable energy transition moving forward. ■

Author

Giriraj Rathore, in his role as the business strategy manager at Wärtsilä Energy, harnesses a blend of technical expertise and strategic acumen to drive innovation in energy storage solutions. His educational background includes a bachelor's degree in mechanical engineering, complemented by an MBA specialising in international business.

Energy storage and energy density: an EPC's view

Energy density is becoming a key tool in optimising the economics of battery energy storage projects as suitable sites become harder to find. Ben Echeverria and Josh Tucker from Burns & McDonnell explore some of the considerations of designing projects on constrained land

When transmission authorities in the USA first began to realise that utility-scale storage facilities would be necessary to help manage the intermittency of renewables being connected to the grid, land availability was not a concern. With Arizona, California and Texas leading the way, land was readily available for large project footprints.

Given both space and favourable market conditions, buildout was not an issue and, as a result, those three states currently contain more than 75% of today's battery storage capacity nationwide.

Those early market conditions are no longer the reality. Sites with large amounts of available land near transmission interconnections are becoming increasingly scarce, and that can make today's project sites more challenging, especially as demand for these facilities continues to grow. A range of federal tax incentives and state mandates is creating more momentum for decarbonisation efforts than ever, further increasing the demand for large-scale battery energy storage systems (BESS).

Sites may still be available near interconnection locations, but they typically have much smaller footprints, and as a result of constrained supply and high demand, land prices in these situations are increasing. As a consequence, developers are seeking to significantly increase the amount of energy storage per acre. This drive to optimise project economics is being pursued by seeking more energy-dense batteries while also optimising the available site footprint.

What is energy density?

The volume of energy contained in each battery cell can play a pivotal role in project economics. The standard definition of volumetric energy density is the amount of energy a battery can store in proportion to its volume (specific energy density is stored energy in proportion to its weight). To be clear, we will be referring to energy density in this article as volumetric energy density. The industry has progressively improved upon battery energy density, with lithium-ion batteries increasing the energy available in the same footprint by about 10-12% over the last year.

Of the most common lithium-ion battery chemistries used today, nickel manganese cobalt oxide (NMC) and nickel cobalt aluminium oxide (NCA) battery technologies are the energy density leaders. Lithium iron phosphate (LFP) battery technology is another common battery chemistry, but it is much less energy dense. More recently, however, LFP has made gains in this area, with some believing there is significant opportunity for this chemistry to attain densities close to NMC and NCA.

Credit Burns & McDonnell

Higher battery racks is one option for increasing energy density as battery sites become more constrained

These lithium-ion technology advances, including energy density, are largely driven by demands from the electric vehicle (EV) industry for improved ranges and performance characteristics for batteries installed in vehicles. Because the power industry holds such a relatively small share of the lithium-ion battery market, the reality is that advances in utility-scale BESS installations will likely move in lockstep with the auto industry. Supply chains, manufacturing advances and general use cases for battery technology are all heavily weighted toward meeting auto industry demands.

On the horizon, it seems that very large, energy-dense battery cells will be developed to produce more energy from increasingly small volumes. With new and improved electrolytes, anode advancements, and cathode evolution, ranges for EVs and output for storage facilities can be greatly improved.

Building up, not out

In densely populated metropolitan areas like Los Angeles, New York City and Boston, decarbonisation efforts are creating unique challenges for battery energy storage projects.

New York is an interesting case example. Though actual numbers will vary by the time of season, it is generally assumed that approximately 70% of the power load within the state of New York is centred around demand from New

York City. As New York utilities move toward meeting regulatory mandates for reduced or zero-carbon emissions, thermal generation systems are being ramped down or retired. Renewable energy backed by storage-based power systems will be needed to fill the gap.

It is logical to locate these renewables and storage systems within the city. In New York City, smaller facilities in the 5-20MW range are being planned and developed. As deadlines for decarbonisation grow closer, it seems likely that these smaller projects will fall short of demand and larger projects will be needed.

However, the reality is that within large, dense urban areas, only small plots of land are available. The only realistic and economically viable option is to design these projects vertically, either with batteries installed in enclosed building structures or with vertically stacked battery enclosures. If the building is the preferred solution, this may involve stacking multiple racks to increase total rack heights up to 15 feet versus the conventional 7-foot racks. This could involve the building having multiple stories of these taller racks.

With this configuration combined with higher energy density within battery modules themselves, the overall energy capacity will come close to meeting higher energy demands of these metro areas.

Going vertical is more complex

Though numerous projects are now on the drawing board, it must be noted that no high-rise BESS facilities are currently operational.

That's because going vertical requires careful evaluation of operations and maintenance impacts, including installation of robust safety systems. These analyses shift the focus from performance and design of modules toward a holistic look at the entire site. Considerations will be given, for example, to the broad operational effects of utilising heavy mechanical equipment in compact spaces that must operate safely.

Operating conditions for vertical BESS projects — as well as conventional projects — must be evaluated for each site. Storm and flood risks, relative humidity, seismic considerations and prevalence of salt within coastal air are among the environmental factors that can affect how the site will be designed and operated. The development of an operations and maintenance programme should include evaluating tolerances of all critical battery chemical processes in parallel with design, safety and equipment decisions.

There are a range of battery storage enclosure design options available, but all must account for the challenges of airflow, thermal management and accessibility for routine maintenance.

Enclosing a BESS facility in a multilevel steel structure may have advantages in accommodating equipment and incorporating critical safety systems. Alternatively, an open-air design, similar to a mezzanine, can create an accessible internal layout with systems on different levels. Many innovative variations of enclosed and open-air systems go beyond rack storage or purpose-built solutions.

The tonnage that can be feasibly transported to land-constrained sites is one consideration to make

Credit: Burns & McDonnell

Other options for density

Battery suppliers are modifying cell and module designs and footprints, along with enclosure designs, to maximise battery density and decrease spacing between enclosures. Numerous creative designs are currently in development to make maximum use of space, thus increasing energy density for the project site.

One realistic constraint is the tonnage that can be feasibly transported to the job site and then lifted into place either by crane or forklift. This becomes a logistics challenge that starts as a total turnkey operation from the original manufacturer (primarily in Asia), transport to a container ship, offloading to a truck, transporting to the project site and final offloading to be set in place.

Planning for these highly energy-dense facilities must also factor in degradation of battery performance over time. The operations and maintenance strategy should incorporate a workable installation process to augment battery capacity over time as the overall system degrades, and/or to overbuild the system from the start to extend the time frame when augmentation is to occur and thus reduce the amount of battery augmentation required.

What about safety?

Thermal runaways start as a short circuit within or external to the battery cell that triggers an exothermic reaction. These reactions produce enormous heat and explosive gases that can lead to fires and/or explosions if the event occurs within a contained space that is not ventilated.

The amount of heat and gas emitted during a thermal runaway event is dependent on several factors including the battery's state of charge. That means that as battery cells are designed to store more energy, thermal runaways can become more intense. Thermal runaway events within NMC and NCA batteries generate more heat, which in turn causes a greater chance of propagating to other cells and modules. NMC and NCA battery chemistries also tend to have a flame associated with a thermal runaway event that can burn off the explosive gases that are emitted from the battery.

LFP technology does not emit as much heat during a thermal runaway event due to the chemistry and metals utilised, and thermal runaway events for LFP can have a lower

risk of thermal runaway propagation. However, this chemistry can pose another set of risks.

Due to lower heat values lower and lack of flame during a thermal runaway event, LFP chemistry can create more explosive gases that can raise the risk of explosions for these batteries located in contained spaces.

Fire suppression systems for all lithium-based technologies currently aim primarily to protect the building and related enclosures. There is no silver bullet for stopping thermal runaway within the lithium-ion technology group, simply because it is a chemical reaction that is hard to stop once it begins.

Effective thermal management programmes may utilise HVAC (Heating, Ventilation, and Air Conditioning) or chiller systems that aid in maintaining operational stability while lowering the risk profile for batteries to go into thermal runaway due to thermal abuse. For example, direct expansion air handling units using refrigerant liquid are an option. Though these are reasonably cost-effective to install, it must be noted that efficiency decreases over time. Central utility plant designs incorporating large centrifugal chillers are another option that can be used to distribute cooled water across large interior spaces. This proven technology offers the potential for redundancy and greater operational flexibility. Placement of racks in vertical configurations can add another element of thermal management by creating different heat zones and hot and cool aisles.

Other battery chemistry options

Though there are a number of non-lithium technologies in development, none to date can compare to the energy densities, better efficiencies and lower capital cost of lithium-ion batteries.

Several non-lithium battery technologies are proven but are unlikely to unseat the dominance of lithium-ion anytime soon. Unless a technology emerges with the scale and economic viability to support a robust supply chain, we are unlikely to see another dominant technology emerge in the utility-scale energy storage market in the near term.

If it weren't for the demand for batteries generated by the automotive industry, it's difficult to predict what type of storage technology would be emerging to meet the changing demands of the power industry. The known alternatives currently provide only a fraction of the energy density available from the primary lithium-ion battery technologies. The round-trip efficiencies — defined as the percentage of electricity put into storage that is later retrieved (i.e., the higher the round-trip efficiency, the less energy is lost in the storage process) — are not as high with alternative battery and other storage technologies at present.

Flow battery technologies, for example, offer certain advantages such as longer output duration and longer cycle life, but are hampered by lower round-trip efficiencies.

The market dynamics will change as more thermal power plants are retired. As dispatchable power units with capacity to provide many gigawatts of round-the-clock baseload power leave the market, use cases for long-duration storage will increasingly come to the forefront. Though market dynamics currently favour lithium-ion BESS facilities, that could change if these facilities were needed to provide round-the-clock power output.

No project is identical

Energy density has become a priority for both operational and financial reasons, but to date, most of the advances have come primarily from the batteries and secondarily from space optimisation within enclosures, along with creative enclosure configurations.

Energy density has become a priority for battery OEMs to help reduce total project cost and fit more capacity within small footprints. However, as the grid continues to change and the market shifts to deeper decarbonisation, it is unclear whether energy storage technologies will advance enough to meet the demand for baseload power. Ultimately, money is the driver within any market, and with the reduction of capital it may be that planners and policymakers begin to conclude that it is imperative to adjust policy or regulatory drivers to keep pace with continued increases in capital cost or to provide further incentives to advance the development of lithium-ion technologies and other technologies.

One possible sign to indicate the technology advancement for the energy storage market is shifting is the development of battery cell types geared specifically to meet the needs of the power industry. The energy storage market previously used battery cells generally designed for the EV market and not necessarily designed with a use case for the storage market. By optimising the cell design for storage applications, improvements in degradation and cycle life (i.e., life of the battery) can be achieved. Some manufacturers are starting to offer a 25-year performance guarantee (one cycle per day) for certain battery types.

As more fossil-based thermal generation exits the market, that capacity must be replaced by other sources along, energy storage playing a key role. As these energy storage systems are moving into more urban areas, energy density and land availability will be topics of great interest for the foreseeable future. ■

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Designing a 200MW/800MWh BESS project in Italy

Engineering firm Benny Energia provides us exclusive insights into a 200MW/800MWh project they developed in Italy, where grid-scale deployments are set to soar over the next few years

Project overview:

- Battery energy storage system (BESS) project in Friuli Venezia Giulia, Italy, designed by Benny Energia
- Power installed: 200MW
- Energy capacity: 800MWh
- Charge and discharge hours: four hours

In the last two centuries, there has been a significant increase in the global demand for energy. However, the consequence of this growing demand is the uncontrolled use of fossil fuels. Fossil fuels have played a significant role in the increase of greenhouse gas emissions, triggering a severe environmental crisis.

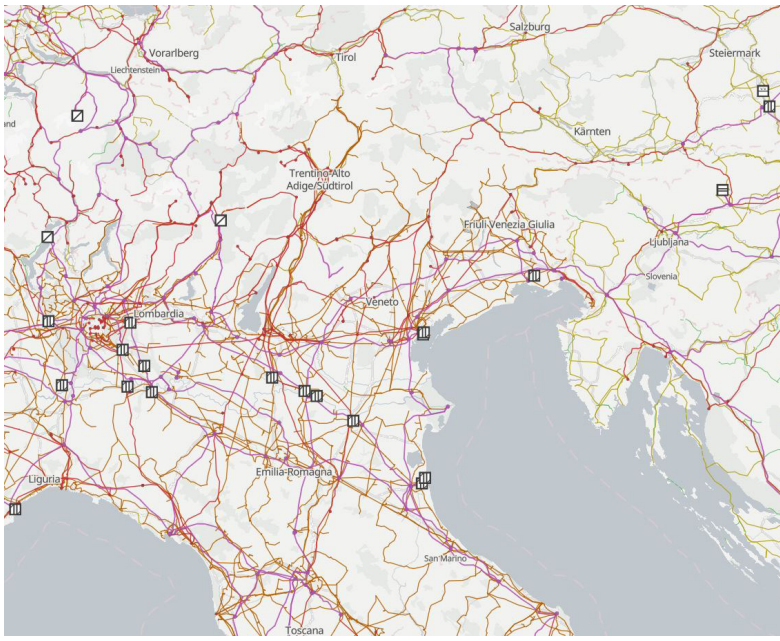
Human activities contribute to the accumulation of greenhouse gases, causing a rise in global temperatures. This, in turn, leads to changes in snow and precipitation patterns, an increase in average temperatures, and a higher frequency of extreme weather events such as heatwaves and floods.

In order to address climate change, the European Parliament has voted in favor of the European Climate Law, raising the target to reduce net greenhouse gas emissions by at least 55% by 2030, compared to the current 40%, and proposing the legal obligation to achieve climate neutrality by 2050.

To achieve its ambitious goal of climate neutrality by 2050, the European Union is promoting the decarbonisation of the energy sector by gradually replacing fossil fuel energy sources with renewable sources such as wind, solar, and biomass. A significant added value in the decarbonisation process is provided by “sector coupling”, which increases the need for flexibility and reliability while reducing the overall costs of the energy transition.

Sector coupling involves two complementary scenarios: the electrification of final consumption and the integration of energy networks and vectors. The first scenario ensures a strong penetration of renewable sources and a push for energy efficiency but requires a high need for flexibility in the network and the enhancement and extension of undersized transmission and distribution networks.

The second scenario involves supplementing renewable electricity with other energy vectors such as biogas, biomethane, and hydrogen for applications in sectors difficult to electrify [1]. In both scenarios, energy storage systems play a fundamental role, allowing the matching of renewable energy production with demand when they are not simultaneous and storing excess energy to prevent wastage.



TSO Terna’s 150 KV transmission network across Northern Italy.

The project

Given the importance of energy storage systems in the context of the energy transition, Benny Energia has developed the largest battery energy storage system (BESS) in Europe, to be located in Friuli Venezia Giulia, Italy.

The project, submitted for approval in December 2021, is expected to be operational by the end of 2024.

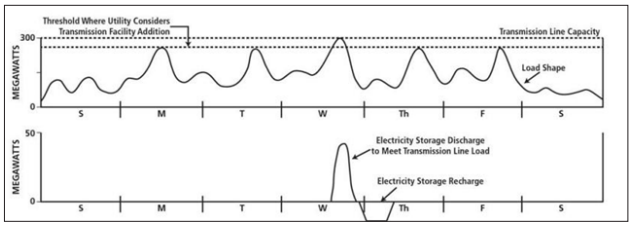
The design of a BESS, the subject of this article, involves determining a suitable area for the system. The chosen area must meet criteria defined by customer’s guidelines.

Location and suitability of land

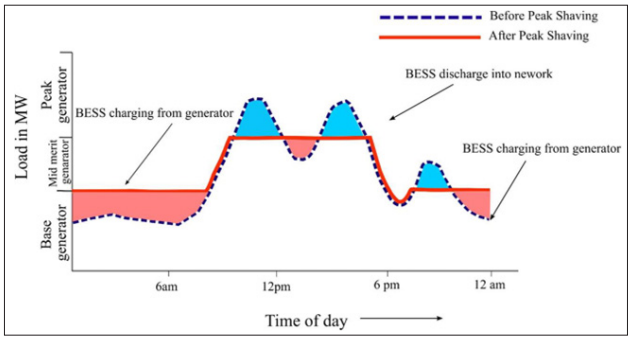
Firstly, the area must be close to the substation, and its dimensions must allow for the placement of all containers and auxiliaries. The connecting roads between the airport and the site, as well as access roads to the area, must be suitable for the transit of vehicles needed for the transport of goods.

Additionally, the maximum slope of the site must be below 15% to optimize design.

Subsequently, after an analysis of the area within the region-



The operation of a BESS project over the course of a week.



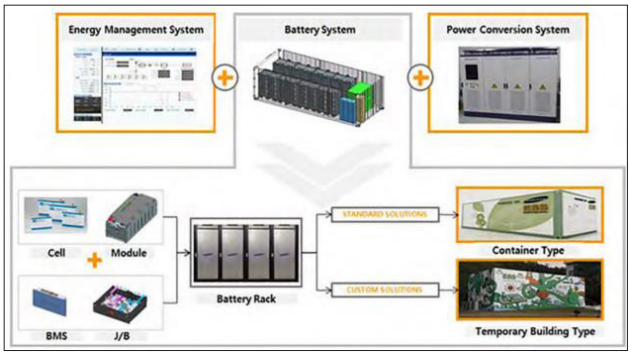
The operation of a BESS project through the day.

al territorial plan, it is necessary to assess urban and territorial compliance through an analysis of landscape, archaeological, and hydrogeological constraints. These are essential to evaluate the risk of possible landslides or seismic events that could lead to ground collapse.

The area identified for the 200MW BESS project is adjacent to one of the main Terna substations in Friuli Venezia Giulia Region.

Using the QGIS software, an open-source Geographic Information System (GIS), the slope of the area and its non-interference with constraints have been evaluated. The slope analysis within the QGIS software can be performed using a Digital Elevation Model (DEM).

The DEM used, obtained from distinct DEMs of individual administrative regions of Italy, was provided by the Pisa section of the National Institute of Geophysics and Volcanology (INGV) and pertains to the elevation of bare terrain, also known as the Digital Terrain Model (DTM) [2]. The DEM is loaded as a layer and can be used to determine the slope of the area, resulting in a temporary layer automatically overlaid on the DEM that generated it.



The composition of a BESS project, including BESS, PCS and energy management system.

The analysis determined that the identified area fell within a zone with a slope of less than 5% and was therefore suitable for the installation of the BESS system. To determine the suitability of the area, it was verified that the chosen area for the BESS system did not interfere with landscape and environmental constraints through overlays of the examined area on maps of the main constraints.

Firstly, Landscape Constraints under Legislative Decree 42/2004 were analysed as well as interference with landscape protection zones such as riverbeds and archaeological areas.

The examined area does not interfere with landslide scenarios and/or seismic events in the territory and complies with the flood risk constraint.

In fact, the area does not fall within flood risk zones and no interference was detected between the area of the BESS system and protected areas.

Configuration of the BESS project

The design of the BESS system involved a layout sized according to the availability of land use making possible a plant having an installed capacity of 200MW.

The plant layout consists of multiple of containers grouped into base units each equipped with its own Power Conversion System (PCS). Within the area, control cabinets necessary for supervision of the transformers in the area, control of measurements (voltage, current, frequency) and optimal working temperatures of the batteries were set up.

In addition, the connection wiring diagram describing the connection of each individual container of the entire plant to the Terna Station stall was made. The single line wiring diagram was equipped with all the necessary control and protection systems.

The design difficulties that Benny Energia encountered and overcame during the plant design phase were the presence within the area of an overhead HV power line, the need to maintain distances congruent with current fire prevention regulations, and finally the need to keep noise below an acceptable threshold.

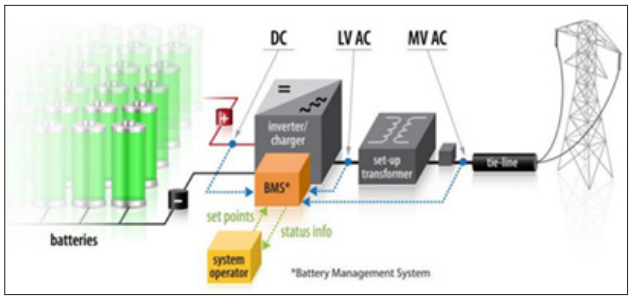
The BESS containers

In the BESS container, secondary lithium-ion batteries are housed, assembled in strings of batteries connected in series, installed in parallel to form modules. These modules, in turn, are connected in strings of modules in series and are housed in rack mounting structures.

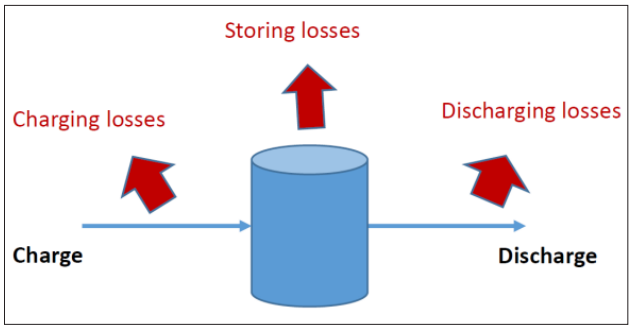
The battery racks are connected in parallel to meet the nominal energy capacity and are arranged inside the battery container.

Lithium-ion battery technology

Lithium-ion batteries represent the most advanced technology in the field of electrochemical storage systems due to their high specific power. However, their main disadvantage is the high cost due to the need to implement safety systems to



How the batteries connect to the grid via DC, low-voltage AC and medium voltage AC connections.



Energy losses occur to some degree during all stages of a BESS activity.

prevent overcharge situations.

Despite the existence of a wide range of lithium batteries with different cathode compositions, they share a common basic structure. These devices include an anode generally made of graphite and a cathode made of a metal oxide, and their assembly creates a layered or tunnel structure to facilitate the insertion and extraction of lithium ions.

The electrolyte, both liquid and polymer, serves as a link between the positive and negative electrode, which are separated by an electronic insulating layer, usually made of polyolefin. The electrochemical reactions vary depending on the type of cell, but the open-circuit voltage ranges between 3.6 and 3.85 V. Lithium batteries are high-energy systems and require extremely cautious handling.

Safety measures

Electrical, mechanical, and thermal abuses can cause problems in their operation such as thermal runaway that damages the cell and, in the worst cases, can lead to gasification and the release of flammable vapors containing solvents present in the electrolyte.

For safety reasons, the cells are often contained in robust metallic containers. One of the most critical aspects of lithium-ion cells is their degradation over time, which leads to a progressive reduction in capacity compared to factory data, even in the absence of charge/discharge cycles.

The system is equipped with a Battery Management System (BMS) capable of monitoring cell-to-cell variations over time: diagnosing errors, detecting safety hazards, and issuing warning signals. It records signals from the battery pack and individual cells, storing data related to the battery's lifecycle history. Additionally, it measures voltage, current, and temperature signals and monitors these parameters to achieve cell balancing and prevent battery damage. Finally, it determines cell and pack levels, such as State of Charge (SOC) and State of Health (SOH).

The container structure considered is self-supporting, metallic, for external installation, built with profiles and insulated panels and is designed for outdoor use. Profiles and insulated panels are used. This design allows the entire system to be transported and installed without the need to disassemble the various components of the container, except for the battery modules, which could be disassembled and transported separately if necessary.

The containers have standard dimensions. Each container is equipped with environmental sensors, including those for temperature and humidity, to constantly monitor internal conditions. If required, the containers have an air conditioning and ventilation system to ensure optimal environmental conditions for the proper functioning of various components. A liquid cooling system is also present.

To prevent emergency situations, the internal temperature of the container is monitored using thermocouples, especially for detecting possible fire residues. The container is protected against the entry of dust and water jets from various directions, providing a safe and secure environment for the energy storage system. ■

Authors

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Dr. Andrea Giulio Barone, founder and CEO of Benny Energia, has more than 20 years of experience in structured finance and 10 years in the financial, economic, and managerial sectors of renewable energy.

Eng. Marta Maiolati, development manager, has over 10 years of experience in the design and development of renewable energy plants, and has worked on over 300MW of solar PV and 3.5GW of BESS.

Eng. Filippo Onori, PhD student at Marche Polytechnic University, worked on a thesis for a master's degree in mechanical engineering on the design and management of the 200MW BESS plant.

References

[1] E. Rodrigues, R. Godina, S. Santos, B. A.W., J. Contreras e J. Catalao, "Energy storage system supporting increased penetration", Energy, Volume 75, 2014, pages 265-280.

[2] S. Tarquini, I. Isola, M. Favalli, A. Battistini e G. Dotta, "TINITALY, un modello digitale dell'Italia con una dimensione della cella di 10 metri (Versione 1.1)," Istituto Nazionale di Geofisica e Vulcanologia (INGV), 2023.

‘Every energy storage project’ will require regular upgrades to stay in the game

FlexGen’s Yann Brandt tells Andy Colthorpe why changing market dynamics mean energy storage systems will need to be upgraded many times over their operational lifetimes

It is a “certainty” that all grid-connected energy storage systems will require upgrades to their software, although the reasons for upgrades will be varied, *Energy-Storage.news* has heard.

Yann Brandt, chief commercial officer (CCO) at software-centric battery storage system integrator FlexGen told us that in his view, “every single project around the world is going to need upgrades at some point”. Brandt gave an interview following a FlexGen announcement a couple of months ago that the system integrator had carried out a number of upgrades to customer battery energy storage system (BESS) assets in the ERCOT, Texas, market.

In addition to providing commissioning, engineering and procurement services for utility-scale BESS, FlexGen also onboards projects with its energy management system (EMS) and digital controls platform, Hybrid OS.

Over in ERCOT, FlexGen carried out upgrades to Hybrid OS for its customers’ sites to meet changing power market regulations as well as new utility standards. The company claimed that through field experience and application of R&D work at its new laboratory and compliance centre facilities, it has managed to reduce the time required for such upgrades by about 75%.

That matters, Brandt said, because whether asset owners and investors are aware of it or not, their BESS project too will be in line for the upgrade treatment, sooner or later.

“The reality is: energy storage projects are going to be upgraded many times over their lives, no matter which ISO you’re in because regulators are going to change the way that batteries have to operate in the grid, power markets are going to change, revenue opportunities are going to adapt, and some projects are going to enter into different financial relationships, whether it’s corporate PPAs, or some other hedges or tolls,” Brandt said.

In this particular case, it was that grid and wholesale electricity market operator ERCOT implemented some new ancillary services products, Fast-Frequency Response (FFA) Advancement and ERCOT Contingency Reserve Service (ECRS).

To keep up with revenue opportunities, BESS assets need to remain in compliance with the codes and parameters governing those opportunities. That necessitates upgrades, and in some of the more fast-acting markets, those will be more frequent. “It’s just a fundamental necessity that you need to update your systems,” Brandt said.

BESS market adaptation

There will be lots of different reasons for upgrading. In December 2023, *Energy-Storage.news* hosted a webinar with Fluence – one of FlexGen’s rival system integrators – on the need for BESS asset operators to respond to changing energy market rules. It examined how Fluence’s Mosaic automated bidding platform was used to adapt the market participation of a 720MWh BESS in California’s CAISO market to changes in market rules. Fluence product manager Drew Skau explained how the BESS’ owner, utility PG&E, was able to optimise the battery’s performance and revenue potential in the face of those changes.

A BESS project integrated by FlexGen

Credit: FlexGen.

Creating new value with upgrades

One interesting difference between CAISO and ERCOT is that CAISO expects to manage state of charge in batteries connected to its grid, while ERCOT does not, although state-of-charge monitoring has been proposed in ERCOT recently.

FlexGen’s EMS is capable of providing good state-of-charge data, Yann Brandt said, due to in-built data analytics capabilities. That’s an advantage in markets like CAISO where that’s a necessity of market participation and has a multitude of other purposes.

“Having an analytic system embedded into an EMS allows you to be able to make real-time decisions based on what you’re seeing from the asset, versus what should have happened with the asset against the theoretical, digital mirror image of that site,” Brandt said.

The energy storage market is still at its early stages, but is already “roaring”, because the fundamental need for energy storage is converging with the market reality that money can be made from it, the FlexGen CCO said. In all of that excitement, asset owners perhaps don’t think too much about what happens a little way into the lifetime of a project, and perhaps aren’t aware that there may come a time when they want to, say, swap out an EMS or change which optimiser takes their asset into the markets.

“Hopefully by telling this story, people will at least think about the reality of: ‘What will I do when I need to do upgrades due to compliance?’ That’s definitely something we want more people to think about when they’re building sites.” ■

Virtual power plants enable operators to pool customer-sited resources into a whole greater than the sum of its parts, as illustrated in this graphic by SolarEdge

Credit: Image: Businesswire.

Virtual power plants: A 'critical resource' for meeting rising electrification

Andy Colthorpe speaks with Jennifer Downing, senior advisor to the Loan Programs Office at the US Department of Energy (DOE) and author of a recent report into virtual power plant technology

Virtual power plants (VPPs) have existed since the latter part of the 20th century, as a form of demand response technology. Large energy users at industrial or commercial sites have been incentivised to turn down their electricity use at the request of utilities or grid operators during peaks, while in some cases, the use of other energy-intensive equipment like water heaters has been managed to help mitigate peak demand.

However, how we look at the term has changed radically in the past 10 years or so, as it has come to encompass different models of aggregated distributed energy resources (DER), pooling their capabilities to provide grid services or energy capacity.

In this way, VPPs can disrupt the centralised model of electricity networks built around large-scale power plants. Customer-sited DERs, like rooftop solar PV, electric vehicle (EV) chargers, heat pumps and, of course, battery storage systems, all have a role to play in today's virtual power plants.

However, the potential use of VPPs as a grid flexibility resource is largely untapped. That led the DOE's Loan Programs Office (LPO) to identify VPPs as a technology area that, like long-duration energy storage (LDES), green hydrogen and other emerging low-carbon resources, could use some help in educating the market.

A September report in the DOE's 'Pathways to commercial liftoff' series for emerging climate tech highlighted the potential of VPPs, as well as the challenges ahead. Report

author and LPO senior advisor Jennifer Downing told *Energy-Storage.news* a while back that battery storage is perhaps the most versatile resource available to VPP operators.

What follows is our conversation with Downing, where we explore some other areas of the LPO's research into the technology and the associated business models.

A variety of factors have been holding VPP technologies back from widespread adoption. What were some of the reasons why the DOE identified this as an area to write about in the 'Pathways to commercial liftoff' series of reports?

From a high-level view, we are experiencing an increase in demand at a pace and magnitude that we have not seen in decades, and that is thanks to the electrification of vehicles, industry, heating, and data centres… it's really increasing the peak demand on the grid that we need to solve.

We think about this at the Department of Energy as really needing three pillars of investment.

One is more generation, two is grid-enhancing technologies that increase the capacity of the lines to deliver the electrons, and three: demand flexibility or virtual power plants that allow us to flex demand with the same level of dexterity as, traditionally, we've only used to flex supply.

That is why we wanted to shine a light on virtual power plants because they are so critical in meeting demand needs on the timescale that we need to electrify. If you look across those three pillars, VPPs can be among the fastest solutions.

If you have a customer-sited resource, you are not waiting in transmission interconnection queues for three, four or five years. If you look at the timeline to build a small modular reactor, it's a lot longer than ramping up your capacity via solar and storage systems on commercial rooftops, for example.

We're going to need 'all of the above', but we wanted to make sure that people weren't discounting demand flexibility as we think about serving higher load. And really, it's about using the infrastructure that we have more efficiently.

I've heard people comment that you could build a single-site battery storage project that's perhaps 100MW, and that could be somewhere between one-hour to four-hour duration. Whereas to build that same amount of battery storage across residential or even commercial VPPs takes a lot of individually sited systems. I guess their argument is that building large-scale is effectively cheaper than aggregating behind-the-meter systems, but what's your take on that view?

It's a couple of things. One is that customer-sited resources don't require the same kind of land and construction. I also mentioned the need for speed, and if you have distributed energy resources on the distribution grid, you don't face the same kind of transmission interconnection hurdles.

Then also when you're looking at the cost of distributed versus utility-scale, you're ignoring the fact that Americans are buying these resources for a different reason in most cases than doing grid services.

People are buying electric vehicles because it's a superior car, or they're buying a smart electric water heater because it's going to save them overall on their energy bill, or it's going to decarbonise their home, and a lot of folks are buying behind-the-meter batteries for backup power.

So, the cost to the customer is justified by the primary function of the DER. Then, we're taking the fraction of the capacity that is flexible and using that for grid services. That's where you get the cost-effectiveness. You have to split the total cost of a distributed storage system versus when you are comparing it to the cost of a utility-scale resource.

If you're just looking at storage, if those behind-the-meter batteries were not used for that homeowner's backup power at all, then maybe yes, you then add up the cost of every Powerwall and compare that to the cost of a utility-scale battery, and that's a relevant comparison. But people are buying these Powerwalls for their own backup power so it's unfair to count the whole cost of the behind-the-meter battery and compare that to a utility-scale battery.

Behind-the-meter resources can have a 'double source of value'

So what we're talking about there is recruiting people that would have installed DERs anyway. But I'm wondering how closely the need for VPPs will correlate with areas where people might already be buying battery systems, and conversely, we've seen virtual power plant programmes and pilots where customers in constrained load pockets are encouraged to buy battery systems that enrol into VPPs. Will scaling up VPPs be possible by enrolling customers who would have bought batteries anyway, or will it also require incentivising new customers as well?

The short answer to your question is that it will require both types of customers. A really good example is Swell Energy's battery VPP in Hawaii, where they recruited people who had batteries already and offered them monthly payments plus an export credit for the use of their batteries. They also expanded the capacity of the VPP by going to households and small businesses that didn't have a battery before and offered them somewhere between a couple of hundred dollars and US$1,000 per kilowatt of flexible capacity. The provider is always preserving 20% to 50% [of the stored energy], maybe depending on your needs, for your backup power.

They recognise that that flexible capacity is valuable for the grid, and that's why they're offering that signup bonus payment. You see that, too, with Green Mountain Power, where they are offering these batteries at a low cost to the homeowner, and, again, the homeowner is willing to pay that because they're getting backup power. ■

The challenges for BESS optimisation firms

Cameron Murray investigates the different approaches being taken by BESS optimisation specialists to help customers maximise their revenue

Credit: Pexels / Саша Алалыкин.

While the demand for third-party battery energy storage system (BESS) optimisation services looks set to grow substantially, challenges for companies specialising in those services remain.

In this piece we interview Habitat Energy, one of the most well-known optimisers, Enertel AI, which provides AI-modelled price forecasting but not optimisation, as well as independent sources in the wider market.

The past possibility of successfully monetising a BESS by having it simply sit in one or two different ancillary service markets is fast disappearing, with those markets' saturation forcing a rapid diversification of the revenue stack. That diversification requires a more sophisticated trading strategy, most likely with the help of AI-based forecasting, which is where BESS optimisation firms' value proposition comes in.

"Energy price forecasts, especially with confidence intervals, will increasingly be used as inputs for batteries as they must decide the extent to which they bid into ancillary services, the day ahead energy market, or save capacity to capture real-time volatility," says Enertel cofounder David Murray.

Energy trading in the day-ahead and real-time markets is likely to become a bigger part of what BESS does is the coming years.

Firms can either simply provide price forecasts to enable in-house decision-making, like Enertel, or go one step further and offer to take over management of the BESS, as Habitat does, while sometimes each part may be offered by a different third party. No model is without its challenges.

Optimisation firms' lack of transparency

The first, which *Energy-Storage.news* has written about extensively, is optimisers' lack of transparency into the AI algorithms that forecast the prices underpinning trading decisions, and even the forecasts themselves, which typically won't be provided either.

This is, according to some, because of a fear that providing the pricing forecasts to customers will allow those customers to reverse-engineer the optimisers' algorithms – their 'secret sauce' – and steal their competitive advantage.

The lack of transparency might be fine for some developers who are happy for "results to speak for themselves", as one optimiser Gridmatic put it to *Energy-Storage.news* a few months ago, but won't be for others.

Habitat Energy cofounder and director Ben Irons says the company takes a similar approach to managing BESS projects: "With our model, you give us the keys, and we'll generate the revenue. Transparency isn't as much of an issue as long as the revenue comes in. The project owners don't necessarily need reporting on a day-by-day basis since they are not the ones pushing the buttons."

There obviously need to be conversations with the asset owner on their specific requirements around BESS' lifetime warranty, and any physical constraints that might bring, as well as their risk-return appetite, he says.

"But once the asset goes live, we give regular performance updates, but we resist letting them get involved in trading because that's a responsibility they've assigned to us."

Irons says that it's actually when you separate the forecasting and optimisation pieces to separate third parties that the lack of transparency becomes a big issue, which is why Habitat only offers the wrapped service and not just forecasting alone.

"If you've got one company sending a stream of instructions saying you should discharge at 4pm, and the other company which is receiving those instructions and responsible for pushing the buttons thinks it should be at 5pm, you can see why tension arises. The trader will call up the forecaster and ask for some transparency behind the recommendation, and the forecaster will say, 'that's our suggestion, take it or leave it'."

Habitat's own forecasting and trading desks work very closely with each other to this end, Irons says.

Giving away 'secret' strategy

Another potential challenge is related to the need to keep a distance between owner and optimiser. One source said project owners have the conundrum of wanting to work closely with an optimiser to come up with a good trading strategy for their BESS portfolio, only for the optimiser to then apply that strategy to other assets in its portfolio.

Irons doesn't see much in this, though: "There's no code to crack. Everyone's trying to make as much money as possible by sticking their battery in whatever revenue stream makes the most sense on a given day. That's not a secret."

"It ultimately comes down to your forecasting, your trading team's experience and your ability to switch in and out of these services. And it's changing all the time, from week to week and day to day. We can all see this trading performance anyway. If something was a secret briefly, it wouldn't stay so for long."

Preference for in-house control of assets

It's fairly obvious that if you can make the same returns on your BESS asset, you would prefer to keep the management of it in-house.

Larger asset owners won't want an automated solution because of over-reliance on a software provider when they have GW+ of capacity and will want to retain agency over optimisation decisions, Enertel's cofounder David Murray claims.

However, Irons says that even as asset owners get larger and more familiar with BESS, there will still be plenty of value for third-party firms to add. It takes around 2GW of operational capacity before the in-house model gets even remotely cost-competitive and even that is with some significant caveats, Irons says.

"If you're a battery owner or developer, your skills are in raising money, procurement and EPC. Do you really want to have to go and hire data scientists and compete with Silicon Valley by creating a tech team within your asset ownership company? You'd need to be very committed and confident to do that."

"There's no code to crack. Everyone's trying to make as much money as possible by sticking their battery in whatever revenue stream makes the most sense on a given day. That's not a secret"

He also points out that many large asset owners, like UK energy storage fund Gresham House, use many different optimisers in order to see how each is performing.

Commoditisation of BESS optimisation

Some sources have suggested the widespread use of third-party optimisation for BESS can be seen as a form of commoditisation, but Irons refutes this, saying there is still a very wide range in performance of as high as 50% more revenues.

"I think we will see consolidation in the BESS space and that raises the question about whether we will start to look more and more the same over time. Quite possibly because that process will remove all the low performers so the difference between the top and bottom performers will reduce."

There are as many as 20-25 companies offering third-party BESS optimisation in the UK, for example.

Habitat Energy was founded in 2017 and acquired by Quinbrook Infrastructure Partners in 2021, and is currently active in the UK, ERCOT (Texas) and Australia. ■

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