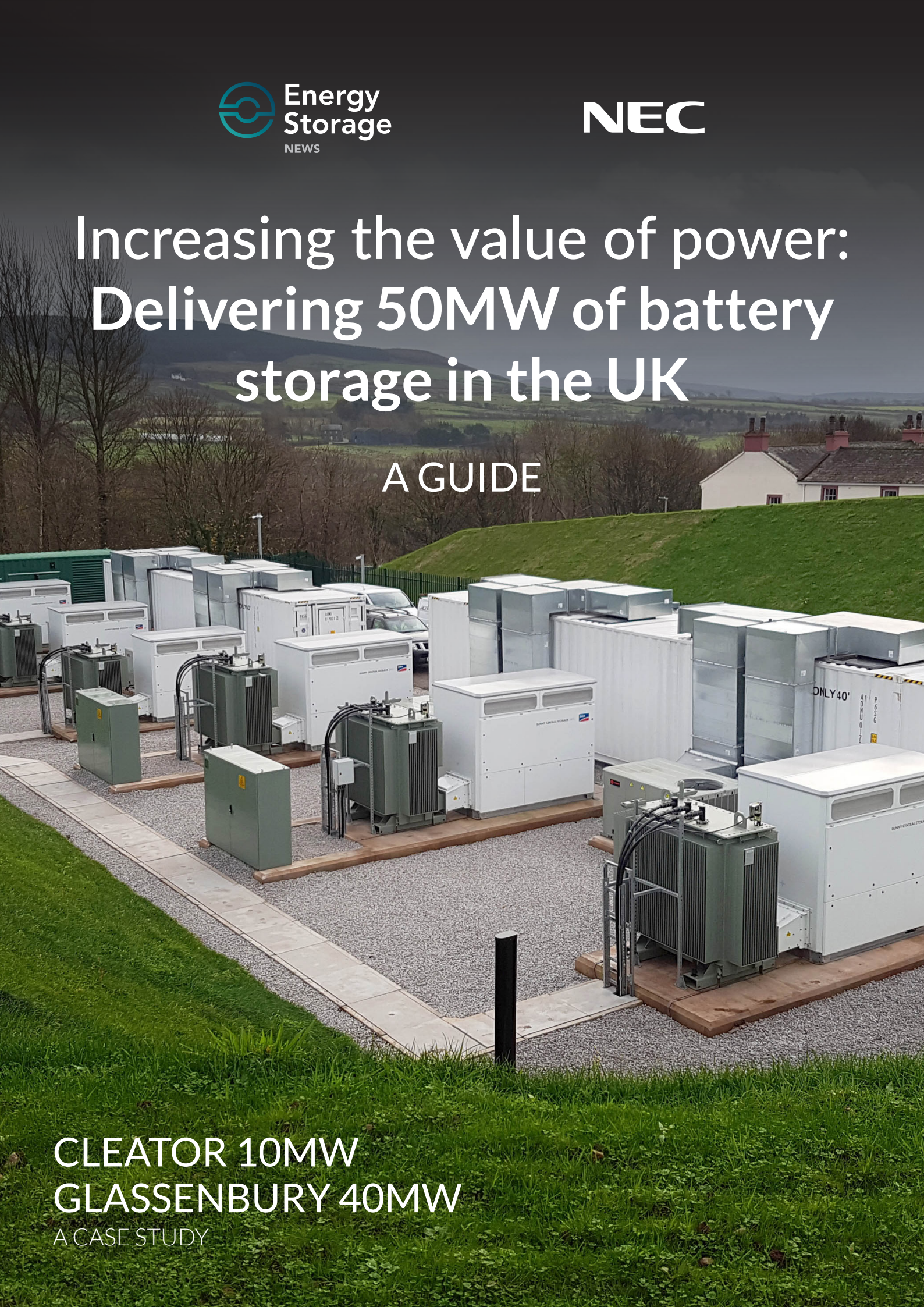
Energy Storage NEWS

NEC

Increasing the value of power: Delivering 50MW of battery storage in the UK

A GUIDE



CLEATOR 10MW
GLASSENBURY 40MW
A CASE STUDY

A HISTORIC MOMENT

Late August in 2016 will be considered a historic month for Britain's energy transition. The auction for 200MW of enhanced frequency response (EFR) by National Grid saw eight energy storage projects awarded contracts.

What this meant was that for the first time, through a competitive solicitation process, batteries were to be put onto the grid in a big way. Ever-increasing amounts of not just renewable but also distributed generation are necessary. The inevitable transition away from centralised, polluting, old-fashioned fossil fuels continues apace and so the need to balance the system also grows.

Low Carbon, a renewable energy investor, which has funded more than 320MW of solar in the UK, partnered with VPI Distributed Generation, owner of a large CHP plant and part of the global Vitol Group of energy and commodities companies. Creating the joint venture, VLC Energy, the pair bid for 50MW of EFR contracts – and got them.

Faced with the task of delivering a significant portion of the total EFR opportunity, VLC turned to a company they knew they could trust – NEC Energy Solutions.

Andy Colthorpe
Editor | Energy-Storage.News

NEC: AN IMPECCABLE TRACK RECORD

Capable of achieving a 24MW ramp in under a second, NEC's first grid-scale project delivered 12MW / 4MWh of battery energy storage to an existing thermal generation plant in Chile. Just under a decade ago, in 2009, the project proved energy storage could provide primary reserve to system operator CDEC-SING, which two years after the start of operation hailed it as one of the best performing primary reserve units in Northern Chile.

While NEC has delivered many storage systems and solutions for many different applications since then, perhaps the next landmark projects in our timeline are to be found in the US, projects which in part informed Low Carbon's decision to choose NEC to help deliver its EFR-performing battery storage. PJM Interconnection, an organisation coordinating wholesale electricity movement and markets in 13 different states, decided in 2012 that it would no longer pay equal amounts per MW of frequency regulation from resources that performed the same task with wildly varying efficiencies.

In other words, a combined cycle gas plant can respond faster and adhere more closely to a signal from the grid than a steam generator, while a battery storage system can do it even faster. PJM's decision to reward fast-responding, reliable assets led to NEC's installation of 32 MW/ 8MWh of its equipment for a customer at Laurel Mountain in West Virginia, and another 20 MW / 5MWh project in Dayton Ohio. Operational in 2011 and 2013 respectively, the projects provide frequency regulation through a competitive market, which is saving PJM and its customers money overall, despite being able to pay higher prices per MW to service providers.

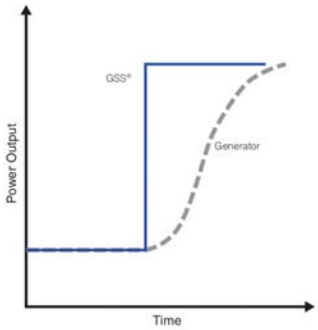
Moving quickly, NEC recognised the potential of the UK frequency response market and developed a new family of fast response, high energy density and low price per MW grid storage system solutions.

NEC Corporation has been known for its excellence in information and communications innovation in industries including telecoms and IT. However, it is less well-known that it is also a leader in Energy, and through NEC Energy Solutions will have installed over 400MW of energy storage worldwide, by the end of 2018.

At the Cleator and Glassenbury sites we'll be looking at, NEC provided turnkey engineering, procurement and construction (EPC) services, which included its GSS® end-to-end grid storage solution and was contracted to operate the sites to provide the EFR service directly to National Grid.

The solutions NEC provided to customer VLC Energy included supply and demand balance adjustment services for power system stabilisation, as well as control software applications that enable flexible, multiple revenue streams for the investor's battery storage assets.

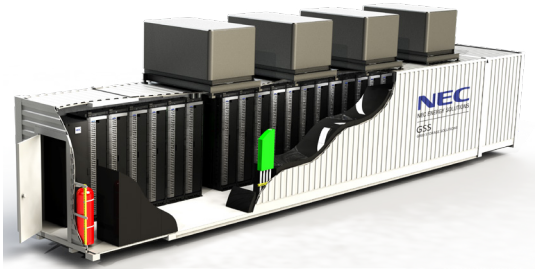
The delivery of the EFR service is now entrusted to an automated operating mode designed specifically for the UK's grid, built on NEC's AEROS® controls platform and software.



NEC's grid storage GSS® is capable of much faster response times (in milliseconds) and power output ramp rates than traditional generators.

BEYOND BATTERIES IN A BOX

Steve Fludder, CEO, NEC Energy Solutions



NEC Energy Solutions' CEO Steve Fludder explains why its work with Low Carbon in the UK goes beyond providing hardware to designing and operating the full revenue-delivering system

Steve, can you tell us a little about NEC's experience to date and what it takes for an energy storage solution to go far beyond just 'batteries-in-boxes'?

We have been developing utility-scale storage systems for about 10 years. We've been doing this as long as anybody else has been doing it. We've got about 400MW of projects in our installed base today that has grown almost by a factor of two within the past year or so. We're aiming to at least double our business year-over-year for the foreseeable future.

What do you think made NEC attractive to VLC for their 50MW of UK projects?

What we brought to the table was obviously from a capital cost perspective, the most competitive proposal. But perhaps more importantly, our control system is really delivering tremendous value for VLC Energy.

We sort of 'rose above' batteries and provided an entire digital solution that really brought multiple benefits around automating the revenue generation, around precisely controlling the frequency at that particular point of interconnection on the grid. In a closed loop fashion, if the frequency rises or falls above the 50Hz set point, our control system is operating the battery system in order to inject or extract energy from the grid. Our control and data platforms also generate all of the reports that are submitted directly to National Grid on a monthly basis, by which Low Carbon receives their revenue.

Why is energy storage so important to an energy future based on renewables and digitised control systems?

The transformation of the electric power infrastructure all around the world is really unprecedented, because it impacts everyone and everyone will be engaged.

The future is about multiple constituents and multiple flows of energy and multiple ways of really delivering cleaner, more reliable electricity through technologies and digital platforms, managed as an enterprise as opposed to managing a one-way flow of electrons.

NEC is uniquely positioned to lean into that and the reason we decided to build an energy business starting from battery energy storage is that we basically have leapfrogged the whole legacy of the past. We leapfrogged over thermal generation, we've leapfrogged over physical generating assets and decided to get right in at this historic point of transition, of the really big change in the system.

We're focused on all of the new technologies and solutions that will make this transformed grid that's going to be majority renewable, in some cases totally renewable. And we're unencumbered by the legacy of the past. I see storage as a central part of many types of energy system that allow other things to happen: it allows more renewables, more grid edge and microgrid projects. It allows us to tell remote desert mining operations that they don't need to build a 250 mile fragile transmission line, we can come in and put a microgrid system in there and storage is really the central component, for example.

What's driving NEC forward to deploy these and other energy storage systems for different applications, in different configurations that also include microgrids and commercial installations?

I want to shift from stuffing batteries in a box to providing really a value-based solution. We're leveraging our knowledge and expertise of the physics and the science of storage systems and we're bringing in expertise in data science as NEC. How do you build a digital enterprise platform, an Internet Of Things system? We do this all the time in different market sectors as NEC Corporation. So we're bringing those two together and that's a very powerful and compelling combination.

When it comes to driving down that capex, which is the foundation of our strategy, it's not just the battery modules, which is what everybody always focuses on, which is fair because the batteries are 35% to 40% of the bill of costs. We're ripping costs out of every aspect of the system and we're driving lower cost of ownership with the digital platform – maximising revenue and lowering the cost of operation at the same time.

Part of our strategy is to layer in more digital solutions and expand the range and scope of services. This is the reason for the 'Energy Solutions' part of the name. We've got lots of things that we're bringing to the table, centred around the market and we've got some great partnerships that span from the grid-scale to behind-the-meter here in the UK.

MEET THE CUSTOMER: VLC ENERGY

One of the UK's most prolific investor's in renewables, Low Carbon, partnered with VPI Distributed Generation to create VLC Energy, which in addition to the 50MW of battery storage we're focusing on here, is developing peaking gas assets. With the involvement of the Vitol Group - which had 2017 revenues of US$181 billion - Low Carbon successfully bid for EFR contracts for the 10MW Cleator and 40MW Glassenbury sites. Both were also awarded Capacity Market contracts, demonstrating the capability of energy storage to cost effectively provide resilience and reliability to the grid. A further upside comes from peak-shifting applications in winter months, known as Triad in the UK.

Chris Morrison, VPI Distributed Generation
EFR provided a unique opportunity to develop a new asset class: utility-scale battery storage. The 4-year term of the EFR contract combined with a Capacity Market contract gave long-term certainty of revenue, reducing the risk of the capital invested.

The Glassenbury and Cleator assets are unique amongst the EFR projects in that they step out of the EFR service during winter evening peaks. This allows the power trading team to optimise the assets embedded benefits and TRIAD revenues giving further upside. Owning and operating this new asset class has given us unique insights into construction, operation and optimisation.

What was needed:

Justin Thesiger, Operations director, Low Carbon
NEC have an excellent track record in battery storage. They already had a number of megawatt-hours in the ground performing frequency response, so they had the systems in place to understand what the EFR contracts needed and were able to quickly get to grips with our grid requirements.

The whole solution offered by NEC was critical to the choice behind their selection and NEC's AEROS® controls platform was part of that winning formula that had already been deployed in the US doing frequency response.

Meeting the return on investment:

Chris Morrison, VPI Distributed Generation
Batteries are a complex asset and our experience over the past year has been invaluable in learning how to optimise batteries across multiple revenue streams as the battery only meets the investment return required when we do so.

The sites have a 15-year Capacity Market contract from 2016 which is not as heavily de-rated as CM contracts from subsequent years and the EFR contract gives further certainty for four years.

We also participate in the energy supply market during winter evening peaks, discharging the battery to take advantage of TRIAD revenues and embedded benefits. When the EFR contract comes to an end we will need to review our business case and determine the best revenue models and contracts for the assets. There are a lot of factors which need to be accounted for, such as warranty restrictions, charging cycle numbers and degradation curves when evaluating different strategies.

A critical role:

Chris Morrison, VPI Distributed Generation
In the UK, energy storage has a critical role to play as renewable energy is an increasing proportion of our energy mix. The principle function of lithium-ion batteries like those installed at Glassenbury and Cleator is to manage short-term changes in frequency – slight mismatches in demand and supply.

This service used to be provided by large coal and gas plants but there are now times when very little thermal plant power is running on the system. With EFR, firm frequency response (FFR) and some thermal generation there is currently sufficient supply of this service, although demand is likely to grow gradually over time with increasing renewables on the grid.

As an island with relatively little interconnection to Europe and high renewables penetration, the UK is facing these problems sooner than most other large economies.

Low Carbon has funded more than 320MW of UK solar PV.

Credit: Low Carbon

PROJECT PROFILES

CLEATOR, CUMBRIA

10MW/5.4MWh (900 LG Chem battery modules)
2 Battery containers
6 Inverters
Operational December 2017

GLASSENBURY, KENT

40MW/21.7MWh (3,640 LG Chem battery modules)
7 Battery containers
19 Inverters
Operational December 2017

WHAT DO THE SYSTEMS NEED TO DO?

Credit: NEC

Enhanced Frequency Response (EFR)

Both projects are contracted for four years to supply EFR services. Tendered for the first time by the transmission operator, National Grid in 2016, with many more grid services market opportunities opening up in the UK and internationally, EFR is a stern test of what batteries can do.

Active power must be changed to respond to changes in frequency. System frequency needs to be maintained within 1% of 50Hz at all times and is a variable that continuously changes, determined and controlled by the need to balance generation with demand on a second-by-second basis.

Both systems must respond within one second to frequency deviations as well as meeting other technical criteria. It's interesting to note that while 1MW minimum capacity - which can include aggregated assets - is required to participate while 50MW is the maximum capacity permitted for a single asset. VLC has delivered 50MW by splitting this capacity across their two EFR projects.
Average price of tendered £/MW of EFR per hour:
Cleator: £7.94
Glassenbury: £9.38

Firm Frequency Response (FFR)

The systems also perform Firm Frequency Response on a commercial basis for National Grid. FFR provides dynamic and non-dynamic response to changes in grid frequency. Again, the aim is to maintain frequency at 50Hz. Dynamic frequency response is provided continuously and manages normal second-by-second changes on the system. Non-dynamic frequency response is triggered at defined frequency deviations. Response times required vary between 10 and 30 seconds of an event, to be sustained for a period of 20 seconds, 30 minutes, or indefinitely in the case of high frequency response.

Capacity Market

Cleator and Glassenbury also have contracts for 15 years to provide Capacity Market (CM) services. These were awarded in 2016. Only two other battery facilities were also awarded these contracts as new build generators. In later years changes to so-called de-rating factors reduced the payment available to short duration batteries (30 minutes or under), meaning the timing was just right for VLC's twin projects. Auctions were completed at a clearing price of £22.50/kW.

Triad avoidance

The Transmission Network Use of System (TNUoS) charge is applied to business users of electricity for their use of the electricity network at certain peak times of year. This is particularly acute in Britain's winter months, and Triad refers to "three half-hour settlement periods with highest system demand between November and February, separated by at least ten clear days", National Grid says.

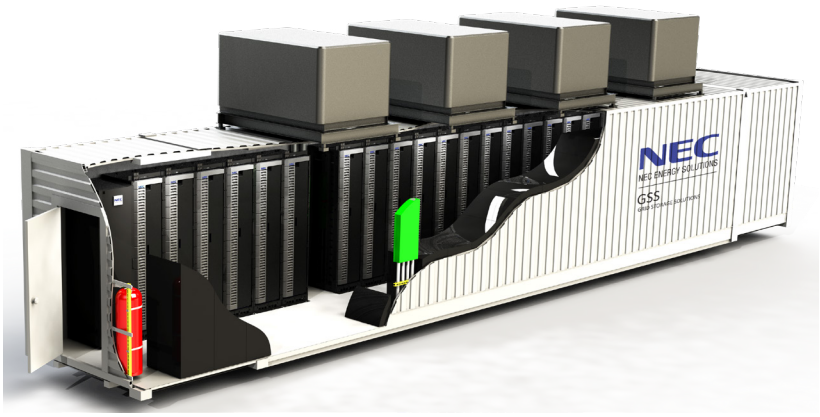
These are calculated after the winter period and released by National Grid the following March. The 'demand charge' system of Triad can cost businesses significant sums of money. By clever forecasting and understanding of onsite demand, the amount of peak energy used can be reduced with a battery system.

Challenges:

No opportunity comes without its challenges. In addition to ensuring the system could deliver the above, NEC and its partner G2 Interconnections also dealt with the following:

- Civil engineering: The Cleator site, located on a hillside, needed foundations dug deep into the ground to ensure the system remained lower than the height of the hill. Along with potential concerns about noise, the local community was assured the visual impact of the system would be minimal, as can be seen in photographs of the Cleator project.
- HVAC positioning: Although an easily overcome design challenge for the experienced NEC team, the HVAC systems needed to be installed alongside the batteries, not on top, for the same reasons as above.
- Strict deadlines: The projects needed to be executed to tight timelines, with service contracts to fulfil. Triad periods span the winter months and so the customer wanted 'Triad avoidance discharges' to be implemented as soon as possible.
- Communications: Financial partners, the operations and scheduling team, the local distribution network operator and grid connection experts G2 Interconnection all had to be continually involved in the communications process developed by NEC.

AT THE HEART OF THE SYSTEMS



Credit: NEC

The pre-engineered, modular, scalable and standardised design of NEC system, including the GSS® (Grid Storage Solution) containerised energy storage helped minimise cost and reduced installation time.

GSS®

Used throughout the world commercially since 2008, GSS® can support grid reliability with system balancing, ancillary service provision, supporting transmission and distribution networks, reducing electricity costs through peak shaving and of course, integrating renewable energy generation including solar, onshore and increasingly offshore wind.

The integrated solution comes configured-to-order and includes energy storage power conversion and NEC's proprietary AEROS® controls suite.

GBS®

The factory-built and tested GBS® (Grid Battery System) sits at the heart of the GSS®. For Cleator and Glassenbury, LG battery modules were used successfully, although NEC has worked with others and remains open to strong suppliers, particularly with a view to reducing costs for the customer while maximising performance.

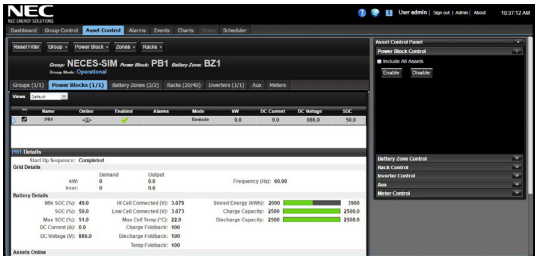
The 53' battery containers used in the UK EFR projects – which look a little like shipping containers before deployment – are connected to SMA SCS2475 inverters. Unlike solar inverters, which manage one-way flows of power from DC to AC, energy storage inverters are bi-directional. Each PCS (power conversion system) is rated at 2.47MW at the two projects.

AEROS® (Advanced Energy Response Operating System)

Data science, machine learning, AI and other forms of digital innovation are at the heart of everything NEC does. Nowhere is this in better evidence than the role AEROS® plays at Cleator and Glassenbury. Also known as the advanced energy response operating system, the AEROS® platform includes controls hardware along with the simple-to-use yet sophisticated algorithms to precisely control and integrate energy storage. Combined with the AEROS® controls suite and already in use at the two UK sites we are looking at is AEROS® Command, which enables the successful control and dispatch of multiple energy storage assets.

Managing state-of-charge in batteries successfully is vital to the lifetime, effectiveness and commercial potential of any type of stationary grid storage. AEROS® does this and also manages system power and the batteries' internal condition. Capable of responding to both external power commands and autonomous control modes, it could also be thought of as the portal to NEC's cloud-based enterprise platform which enables owners and operators to accrue masses of valuable data. In the immediate term this means easy access to real-time market opportunities, while that data can also be fed back into the system, driving further improvements to efficiency and application.

Supporting multiple applications that also include volt/VAR support, ramp rate management and load levelling, AEROS® can enable 250 millisecond standard response times as well as a <30 millisecond high speed option. As well as being the brains and nerves of the two EFR storage systems, AEROS® also enables all of the smart ways the projects can maximise their revenue streams. As we've heard from CEO Steve Fludder, the digital enterprise platform that AEROS® is the fundamental building block of, could unlock much further potential for economic as well as long-term environmental investment in energy assets.



Credit: NEC

ADVANCED ENERGY TECHNOLOGY MEETS CLASSIC BRITISH WEATHER

Matching expectations during the construction phase is only half the battle. NEC's Laura Kozel explains the importance of effective monitoring once a system is operational

For both projects, NEC collaborated from the early stages with UK-based partner G2 Energy, an Independent Connection Provider which helped form the construction team. NEC designed and configured the systems, while G2 remains involved servicing medium voltage equipment onsite. Balance of plant equipment including transformers and switchgear and interconnection with the local distribution network operator (DNO) grid were also duties performed by G2 Energy.

The British weather is a famous point of conversation for anyone familiar with the islands, and the NEC and G2 teams were at times faced with unforgiving wind, rain and mud while executing the projects to meet a deadline that was shortened from the original schedule. Partly based on engagement with the local community, it was decided Cleator would be built onto a hill in such a way that the containers could not be visible from over the horizon.

Managing batteries, managing revenues

"We're trying to help our customers save money on the install but make money on the performance of the system," Laura Kozel, NEC Energy Solutions' director of platform engineering and service, says.

In other words, while the installation has to be executed with total confidence, it's the ongoing operation of the system that will be vital to creating a return on investment. Kozel and her team now operate the entire 50MW at Cleator and Glassenbury. It is done remotely, from the control room in the eastern US.

"Battery systems are similar to solar, in that they don't require a huge amount of maintenance," Laura Kozel tells us. Instead, it's the controls system and how the battery is operated that is absolutely of paramount importance. The Cleator and Glassenbury projects have achieved over 99% availability, which is vital to fulfilling the terms of its EFR contracts. NEC needs to be able to deliver widely variable energy and power output – or input – to follow local frequency variations. To deliver Triad Avoidance, the systems need to be able to discharge for the full 30 minute or 60 minute potential system peaks during winter months.

In other words the batteries – and the entire projects – need to be monitored and operated 24/7. According to Laura Kozel, the aim is also to minimise the amount of time required to perform maintenance at the sites themselves. As well as performing 'basic' but critical functions such as weak battery module detection, AEROS® lets the equipment 'watch' itself and send proactive alerts via sophisticated communications channels. In the instance of Cleator and Glassenbury, separate protocols were developed to help meet those availability assurances.

Kozel says that NEC's 400MW of energy storage around the world give an unparalleled insight into what makes these projects succeed. Industry-leading warranties and preventive maintenance, 24/7 monitoring and escalation and monthly assessments of site performance are just a few of the ways NEC is committed to continually improving and building value into every contract. Different markets and different applications will require different response rates and capacities of energy storage, meaning adaptable solutions such as those enabled by NEC's GSS® and Distributed Storage System (DSS) will be more than capable of competing for many years to come.

GSS® already enables many applications at generation, transmission and distribution levels:

Generation

- Ancillary Services
- Renewable Integration
- Frequency Response
- Frequency Regulation
- Power Plant Hybridisation
- Ramp Rate Management

Transmission

- T&D Support
- Voltage Support
- Renewable Integration
- Loss Reduction

Distribution

- Residential and Industrial Backup Power
- Microgrid and Island Grid Support
- Distribution Upgrade Support
- Peak Load Reduction

SOLUTIONS FOR THE ERA OF DIGITAL AND RENEWABLE ENERGY ENTERPRISE

Laurel Mountain and other projects executed since 2009 in the US, Spain, Japan, Brazil, Chile and other territories have helped set NEC's impeccable track record and unparalleled experience.

The world is changing fast. We often hear about the three Ds of the energy transition: decarbonisation and decentralisation, which will all exist in a digital realm.

Experience from Cleator, Glassenbury and NEC's other energy storage projects globally help us understand what energy storage can do today. It also offers a glimpse into the future of energy - and the energy business.

"Over four years Low Carbon estimates that [the EFR] service will save the system operator around £200 million. This is good news for consumers who benefit from our cost efficiencies, and paves the way for battery technology to establish itself as an important component of our energy system," Low Carbon's Justin Thesiger says.

The combination of NEC's AI, Internet of Things and cybersecurity technologies with the AEROS® controls and software suite creates an energy enterprise platform that truly can increase the value of your – or your customers' – power.

Some final points to take away:

While EFR is a historic milestone, the world is changing quickly to new business cases for storage

Ancillary services provision and grid-balancing through batteries and other flexible assets are an exciting new way to enable renewable energy and invest in resilient networks of the future. However, there will only be a limited range of opportunities for applications such as frequency response.

In addition to such projects and those in Ohio and West Virginia for PJM in the US, NEC is also able to integrate storage with solar, wind, thermal generators and other resources. In the future, as the need to decarbonise cost-effectively grows, time-of-use tariffs and longer peak demand periods are expected to also drive the case for storage not just dense in power, but also those with larger energy density. NEC is comfortable with a range of battery technologies and while lithium-ion is the choice of today, the future could include greater proliferation of long duration devices such as flow batteries.

Energy storage is crucial to distributed energy systems, but AI and data science are crucial to a distributed energy business case

Distributed energy systems will enable greater and diverse use of renewable energy, as well as other resources such as demand side response, electric vehicles and even natural gas. While, yes it is a source of emissions, it is less polluting than coal. Energy storage will be a central component of how these systems all fit together. Combined with artificial intelligence and data science built into platforms such as AEROS®, it will also be a central component of the ongoing business case for owners, investors and other stakeholders. Variables from technical performance data to regulations and technical standards, electricity market and revenue data are all metrics that can be fed into a project's operational parameters.

We can already see from Cleator and Glassenbury how important this intelligent monitoring, forecasting and data feedback can be to the revenue streams of energy storage assets. Moving forward, NEC will leverage the excellence of NEC Corporation's IT, communications, machine learning and data science technologies and NEC's own technologies and experience in the market to layer a 'digital enterprise platform' onto its services.

NEC: MAXIMISING THE VALUE OF POWER

Batteries will still be the crucial component, but the digital layers on top of the system are what create value and long lifetimes of service.

While the battery itself might be the most noticeable asset, the benefits of an energy storage system run deeper.

I tell my team: we've been doing this for 10 years, we're very proud of it but we need to move from stuffing batteries in a box to enterprise solutions," NEC Energy Solutions CEO Steve Fludder says.

"I see the physical asset as the foundation upon which the digital asset really creates the value. Going forward, we're focused on that interface where the customer is extracting value from our system and the interface is the digital platform."

Many electricity markets around the world are moving to what Steve Fludder calls a more "flexible situation", which could be described as merchant, contract-based or open markets, as opposed to the subsidy or long-term power purchase agreement type of arrangement seen with solar assets. Batteries, a movable resource, can truly be the flexible asset that meet both energy network needs, create a huge industry and benefit the environment through enabling the demand for fewer and less intensive thermal resources and more and allowing more renewables onto the system.

Over almost 10 years, the energy business that NEC decided to build has fostered great partnerships from grid-scale to behind-the-meter, Steve Fludder says. As well as the corporate strength to bring debt and equity financing to projects, customers can benefit from NEC Corporation's experience in building data systems for international airports, telecoms networks or even artificial intelligence for the Tokyo Stock Exchange.

At Cleator and Glassenbury, there are two exciting projects and one very satisfied customer. Low Carbon's Justin Thesiger also emphasises the importance of the batteries to the local community and network.

"The two new battery parks at Glassenbury and Cleator will ensure stability within the local grid and that the electricity demands of residents can be consistently met, including at times of high demand. Sites such as these are fundamental to our energy security and also to realising the full potential of renewable electricity generation that hit record levels earlier this year."

Thank you for reading the case study. Visit NEC's stand at Solar & Storage Live 2018, at NEC, Birmingham, England from 16th to 18th October 2018.

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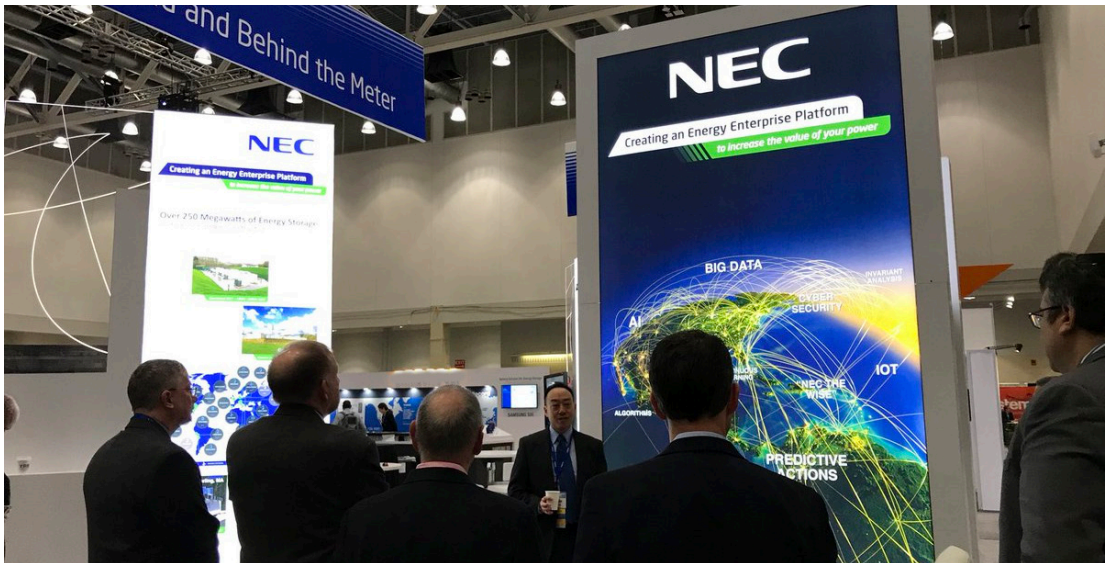

NEC looks forward to meeting you to discuss how to maximise the value of power, for you or your customer.

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