WESTERN POWER DISTRIBUTION

INNOVATION

NEXT GENERATION NETWORKS

Solar Storage

WPD_NIA_004

NIA MAJOR PROJECT PROGRESS REPORT

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Low Carbon Networks

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Glossary

Term	Definition
API	Application programming interface
BAU	Business as usual
BMS	Battery Management System
BSRL	British Solar Renewables Ltd
BRE / NSC	Building Research Establishment / National Solar Centre
BSRL	British Solar Renewables Limited
DG	Distributed Generation
DNO	Distribution Network Operator
EFR	Enhanced Frequency Response
GB	Great Britain
HV	High Voltage
IPR	Intellectual Property Register
LCNI	Low Carbon Networks and Innovation
LCT	Low Carbon Technologies
LV	Low Voltage
NIA	Network Innovation Allowance
PEA	Project Eligibility Assessment
PV	PhotoVoltaic
SOC	State of Charge
WPD	Western Power Distribution

1 Executive Summary

Solar Storage is funded through Ofgem's Network Innovation Allowance (NIA). Solar Storage was registered in April 2015 and will be complete by April 2018, however consideration is being given to extending the project duration to accommodate additional testing and learning.

Solar Storage aims to install and operate a battery at Higher Hill farm to;

1) Quantify the potential value to network operators and others of integrating storage with solar generation by demonstrating a set of use cases;
2) Use real-world operation of an integrated utility scale storage / generation system to provide data to regulators and potential investors; and
3) Demonstrate safe, reliable operation of the system under operational conditions.

The battery chemistry is Lithium Iron Phosphate, which is less energy dense than Lithium Ion batteries but has the advantage of having greater thermal stability and is at lower risk of overheating.

This report details progress of the project, focusing on the period between April 2017 and September 2017.

1.1 Business Case

The reduction in the cost of battery storage, along with increased demand for fast response flexibility services such as Enhanced Frequency Response (EFR), has generated a huge amount of interest in battery storage technology. Battery installations can vary in size from domestic to large grid connected installations. This project considers the use cases for a moderately sized battery (300kVA, 640kVAh) co-located with a solar farm.

Integrating storage with renewable generation offers a route to addressing some or all of the following issues:
(i) Renewable generation does not predictably match peak local demand;
(ii) Renewable generation is often 'spikey', which can introduce short-term impacts on grid voltage or other quality of supply factors;
(iii) Unpredictability, lack of control mechanisms and power quality mean grid operators use very conservative rules to allocate grid connections;
(iv) Grid operators have to introduce new equipment to manage power quality, a service which could be provided by operators of utility scale renewable installations;
(v) Without the ability to respond quickly to local surges in load, grid operators manage network capacity within tighter limits than might otherwise be possible; and
(vi) Introducing two or more active storage or quality management devices onto the same HV circuit may cause them to interact with each other and have a negative impact on power quality.

Using flexibility services provided by a battery is expected to be cheaper than conventional reinforcement. The figures below are taken from the Project Eligibility Assessment (PEA).

DNO annualised cost for current conventional method is £570k/MVA
DNO potential annualised cost of the Method being trialled is (£13K/MVA+£5k)/year
DNO expected financial benefit is £570k/MVA-(£13k/MVA+5k)/year

The battery used in Solar Storage has an additional benefit, in that it is containerised which should make not only installation, but any subsequent relocation simpler. If a battery can be relocated cost effectively then this suggests that battery storage can provide a DNO with a temporary solution where future load/generation profiles are hard to predict. It is expected that after a term of deferral there will be more certainty over the case for traditional reinforcement, applying a smart technique or the commercial purchase of flexibility services, and that the temporary use of a battery will therefore reduce the risk of stranded assets.

1.2 Project Progress

This is the second progress report. It covers progress from April 2017 to September 2017.

The situation in March 2017 was that the battery was installed and being operated, but operation was continually affected by various teething problems, most notably those relating to the state of charge management of the battery, resulting in significant imbalance between the four battery strings.

Since March, the key areas of progress are:

- The String imbalance issue has been resolved;
- The test schedule has been re-planned to take the shortened timescales into account;
- More regular battery operation has identified a further issue with the capacity of the air conditioning units which have been replaced;
- An issue regarding the connection agreement limits for power factor has been identified and resolved;
- The algorithm for peak lopping the solar park has been significantly improved;
- Argand power quality monitoring equipment has been installed and is providing data;
- It is now possible to access the battery data and to extract and reform the data to support the required analytics;
- An initial meeting has been held with BRE to explain the process used to test the battery and show the data format. BRE are providing third party review and oversight of the testing process to ensure sufficient quality; and
- The issue concerning battery access by visitors has been resolved.

These are described in more detail in sections 2.2.4 Operation, 2.2.5 Analytics and 2.2.6 Process overview and validation.

1.3 Project Delivery Structure

1.3.1 Project Review Group

The Solar Storage Project Review Group meets on a bi-annual basis. The role of the Project Review Group is to:

- Ensure the project is aligned with organisational strategy;
- Ensure the project makes good use of assets;
- Assist with resolving strategic level issues and risks;
- Approve or reject changes to the project with a high impact on timelines and budget;
- Assess project progress and report on project to senior management and higher authorities;
- Provide advice and guidance on business issues facing the project;
- Use influence and authority to assist the project in achieving its outcomes;
- Review and approve final project deliverables; and
- Perform reviews at agreed stage boundaries.

1.3.2 Project Resource

Organisation	Staff
British Solar Renewables Ltd. BSRL	Luke Hoskins - Overall project manager for BSRL Christie Simms – Battery operation and analytics
Renewable Energy Systems RES	Tracy Scot – Project manager for RES Simon Johnson - Resolve manager BYD support accessed via RES.
British Research Establishment / National Solar Centre(BRE/NSC)	Christine Coonick
Argand	Fraser Durham Ben Markille
Utilities Insight	John Lindup
SRI Technologies	Geoff Foote
Western Power Distribution	Jenny Woodruff – project manager Chris Hjelm (or nominated Team Manager) – Project Sponsor

1.4 Procurement

The following table details the current status of procurement for this project.

Provider	Services/goods	Area of project applicable to	Anticipated Delivery Dates
RES	Battery, installation and support	As per services/goods description	Construction complete – support ongoing
BSRL	Battery operation and analytics		Ongoing till end of project
SRI	Techno-economic modelling		Complete
Utilities Insight	Regulatory analysis		Complete
Argand	Power Quality Monitoring		Installation in April 2017 with support to end of project
BRE/NSC	Process validation and oversight		Operational review commenced September 2017

Table 1-1: Procurement Details

1.5 Project Risks

A proactive role in ensuring effective risk management for Solar Storage is taken. This ensures that processes have been put in place to review whether risks still exist, whether new risks have arisen, whether the likelihood and impact of risks have changed, reporting of significant changes that will affect risk priorities and deliver assurance of the effectiveness of control.

Contained within Section 7.1 of this report are the current top risks associated with successfully delivering Solar Storage as captured in our Risk Register. Section 7.2 provides an update on the most prominent risks identified at the project bid phase.

1.6 Project Learning and Dissemination

Project lessons learned and what worked well are captured throughout the project lifecycle. These are captured through a series of on-going reviews with stakeholders and project team members, and will be shared in lessons learned workshops at the end of the project. These are reported in Section 5 of this report.

<u>Site Visits.</u>

Site visits were halted due to concerns over the complexity of the procedure for entering the battery. This seemed to stem from a misunderstanding that the procedure used by maintenance teams should be used by anyone entering the battery. There are additional risks faced by maintenance teams who inspect parts of the battery by removing covers over live LV components. The procedure for maintenance teams therefore involves switching off the battery and operating a circuit breaker to isolate the LV power supplies. However for site visits, where covers prevent contact with live LV components, there is no reason to switch off or isolate the battery. A procedure for entering the battery for non-invasive purposes has now been produced to clarify the requirements.

Presentations.
The project was featured in upcoming presentations at EDIE live and at the Balancing Act event. An overview of the project will be presented at the 2017 Low Carbon Networks and Innovation (LCNI) Conference.

2 Project Manager's Report

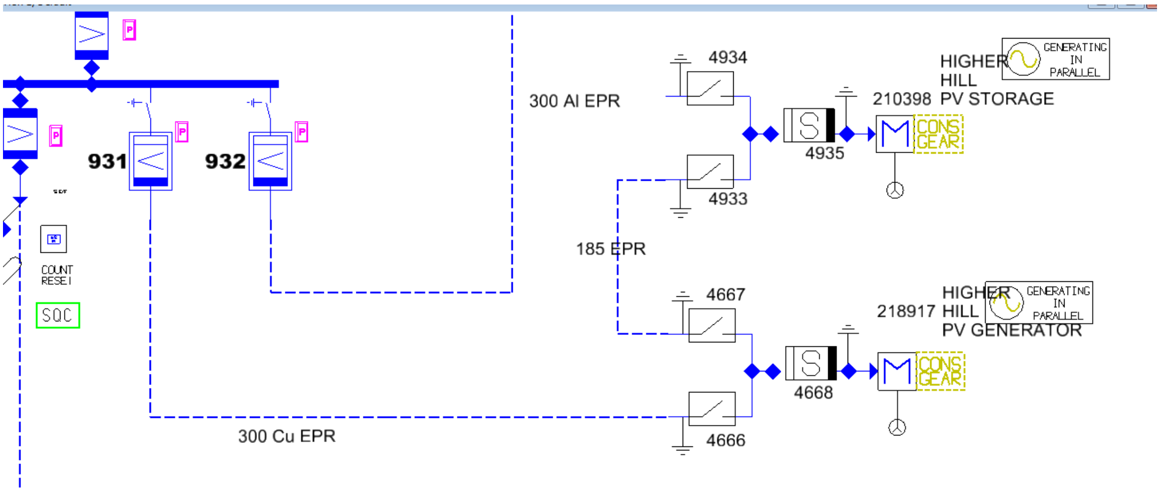
2.1 Project Background

The project aims to test the nine use cases listed below in table 2-1 where a battery can provide benefits to different parties. As well as evaluating the efficiency and efficacy of the battery at delivering the use cases, the project will also estimate the financial benefits and consider how these use cases reflect the potential for layering revenue streams. The project does not include the provision of services to National Grid, such as Enhanced Frequency Response, which is one of the major drivers of storage connections. However testing the battery to see how well it could provide such services is of interest to BSRL and will be included if time allows.

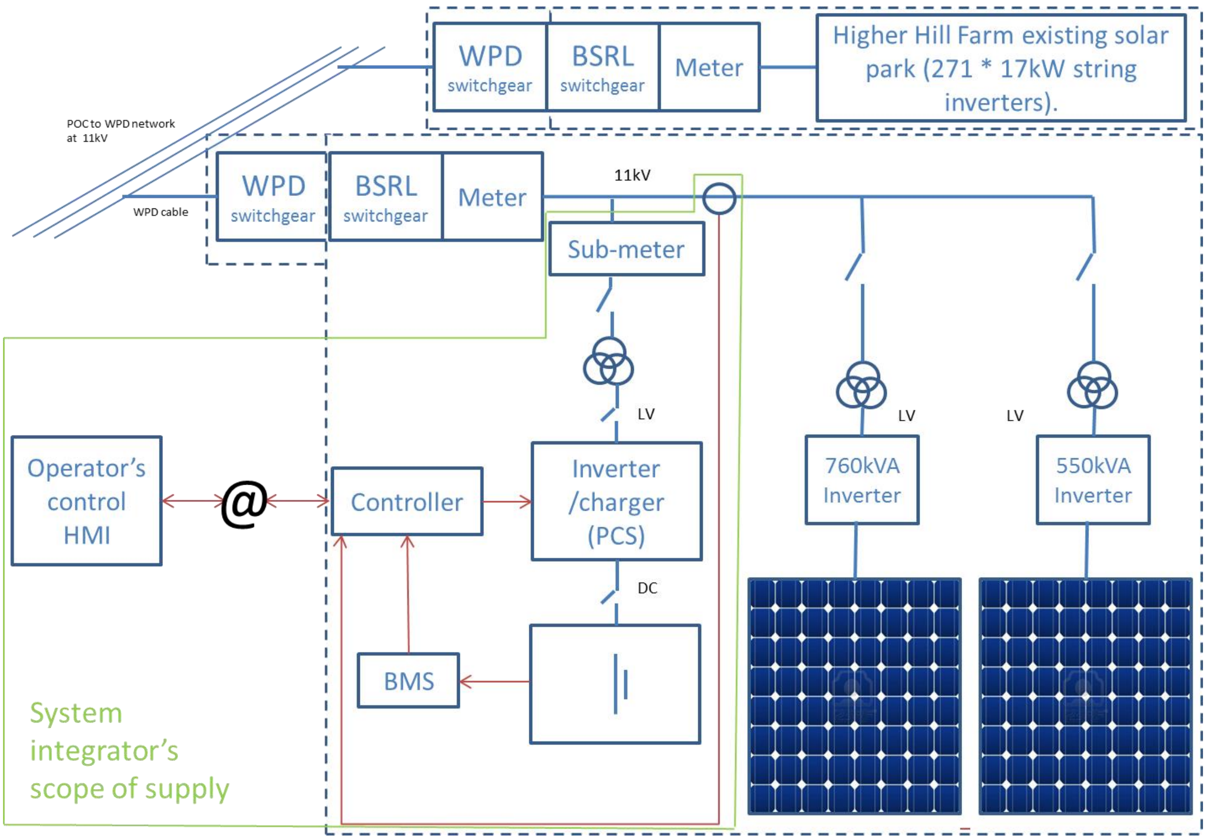
Usage Case	Beneficiary
1) Arbitrage - Sell electricity for a higher price per kWh	Owner
2) Local demand peak lopping e.g. as a service to a customer with a soft intertrip connection who would otherwise be constrained.	DNO / load customer
3) Peak lop network demand at the local primary	DNO
4) Raise minimum demand to limit voltage rise.	DNO
5) Voltage control via reactive power.	DNO
6) Peak lop generation to enable solar parks with an installed capacity over that of the connection agreement	Owner
7) Smoothing / Power Quality.	DNO
8) Change peak lopping level (glass ceiling).	DNO
9) Multiple storage system control (To be demonstrated via modelling only)	DNO

Table 2-1 :Use Cases

The solar farm where the battery is installed is electrically connected to a clean 11kV feeder supplied by the Millfield primary substation. This has been altered to introduce an additional ring main unit to provide isolation between the battery and the solar farm.



Electrical connection to Higher Hill battery.



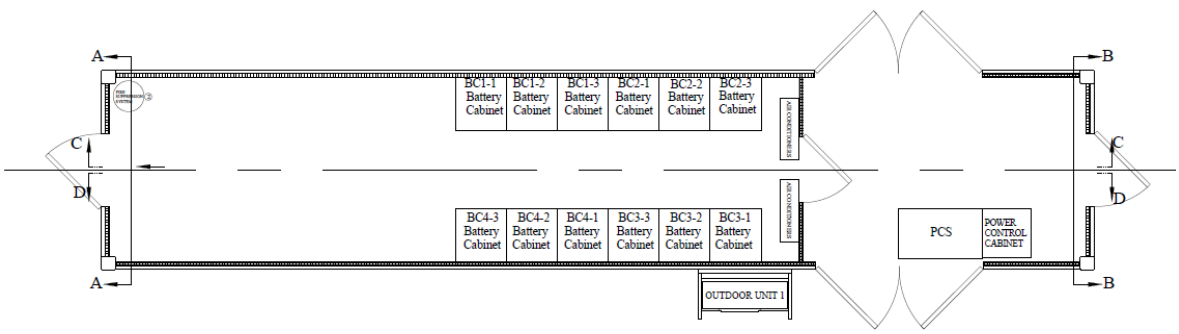
The battery is metered separately and connected via an LV isolating transformer.

2.2.1 Design & Procurement

These activities have been completed successfully. The process of obtaining planning was relatively onerous and non-material amendments to the planning permission were required when the outline of fenced area was altered to more accurately reflect site conditions. The total area of the enclosure was reduced to allow for improved access across the BSRL site without compromising vehicle access to the battery itself.

The design sign-off was a two stage process that covered the battery itself followed by the balance of plant.

Examples of the images from the design process are given below. It can be seen that the container is divided into two compartments for safety reasons, such that the battery operator is separated from the battery itself and the fire suppression system. The drawings also show that only part of the usable space within the battery compartment is used and that it would be possible to approximately double the battery capacity if desired.



Access doors

2.2.2 Construction

Construction was completed in October 2016 with the exception of a couple of minor snagging items which have since been resolved. A separate report covering the site commissioning tests has been produced. Issues encountered during the construction phase included:

1) Location of cables differing from plans;
2) Damage to communications cables during the erection of fencing; and
3) The requirement of a specialist driver to transport the battery due to its hazard rating.

The photographs below show some key stages of the construction.

Battery arrival

Battery offloading


Battery on plinth before and after fencing.

Left – Circuit breakers and emergency stop.

Right – Resolve control panel.

Battery strings and fire suppression system.

2.2.3 Argand Power Quality Monitoring

To compare the impact of the battery at the solar site and at Millfield Primary, power quality monitoring equipment was installed on the Millfield 11kV circuit breaker for the feeder to which the solar park is connected. This monitoring equipment is designed to remain permanently installed, rather than being a temporary installation which is far more common for power quality monitoring. This installation was designed and installed by Argand Solutions, and has several innovative features, for example the CT used was specially commissioned to handle the physical space limitations, the requirement to be fitted without a shutdown and the requirement for high accuracy. The CT, which clips over the circuit breakers existing secondary protection wiring, uses the Hall effect to measure with higher accuracy than Rogowski coils, while still providing an output in the 1A -5A range required by the PQ meter, in this case manufactured by Bender. This unit can measure up to the 63rd harmonic but will soon be upgraded to measure up to the 100th harmonic (or possibly higher).

The meter records 800 data points every 10 minutes which are then stored locally on a Linux based system before being transmitted. Millfield primary poses communications challenges as neither broadband or 4G are available, and the 3G network signal is not consistently available. The solution in this case uses the 2G network but makes use of message broker technology to push data to a cloud database. If the communications are interrupted, the messages can be resent and data is not lost. These message brokers are typically used for financial systems such as trading where 100% data integrity is required. These brokers also offer the potential for instantaneous exception alerts. The message brokers are open source and could operate with other types of telecommunication i.e. broadband or UHF radio systems.

The information stored in the cloud-based database is then accessed by authorised users via a web-based front end or mobile phone app, but could be used to support a number of different applications via Application Programming InterfacesAPIs.

At present, most power quality software is specific to the power quality meters being used. However this approach disaggregates the data collection from the data processing so it should be possible to mix-and-match meters and software more flexibly.

The screenshot below in Figure 1 shows the web-based front end for the data from Millfield, in this case showing the power exported on the feeder including the solar park for four days, including one particularly sunny and cloud free day.

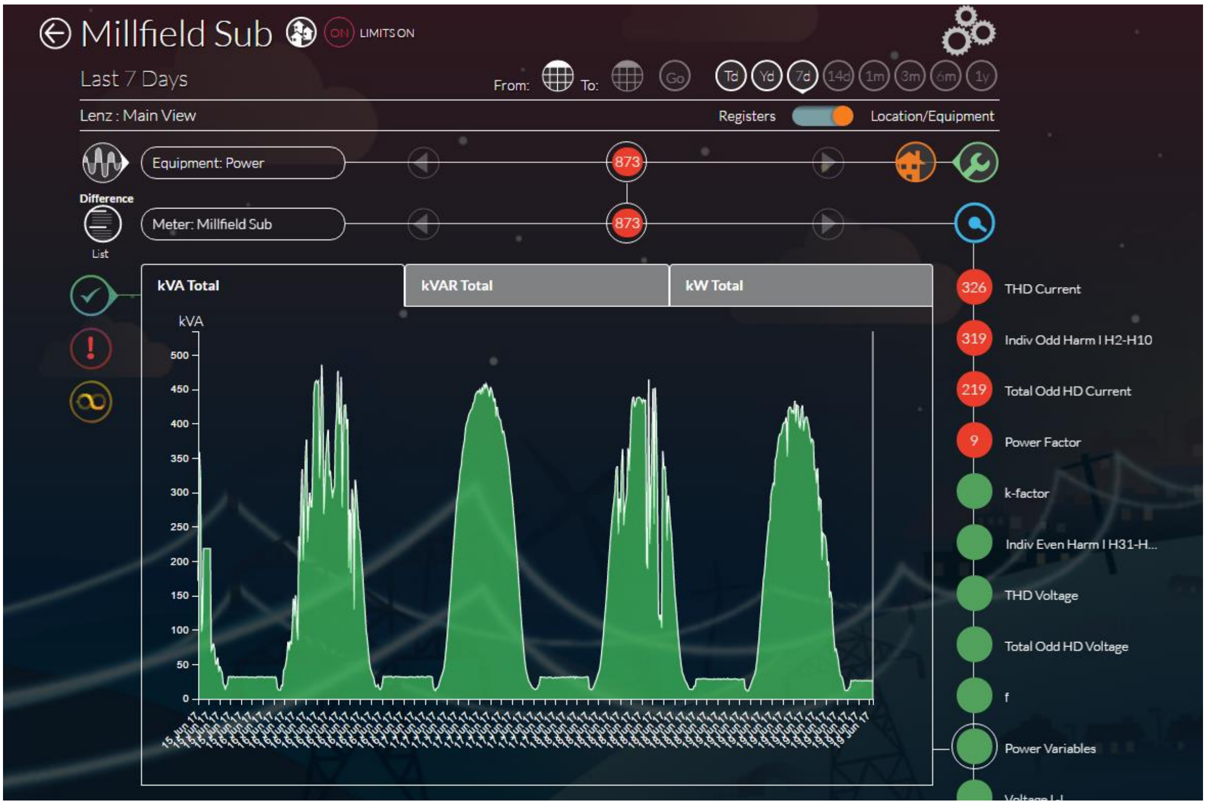


Figure 1: Argand monitoring web interface – power output by solar park

This front end has been used by the analysts at BSRL to support their work and they have reported finding it very comprehensive and user friendly compared to other systems.

2.2.4 Safety

Safety was given a high priority during construction with direct oversight and co-ordination between RES and BSRL staff. The construction was completed without injuries. While the fire risk of the installation is low, the local fire brigade have been notified of the battery's presence and consulted on safety procedures. As the battery can be operated remotely, personnel are rarely on site other than for routine inspection visits. A process has been put in place to notify battery operators if staff are expected on site.

2.2.5 Operation

The battery has been operated sporadically since its commissioning. There have been frequent interruptions to the testing schedule as a result of the battery not operating as expected and time taken to investigate and resolve the unexpected behaviour.
Issues include:

- Imbalance between the State Of Charge (SOC) of the four battery strings;
- Unexpected G59 trip that does not appear to relate to genuine events;
- Battery temperature resulting in protective overrides due to calibration issues with the air conditioning units;
- Execution of "ghost" schedules that cannot be viewed using the control software;
- Apparent sudden loss of charge;
- Apparent loss of charge while the battery is inactive at higher than expected levels; and
- Erroneous alarm indication.

Of these issues, the imbalance between battery strings has been the most frequent. While the battery can be operated with a degree of imbalance between the strings, this restricts the range over which the battery can be operated. As operating the battery above or below certain SOC limits could damage the battery, and would invalidate the battery warranty, the approach taken, which is to err on the side of caution where there is uncertainty, is reasonable. This problem has now been resolved by a combination of actions, including:

- Replacing CTs with newer versions, better reflecting the range of currents expected and increasing sensitivity;
- Changing the methodology used to estimate state of charge, specifically the points at which the estimation changes between an integrated current estimate to one based on the cell voltage; and
- Changing the SOC value used within the BMS to be consistent. Within the BMS two different SOC estimates were being referenced causing inconsistencies.

Resolving the SOC issue allowed the battery to be operated at higher power export and for longer without interruption. This resulted in a greater heating load which in turn highlighted the issue with the air-conditioning units not being able to extract sufficient heat when the battery was operating to a more onerous schedule. One of the air conditioning units was not operating correctly. Both units were replaced as it was thought likely that the other original unit may suffer from a similar fault in the future, and this replacement allowed for separate, rather than a shared, condenser unit to be installed , removing a potential single point of failure.

Despite the interruptions to testing, a set of test results were produced. However, the unstructured nature of the data and analytics relating to the testing has been problematic due to a change in staffing. To ensure future usability by third parties a new structure for the data and analytics documents will be agreed, documented and validated by BRE/NSCas part of their review into the project.

An issue with the data coming from the RES system highlighted the different requirements for existing battery operators and the analytics for the project. It was seen that the graphed valued which could be easily downloaded represented maximum or minimum values in a time period rather than averages, and it became clear that even average values would not sufficiently support the required analysis.

Access has now been provided to the data held within the battery system. The form in which the data is held is suitable for compact storage, only recording when an item changes rather than recording values for every five minutes, say. A method to create different forms of the data to support different analysis has been put in place by BSRL.

2.2.6 Analytics

The operational data from the battery is recorded constantly within the Resolve system and can be reviewed and downloaded using the Resolve system.
An additional "backup" database has been provided in ODBC compliant format that can be used to support the analysis by BSRL. This is now available and BSRL have been able to write scripts to retrieve the data and reformat it to enable the use of spreadsheets for each use case. It is likely that third parties wanting to carry out their own analysis would prefer to use the reformatted versions produced by BSRL, but in theory they could be provided with access to the ODBC compliant database.

Some initial analysis was carried out in the first set of operational data that considered the viability of arbitrage using the battery to charge overnight and discharge during the morning.

Separately, the Argand power quality monitoring equipment installation has now been completed, with the data visible to registered uses via an interactive website. Please see section 2.2.3 for more detail. Initial analysis of the data shows that there are some power quality issues occurring but that these seem to relate to the solar parks. Many of the data items show cyclic patterns reflecting the typical generation profile for a solar park with harmonics having a higher percentage impact at times when the generation is low at dusk and dawn. The chart in Figure 2 demonstrates this pattern, seen with the total harmonic distortion for even numbered harmonics for a four and a half day period.

Figure 2: Argand monitoring web interface – Total Harmonic Distortion – Even Harmonics – Daily Pattern

2.2.7 Process oversight / validation

The first meeting with BRE to validate the process and methodology took place on 11th October. This had previously been delayed due to a lack of available, well formatted data. BRE will now be able to review the test schedule, operational logs, data extraction process and data and the analytics spreadsheets to ensure;

- The test schedule covers a wide enough range of seasons, days of the week, operating modes, use cases and combinations of use cases to support meaningful analysis; and
- The methods used for operating the battery, logging operations, reporting issues, extracting and analysing data are of sufficient quality to ensure confidence in the results.

2.2.8 Auction / Removal

The lease for the battery site expires at the end of March 2018 and requires that the land be restored to its former condition. At the time of the lease negotiation it was expected that the battery would be auctioned off and that either the battery would be bought by BSRL (in which case the removal work would not be required) or that an agreed buyer could be found in September / October 2017, with removal by the buyer planned for January / February 2018 and restoration of the site in February / March 2018. The auction would be preceded by an independent evaluation of the capacity of the battery which would confirm its function and help in the process of setting a guide price. Potential interested parties would be notified of the battery sale by WPD and would include the Energy Storage Network, other DNOs, aggregators etc.

There was a risk that the batteries operational issues would reduce interest in the battery, however since this has improved significantly, it would seem worthwhile extending the testing of the battery to include items not originally within the scope of the Solar Storage project, that may reduce uncertainty for potential buyers. This would focus on testing whether the battery could be used for frequency response, which is a service that underpins much of the current battery investment. The possibilities for extending the lease and testing will be investigated in the next months.

2.2.9 Dissemination

As per section 1.6, the project has had a relatively high profile externally and has attracted interest and enquiries from third parties. Future dissemination work will depend on the availability to obtain sufficient operating data to support the analysis and learning.

3 Progress against Budget

Spend Area	Budget (£k)	Expected Spend to Date (£k)	Actual Spend to Date (£k)	Variance to expected (£k)	Variance to expected %
WPD Project Management & dissemination	143	91	93	-2	-2%
Project Partner Project Management	123	43	14	29	-67%
Equipment & Installation and decommissioning	467	468	468	0	0
Trials	123	43	14	29	-67%
Specialist analysis / review	47	33	33	0	0
TOTAL	921	678	622	-28	-4%

Comments around variance

The total budget is lower than the value in the PEA reflecting the actual costs for battery procurement being lower than anticipated.

The underspends on project management and trials activities relate to work which is largely complete but has not been invoiced while a minor issue remains outstanding.

4 Progress towards Success Criteria

The success criteria from the PEA are as follows;

Criteria	Progress
Phases a to d below completed safely, on time and on budget. a) Complete Design of BESS. b) Procure equipment, install and commission. c) Run trials and write report. d) Identify changes necessary for participation on the Balancing Mechanism.	Items a, b and d have been completed. Item c is ongoing. Positive developments include the improvement of the control algorithm within Resolve to 1) Ensure the combined output of the battery and PV site do not exceed the connection agreement 2) Improvement of the algorithm for PV peak lopping. Also the development of an alternative signal by BSRL to test the soft-intertrip use case which has reduced the instrumentation and communications requirements.
All usage cases are investigated and a comprehensive analysis of all data collected undertaken. Useful and applicable conclusions generated from the data analysis.	Arbitrage use case investigated and analysed. Testing schedule re-planned after battery availability issues delayed the execution of the test schedules. We now have some data for the majority of use cases and can build up a more substantive dataset for analysis. Progress has improved in terms of being able to execute the test schedule without battery issues preventing the tests taking place. Some good preparatory work has taken place in terms of extracting relevant data and formatting spreadsheets to carry out the analysis. The review by BRE has begun.
Effective communication of the project's results and conclusions to the UK renewable energy and power distribution community.	Good progress on publicising the project itself. Progress on disseminating results is limited until more results are available for

	dissemination.
Successful engagement with stakeholders, influencing the development of relevant governing mechanisms such as the grid code or balancing mechanism (BM).	Regulatory report shared with key stakeholders and contributed to WPD's response to the joint call for evidence in November 2016.

5 Learning Outcomes

The majority of the learning is expected to come after more battery operational data is available, however a summary of learning points to date is given below.

5.1 Design and Procurement

- The use of a partner to assist with the procurement of the battery was essential as DNO staff were not yet sufficiently familiar enough with battery technology to carry out procurement unaided;
- Include more flexibility in the Statements of Works to avoid the significant work of re-signing;
- Having as much access to technical detail as possible during the procurement stage is beneficial;
- The contractual conditions covering the battery operation should have included a clause concerning the imbalance between strings. It appears this is a standard clause in other battery contracts; and
- Identify any issues with the contractual limits for items such as power factor early on. This required modelling by WPD staff to ensure that if the algorithm were to fail to operate correctly, that the reactive power element would not cause network issues. The selection of a clean feeder for the trial has limited the potential impact on other customers from voltage fluctuations during testing.

5.2 Construction

- Ensure that legal issues are resolved early in the construction schedule;
- Expect a degree of inaccuracy in plans; and
- Power Quality monitoring was something of an afterthought to the project and procurement and installation has taken longer than expected.

5.3 Operation

- Establish a log of daily operations and issues early on;
- The process for communications and notifications is made more complex by having multiple parties involved in different countries;
- Operational issues will not always be detected during FAT and SAT testing;
- Issues can mask each other e.g. the air conditioning issue only became evident after the SOC issue was resolved; and

- Problems with the control algorithms and presentation of the data seem to stem from making a large change in the use of the battery and the new use cases have little in common with the way the control system has been used traditionally.

5.4 Analysis

- Determine a structure for storing data early on; and
- Determine conventions to ensure that variables in analysis are used consistently and can be updated centrally.

5.5 Project management

- Including contingency in both budget and schedule is essential;
- Having a structured means of managing project documentation is essential when there are staffing changes; and
- It is difficult to shift focus and plan for the next stage of a project when the current stage is not progressing as planned.

5.6 Use Cases

The capability of the battery to perform the majority of the use cases was demonstrated, albeit in a shortened and simplified form, during the commissioning tests. Since then all the use cases (except Use case 9 – co-ordinated control of multiple systems) have been demonstrated individually and in certain combinations. The remaining tests allow for seasonal variations to be seen and will be adapted to reflect the review by BRE.

5.6.1 Arbitrage

As predicted by the techno-economic modelling, the arbitrage use case was not often seen to be profitable. Part of this relates to the contract through which the energy is sold by the PV site which is tailored to PV supplies. It may be possible to improve sales prices, however the price differential was rarely sufficient to overcome the energy losses and costs of operating the battery.

This was seen to be the case with the repeated tests that showed that even a two-stage arbitrage approach was not viable. While the morning sale of electricity from the night before almost broke even, the cost of charging and discharging to meet the evening peak was consistently loss making. Once again this reflected the sales price under the solar park's power purchase agreement, which has little variation in price across the day. To really benefit from the peak prices seen on the wholesale market, a different trading mechanism would be required and in general solar park investors prefer the certainty afforded by PPAs over volatile prices, even if this includes an opportunity to make greater profits at peak times.

5.6.2 Local Demand Peak Lopping

Local demand peak lopping e.g. as a service to a customer with a soft intertrip connection who would otherwise be constrained, requires the battery to be charged to a certain degree before the service is triggered. Testing has discovered the difficulties of predicting the level of charging from the solar park. Predicting the solar output for a particular day is often of little interest to solar park operators, who focus instead on ensuring peak operation of the plant using monitoring data. Experience, and including additional, conditional schedules to ensure a minimum SOC have reduced the risk of insufficient battery charge being available.

5.6.3 Peak lop network demand at the local primary

This has the same issues in common with providing the local demand peak lopping. To be most cost effective, the battery should be charged by peak lopping the solar output during the day, rather than charging from the grid supply. Estimating the level of solar output at which to set the threshold for peak lopping to ensure a charged battery is an evolving art form.

5.6.4 Raise minimum demand to limit voltage rise

This is executed by a simple timed schedule. When the battery has not been affected by issues, this has been executed reliably. Now that the Argand equipment has been installed the impact on voltage at Millfield, as well as locally will be analysed.

5.6.5 Peak lop solar park output

As per the comments for the previous use cases, as the solar park where testing is taking place does not require peak lopping, the threshold setting is being tested at a various levels, often reflecting other use cases to be carried out subsequently. The testing has demonstrated that the battery can be used to peak lop the solar park, however having a successful control algorithm for peak lopping is not sufficient on its own to ensure that the use of the battery is optimal and at present there is a reliance on user experience to set to threshold at a useful level.

5.6.6 Temporary glass ceiling Peak lop solar park output at a lower value

As there hasn’t been a set value at which to lop the solar park output, this testing has overlapped to a certain degree with the testing of “normal” peak lopping in that the algorithms are identical and the peak lopping limit has been set to a value reflecting the daily condition. i.e. lower limits have been used on days where the solar output is expected to be low to avoid the peak lopping algorithm never taking effect.

5.6.7 Voltage control

The algorithm can be seen to be working, in that the control set point changes in a way which would be expected for a given level of voltage relative to the desired voltage level. However, the voltage signal is highly variable, and the impact of the reactive power is difficult to detect.

5.6.8 Power Smoothing / ramp rate control

The algorithm to smooth the output from the PV site was seen to be very effective, though currently the business case is less clear.

6 Intellectual Property Rights

A complete list of all background IPR from all project partners has been compiled. The IP register is reviewed on a quarterly basis. No foreground IP has been identified for this project to date.

7 Risk Management

Our risk management objectives are to:

- Ensure that risk management is clearly and consistently integrated into the project management activities and evidenced through the project documentation;
- Comply with WPDs risk management processes and any governance requirements as specified by Ofgem; and
- Anticipate and respond to changing project requirements.

These objectives will be achieved by:

- ✓ Defining the roles, responsibilities and reporting lines within the Project Delivery Team for risk management;
- ✓ Including risk management issues when writing reports and considering decisions;
- ✓ Maintaining a risk register;
- ✓ Communicating risks and ensuring suitable training and supervision is provided;
- ✓ Preparing mitigation action plans;
- ✓ Preparing contingency action plans; and
- ✓ Monitoring and updating of risks and the risk controls.

7.1 Current Risks

The Solar Storage risk register is a live document and is updated regularly. There are currently eight live project related risks. Mitigation action plans are identified when raising a risk and the appropriate steps then taken to ensure risks do not become issues wherever possible. In Table 7-1**Error! Reference source not found.**, we give details of our top five current risks by category. For each of these risks, a mitigation action plan has been identified and the progress of these are tracked and reported.

Details of the Risk	Risk Rating	Mitigation Action Plan	Progress
Battery operational issues prevent test schedule completion	Major	Continue to provide comprehensive information to RES and BYD and monitor	Battery operation is now more reliable, but the risk is still high due to the potential for

		availability for comparison to contractual requirements.	unknown issues to be discovered during testing.
Continuous support of all partners for the duration of the project is not possible.	Moderate	Continue to emphasise the value of the project and ensure the learning is useful to all parties.	Commitment from parties is still strong despite changes in staff
Insufficient data to determine power quality impacts	Minor	Use of temporary monitor until permanent equipment is installed.	Data is now available
Potential for additional removal / storage costs if the battery cannot be sold at the end of the project	Minor	Resolving the operational issues and demonstrating the battery value.	BYD have identified the algorithm that requires improvement for string balancing and are investigating options.
Lack of experience with complex analytics prevents timely analysis	Minor	Data now available for setting up analytics. This can be completed after the battery is removed if necessary	Both battery and power quality data sets are now available.

Table 7-1: Top five current risks (by rating)

Table 7-2 provides a snapshot of the risk register, detailed graphically, to provide an on-going understanding of the projects' risks.

Likelihood = Probability x Proximity	Certain/Imminent (21-25)	0	0	0	0	0
	More likely to occur than not/Likely to be near future	0	0	0	0	0
	50/50 chance of occuring /Mid to short term (11-15)	1	0	0	0	0
	Less likely to occur/Mid to long term (6-10)	0	1	0	1	0
	Very unlikely to occur/Far in the future (1-5)	1	1	2	0	1
		1. Insignificant changes, re-planning may be required	2. Small Delay, small increased cost but absorbable	3. Delay, increased cost in excess of tolerance	4. Substantial Delay, key deliverables not met, significant increase in time/cost	5. Inability to deliver, business case/objective not viable
		Impact				
	Minor	Moderate	Major	Severe		
Legend	6	1	1	0	No of instances	
Total	8				No of live risks	

Table 7-2: Graphical view of Risk Register

Table 7-3 provides an overview of the risks by category, minor, moderate, major and severe. This information is used to understand the complete risk level of the project.

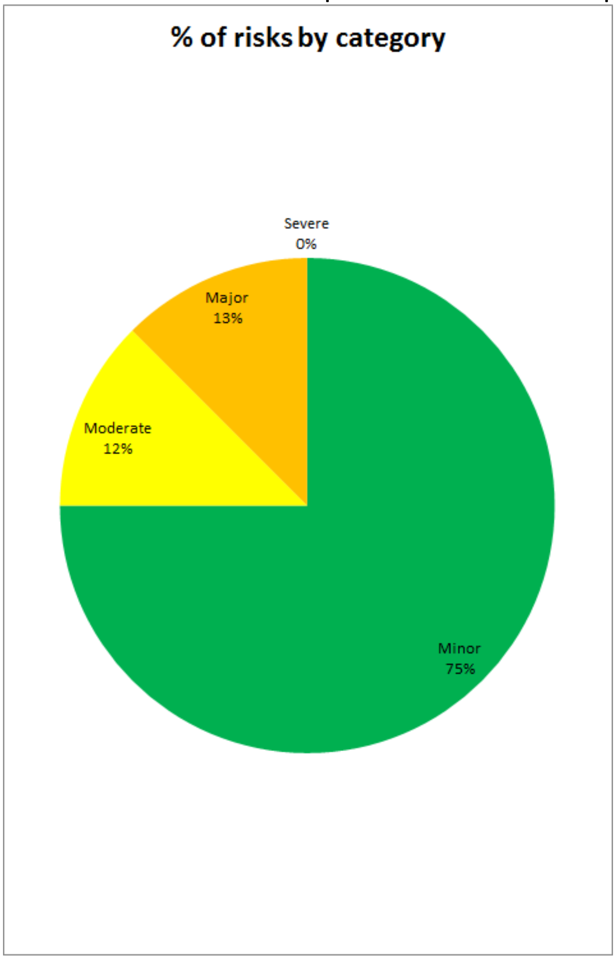


Table 7-3: Percentage of Risk by category

7.2 Update for risks previously identified

Descriptions of the most significant risks, identified in the previous six monthly progress report are provided in Table **7-4** with updates on their current risk status.

Details of the Risk	Previous Risk Rating	Current Risk Rating	Mitigation Action Plan	Progress
Insufficient data to determine power quality impacts	**Major**	Minor	Use of temporary monitor until permanent equipment is installed.	Risk reduced now that data is available.
Battery operational issues prevent test schedule completion	**Major**	Major	Continue to provide comprehensive information to RES and BYD and monitor availability for	While battery operation has improved, this is still the largest risk

			comparison to contractual requirements.	
Continuous support of all partners for the duration of the project is not possible.	**Moderate**	Moderate	Continue to emphasise the value of the project and ensure the learning is useful to all parties.	The partners continue to work well together.
Managing health and safety risks causes delays or over spends	**Moderate**	Minor	Continuous risk assessment process from project start and contingency in budget.	Risk diminishes as the project progresses.
Potential for additional removal / storage costs if the battery cannot be sold at the end of the project	**Moderate**	Minor	Resolving the operational issues and demonstrating the battery value.	Risk reduced now that more consistent battery operation can be demonstrated

Table 7-4: Risks identified in the previous progress report

8 Consistency with Project Registration Document

The scale, cost and timeframe of the project has remained largely consistent with the registration document, a copy of which can be found here https://westernpower.co.uk/innovation.

There have been changes to the timescales reflecting delays in the procurement and construction phases such that the battery operation is now from October 2015 to February 2017. Additionally the cost of the battery was less than the original estimate so it is likely that the project costs will be significantly less than the budgeted value.

9 Accuracy Assurance Statement

This report has been prepared by the Solar Storage Project Manager Jenny Woodruff, reviewed and approved by the Future Networks Manager (Roger Hey).

All efforts have been made to ensure that the information contained within this report is accurate. WPD confirms that this report has been produced, reviewed and approved following our quality assurance process for external documents and reports.