Demand Management Innovation Allowance Report – 2020

02.03.21

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1. Introduction

During the 2020 calendar year, United Energy (UE) undertook the following initiatives funded from the Demand Management Innovation Allowance (DMIA):

a) Installation and commissioning of two pole-mount grid-side battery energy storage systems (BESSs) on the low-voltage (LV) network of UE distribution area and support of the closure of the preceding virtual power plant (VPP) trial.

This report delivers the annual reporting requirements for the work undertaken on these initiatives during 2020 and documents the outcomes and key learnings.

2. Regulatory Requirement and Compliance

The Australian Energy Regulator (AER), in its DMIA applied to UE for the 2016-2020 regulatory period, sets certain criteria and reporting requirements for expenditure from the DMIA. These are detailed below along with a description of how UE complies with each of these requirements for each project.

2.1 Grid-Side Battery Energy Storage Systems Pilot Project

1. Demand management projects or programs are measures undertaken by a DNSP to meet customer demand by shifting or reducing demand for standard control services through non-network alternatives, or the management of demand in some other way, rather than increasing supply through network augmentation."

The LV grid-side BESS pilot aims at shaving the peak demand on the network by charging the battery during low demand periods i.e. overnight or mid-day when solar PV generation is at its maximum and discharging the battery during early evening when the demand on the UE network is at its maximum. LV BESS pilot is an extension to UE's VPP project which looked at installing solar PV and battery storage behind customer meters and aggregating the VPP units in providing network support.

"2. Demand management projects or programs may be:

(a) broad-based demand management projects or programs—which aim to reduce demand for standard control services across a DNSP's network, rather than at a specific point on the network. These may be projects targeted at particular network users, such as residential or commercial customers, and may include energy efficiency programs and/or

(b) peak demand management projects or programs—which aim to address specific network constraints by reducing demand on the network at the location and time of the constraint."

The LV BESS pilot is sought to address specific network constraints by reducing demand on the network at the location and time of the constraint. It is intended to locate such units in areas where there are identified network constraints. In the first instance, this is likely to be in areas where there are significant distribution transformer constraints. Ultimately, the goal is to alleviate constraints higher up in the network such as at the distribution feeder or zone substation level.

"3. Demand management projects or programs may be innovative, designed to build demand management capability and capacity and explore potentially efficient demand management mechanisms, including but not limited to new or original concepts."

LV Grid-Side BESS pilot offers a new solution for a constrained network area, particularly where load growth is low, uncertain or is expected to plateau in future. The ability to provide incremental amounts of capacity through combining renewable generation and storage to meet the demand as it materialises could be economic against a more traditional network solution that provides significant step increases in capacity at higher cost.

As part of this pilot, UE has installed two LV pole-mount grid-connected BESSs in the network area to manage the loading on distribution transformers and LV circuits. The installed LV grid batteries have been successful in flattening the load profile under the LV circuit and substation.

"4. Recoverable projects and programs may be tariff or non-tariff based."

The LV Grid-Side BESS projects are non-tariff based.

"5. Costs recovered under the DMIA:

(a) must not be recoverable under any other jurisdictional incentive scheme

(b) must not be recoverable under any other Commonwealth or State/Territory Government scheme and

(c) must not be included in forecast capital or operating expenditure approved in the distribution determination for the regulatory control period under which the DMIS applies, or under any other incentive scheme in that determination."

Costs recovered under the DMIA for the LV Grid-Side BESS pilot are costs incurred by UE in procuring, installing and commissioning the BESS units for the project.

In 2020, UE progressed with the delivery of the two BESS units. Installation of the first unit was completed on 28th February 2020 and the second unit was completed on 4th May 2020.

These costs have not been recovered from any other scheme. The costs do not include labour for UE employees' time toward this project. This cost is absorbed by the organisation and is regarded as in-kind contribution towards the project.

"6. Expenditure under the DMIA can be in the nature of capital or operating expenditure. The AER considers that capex payments made under the DMIA could be treated as capital contributions under clause 6.21.1 of the NER and therefore not rolled into the regulatory asset base (RAB) at the start of the next regulatory control period. However, the AER's decision in that regard will only be made as part of the next distribution determination."

All costs incurred by UE under the DMIA for the projects are classified as operating expenditure.

3. DMIA Reporting

The information contained in this report is suitable for public publication.

The AER requires that a DNSP's annual report must include the following for each project.

3.1 Grid-side Battery Energy Storage Systems Pilot Project

1. The total amount of the DMIA spent in the previous regulatory year, and how this amount has been calculated.

UE had $545 excl. GST of expenses during the 2020 calendar year on activities associated with the DMIA for VPP trial. This ongoing operational expense (such as sim cards to enable remote control and continuous live monitoring of the systems) was associated with the unit installed at UE Burwood maintenance depot.

In 2020 UE progressed with the delivery of the two LV grid-side BESS units. A total of $503,310 was incurred against this project for the procurement and installation of the BESS units. This pilot project is funded from UE capex budget and from DMIA allowance. DMIA has funded 82.5% of the project cost with the remaining 17.5% coming from UE capex budget. Based on this proportion, in 2020 DMIA contributed $415,431 for the LV BESS project.

2. An explanation of each demand management project or program for which approval is sought, demonstrating compliance against the DMIA criteria in section 3.1.3 with reference to:

(a) the nature and scope of each demand management project or program

Grid-side BESS pilot looks at expanding UE's learnings from the VPP trial to install grid-side batteries on the LV network. This pilot does not have any solar PV systems installed as part of the project. However, the aim of the pilot is to charge the battery during low-demand period i.e. overnight or mid-day when solar PV generation is at its maximum and discharge during peak demand period to manage the loading on UE LV network.

As more and more BESS units are installed on the network, the aggregated BESS units will be used to test the market benefits of LV grid batteries and in future used to manage the loading on upstream assets.

(b) the aims and expectations of each demand management project or program

The objective of the project is to use the BESS units to manage the existing load on distribution transformers and LV circuits.

Traditional network solutions usually result in sunk capital; the resulting augmented asset cannot be easily recovered and used elsewhere if future demand falls. This project aims to validate or otherwise, the use of grid-side batteries solution on LV networks for the provision of efficient and prudent network augmentation. The solution will be validated if it:

- effectively avoids/defers capex/opex requirements in a prudent and efficient manner
- is the most economic outcome when actual costs and benefits are known
- is a technically appropriate solution with appropriate mitigation of any risks.

The objectives of this pilot are to validate LV BESS as a suitable approach for managing augmentation on the UE distribution network with no adverse impacts to network reliability and safety. The LV BESS pilot aims are:

- evaluate the performance of the grid-side BESS as one of UE's range of options available for rectifying sites experiencing overload operating conditions to deliver the benefits of traditional augmentation
- confirm the total cost to supply and install the grid-side BESS (for use in future business case options analysis)
- evaluate the potential of using BESS units in managing the quality of supply and in enabling higher level of solar PV penetration on distribution networks
- evaluate the grid-side BESS products (build quality, reliability, standard adherence, operational experience, etc.)

- develop the design, specification, construction, maintenance and operation skills needed to manage this potential fleet of new assets
- determine the benefits of using grid-side BESS technology on the UE network including market revenues (for use in future business case options analysis and to inform the business model for LV grid-side storage) by partnering with one or more retailers for the duration of the pilot.

(c) the process by which each project or program was selected, including the business case for the project and consideration of any alternatives

This pilot proposes LV BESS as a solution to address peak demand issues in LV circuits and distribution transformers when augmentation costs using traditional solutions are high. It is anticipated that in the future, energy storage would have applications for the entire network as costs continue to fall.

(d) how each project or program was/is to be implemented

This project involves installing grid-side LV storage systems to manage the loading on distribution substations and LV circuits. As part of this project, UE identified three constrained distribution substations to install the BESS systems. UE has completed the installation of two BESS units in 2020.

(e) the implementation costs of the project or program

In April 2018, UE submitted application to the AER to use part of the 2016-2020 DMIA funding to support stage 2 of the project, LV grid-side BESS pilot on capacity constrained part of UE LV network. AER provided indicative approval for the project in May 2018. The proposed stage 2 of the program is estimated to cost $945,000 with DMIA funding $780,000 with the remaining $165,000 coming from UE capex budget by differing the augmentation of the LV network.

(f) any identifiable benefits that have arisen from the project or program, including any off peak or peak demand reductions.

UE identified a number of constrained locations on the distribution network where deployment of LV grid-side BESS would be able to achieve peak demand reductions economically.

3. The costs of each demand management project or program:

(a) are not recoverable under any other jurisdictional incentive scheme,

(b) are not recoverable under any other state or Commonwealth government scheme, and

(c) are not included in the forecast capital or operating expenditure approved in the AER's distribution determination for the regulatory control period under which the DMIS applies, or under any other incentive scheme in that determination.

- Expenditure under DMIA is not eligible for recovery under any other jurisdictional incentive scheme.
- Expenditure under DMIA is not eligible for recovery under any other state or Commonwealth government scheme.
- Expenditure under DMIA has not been approved in the AER's distribution determination for the regulatory control period under which the scheme applies, or under any other incentive scheme in that determination.

4. An overview of developments in relation to projects or programs completed in previous years of the regulatory control period, and of any results to date.

Not applicable.

4. Grid-Side Battery Energy Storage Systems Pilot Project

The 2019 DMIA annual report published information about the project need, details of the site selection, stakeholder engagement plan, social and reputation risk assessment, technical specifications, design and the procurement of the BESS for the pilot project.

In this report, the key findings about commissioning and operation of the pilot BESS units are described in detail.

4.1 Single Line Diagram

The BESS system is connected to the network via the Q2 breaker, AMI meter and the S1 isolator. The system is also protected using a 100A fused overhead line connection box (FOLCB). Figure 1 shows the single line diagram of the system.

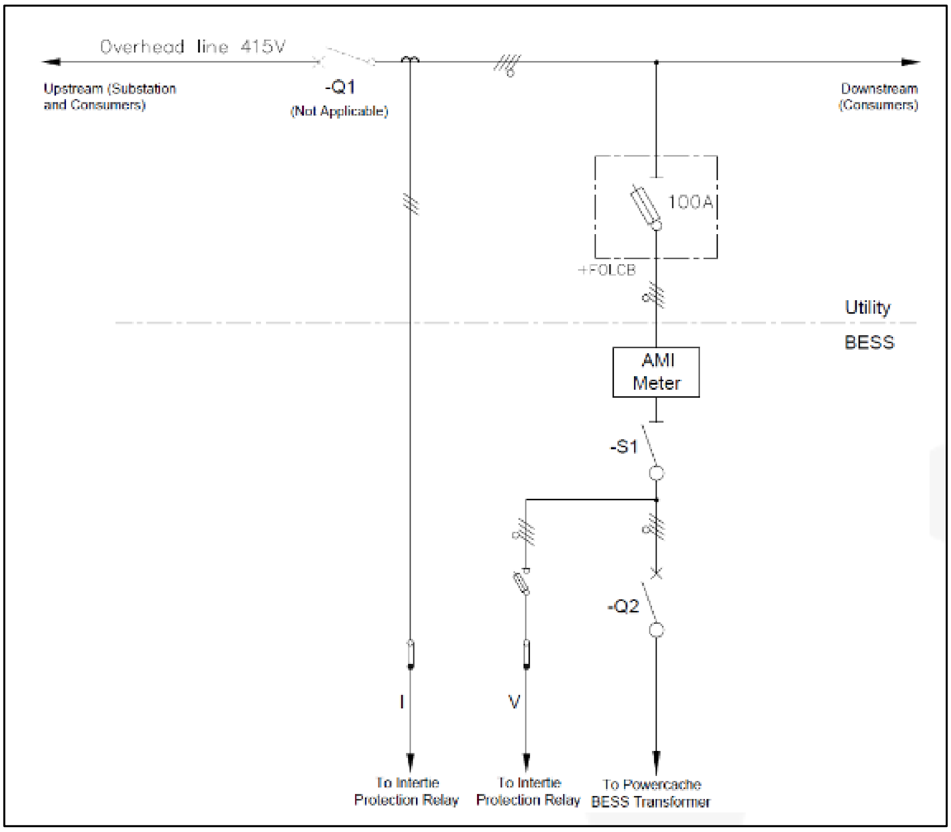

Figure 1: BESS single line diagram

4.2 Factory Testing

The BESS factory acceptance test involved three parts and was completed over multiple days:

1. Manufacturer acceptance test
2. UE witness testing
3. Protection injection testing by UE Service Provider

The same set of tests were performed for the manufacturer acceptance test and UE witness testing which included:

- Physical inspection of all electrical and mechanical components for damage, confirm auxiliary supply to all components, checked installation of fire suppression unit and confirmed breaker settings.
- Auxiliary system checks performed on all cabinet fans, anti-condensation heater and thermostats.
- Sensor checks completed on temperature and humidity sensors.
- Emergency stop (E-stop) functional checks to confirm wiring is correct.

- Simulated faults on all hardwired alarms to check performance.
- Performed functional tests on inverter and battery units.
- Complete system level functional test.
- Performance testing of the four quadrant inverter.
- Sustained full power test i.e. measure system output at different set points for at least 15 minutes.
- BESS islanding performance with load i.e. operate BESS as island with a small load.
- Battery full charge test i.e. charge battery to its maximum capacity.
- Anti-islanding test i.e. test BESS performance to disconnect when grid supply is lost.
- Set point limitation test to confirm BESS will not charge or discharge above set limit.
- Test all SCADA alarms.
- GUI remote functional test.

Injection testing of the protection relay was performed to confirm relay settings and performance. The below tests were completed as part of the injection tests:

- Over current
- Over voltage
- Under voltage
- Under frequency
- Over frequency
- Rate of change of frequency (ROCOF)
- Synchronous check to confirm that relay will not close the circuit breaker if the mains voltage and generator voltage are out of sync
- Relay logic testing
- CT ratio, class and polarity checked and confirmed against specification and CT nameplate

Both units passed all of the above tests.

4.3 Transportation

The BESS units were transported directly from the supplier factory to the installation sites. All the items including battery, inverter, transformer and control equipment were in the cabinet during transportation. The BESS was transported in four parts.

1. Battery cabinet
2. Inverter/Control cabinet
3. Two roof halves and
4. Platform

Each cabinet half is a frame structure designed to be lifted by eye bolts on the top. The cabinets cannot be lifted with a fork-lift. The cabinet halves must be lifted separately onto the truck by the four outer eyes using a crane as per Figure 2.

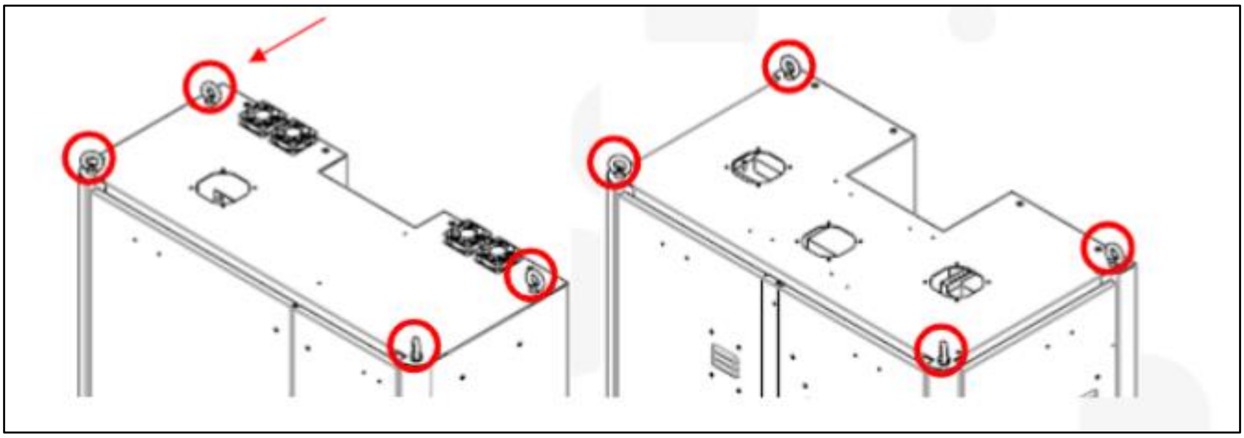

Figure 2: BESS cabinet halves with eye-bolts installed for lifting

The cabinet joiner plates needed to be removed prior to transportation. Each eye bolt has a 340kg load capacity. The total weight of the battery cabinet is 900kg and the inverter cabinets is 700kg. The eye bolts were used with slings and a spreader bar such that the angle of the slings are vertical. Spreader bar was important to avoid damaging the top edge of the cabinet.

The BESS units were transported on a truck with an in-built crane. The equipment particularly the battery modules are sensitive to vibration and impact. While the battery modules were held in their shelves, additional cardboard filling materials were added to avoid vibration. These cardboards were removed after installation of the battery cabinet onto the pole. The truck was required to have airbag suspension to limit vibration.

4.4 Mechanical Installation

The BESS units were installed on a new 10.5m/12kN wooden LV utility pole. Both units were installed at 3.6m height above ground level. The wooden pole was installed prior to the installation of the BESS unit.

The platform was the first component installed on to the pole. Due to the wrap around design for the BESS system the platform had to be placed between the pole as per Figure 3. Due to the uneven circumferences of the wooden pole, a wooden plane was used to shave protruding knots so that the BESS unit could be installed safely. For future systems it is recommended to consider increasing the circumferences of the BESS design to accommodate for uneven poles. The platform is held in place using two king bolts (M24 x 400 Hex Bolt) as shown in Figure 3.

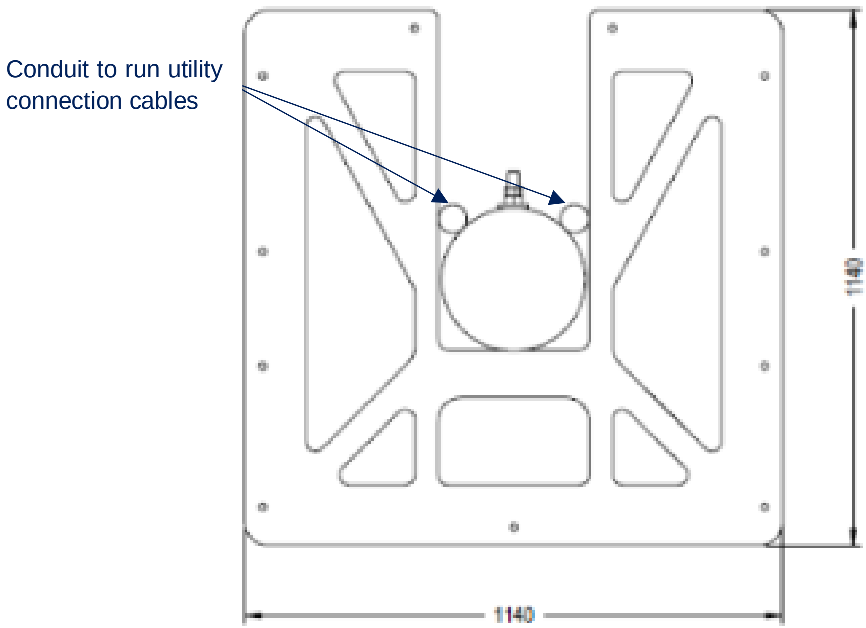

Figure 3: Platform installed between the wooden pole (Top View)

The battery cabinet was installed first followed by the inverter/control cabinet. Lifting and position of the battery cabinet had to be slow to avoid any damage to the batteries. The battery cabinet shall not be tilted more than 10 degree in any direction. Both cabinets were placed carefully on to the platform and were bolted to the platform using six M12 x 30 hex head bolts.

The lifting eyebolts had to be removed prior to the installation of the roof. When installing the roof extra care had to be taken to avoid any damage to the sensitive fans, alarm sensors and wiring on top of the cabinet. Both halves of the roof were installed from the inside of the cabinet and were bolted to the cabinet using eight M6 x 20 hex head bolts. A weather strip was bolted to the battery side of the roof to avoid any possibility of a water leakage between the roof halves.

Figure 4 shows the installed BESS unit on the LV network.

Figure 4: Installed BESS unit on UE LV network

4.5 Network Connection

All network connections, cabinet connections and antennae penetrations are through the bottom of the device. The BESS device has provision for three antenna installations: one for the AMI meter, one for control system and one for SCADA, respectively. Dedicated 40mm corrugated conduits with associated glads were provided for the cabinet interconnections, one for the auxiliary and control cable and the other for the battery DC cables. Two 63mm conduits were installed along the pole to run the utility connection cables (refer to Figure 3).

The BESS is connected to overhead conductor using a 4C x 16mm^2 Al XLPE cable. The cable runs along the pole via the 63mm conduits to the bottom of the cabinet and from there to the grid connection compartment in the inverter cabinet half. In the cabinet, the Red, White, Blue and Neutral wires are connected to their respective terminals in the AMI meter.

Three overhead split core current transformers (CTs) were installed on the upstream overhead conductors to monitor the network conditions.

4.6 Commissioning

Both cold and hot commissioning tests were completed post installation of the units.

The scope for the cold commissioning checks included:

1. Fan operation test: Confirmed operation of all fans via the thermostats. Testing of the fans operation was conducted with the roof installed.
2. Thermostat settings: Confirmed all thermostat settings were returned to normal operational settings.

3. Auxiliary power: Confirmed auxiliary power was being supplied to all the devices. Green LED light was observed on the devices in the control compartment to confirm that they were operational.
4. Confirmed tightness of components: Completed checks to confirm that the terminals on the transformer, LC filter and batteries had not loosed during transportation and installation.
5. Confirmed component status in graphical user interface (GUI): Remotely confirmed the status of all the devices on the GUI. Confirmed that all control functions were enabled and no alarms were present before commencing the hot commissioning tests.

Hot commission test (system functional checks) were carried out remotely via a web GUI using a notebook computer. Apart from testing the E-stop mushroom button on the device, manual interaction with the hardware was not required to perform functional checks. On-site hot commissioning test was conducted to confirm safe installation of the device and to detect any system damages.

The following actions had to be completed prior to commencing the hot commission test.

a. Close system main isolator
b. Set protection relay to AUTO mode
c. Set inverter control to AUTO mode
d. Close the battery string isolators
e. Set battery control to AUTO mode.

On completion of the above actions, the following commands were actioned using the web GUI to confirm system functionality.

a. Get ready – Pre-charge battery and inverter terminals prior to system start.
b. System start - Close Q2 breaker to connect the BESS to the grid.
c. Shutdown – Inverter stopped, opened breaker Q2 and DC contactor.
d. Repeat step (a) and (b)
e. System stop – Opened Q2 breaker to disconnect the BESS from the grid.
f. System start– Closed Q2 breaker to connect the BESS to the grid.
g. Manually press E-stop button – Inverter stopped, opened Q2 breaker and DC contactor. Alarm raised in GUI.
h. Alarm Reset – Reset all active alarms via the GUI.
i. Repeat step (a) and (b).
j. E-stop via GUI – Inverter stopped, opened Q2 breaker and DC contactor. Alarm raised in GUI.
k. Repeat step (a) and (b).
l. Set different charge and discharge rate for the BESS.
m. Confirm BESS performance using historian data.
n. Check alarm manager to confirm E-stop event logs.
o. Confirm data historian for BESS data.
p. Confirm SCADA alarms.

4.7 Maintenance

BESS maintenance included both onsite and remote maintenance programs. The supplier recommended the below maintenance interval for the BESS systems:

a. Annual on-site maintenance
b. Major maintenance required after 6 years
c. Quarterly system health check to be completed remotely

Any on-site maintenance will require the BESS to be shut down and isolated prior to commencing the work. On-site maintenance will require a bucket truck for access and will be carried out by UE's Service Provider. Quarterly system health check could be completed remotely by the supplier.

Table 1 list the components that require planned or preventative maintenance during the life of the system.

Table 1: Hardware components planned maintenance

Object	Activity	Maintenance Cycle
Air filter in the doors	Inspect and if required replace	Annually

Object	Activity	Maintenance Cycle
Cabinet fans	Test performance of fans	Annually
Inverter fan	Replace inverter fan	Every 6 years
Fire suppression system	Test and Inspect	Annually
	Replace	Every 6 years
UPS battery	Test	Annually
Cabinet general	Clean and de-dusting	Annually

4.8 Lessons Learnt

This sections details the additional lessons learnt during the delivery, installation and commissioning of the pilot BESS systems. Any lessons learnt which was shared in UE's 2019 DMIA report is not included in this section.

Table 2 lists project management related lessons learnt on this project.

Table 2: Project Management Lesson Learnt

Situation	Action	Recommendation – Future Projects
The supplier did not review the final design against the UE technical specifications. Some of the requirements were identified during the assembly and commissioning phase, which resulted in re-work and additional delays to the project.	UE had to work with the supplier in including the requirements when it was identified. This resulted in UE spending more time doing performance testing and quality control.	Identify dependencies in technical specifications requirements prior to moving on to next stage i.e. the supplier needs to review their current design and ensure that it meets all UE requirements before progressing further. UE technical specification to include a list of deliverables. UE to develop a checklist as part of the updated technical specification document. Enforce the supplier to complete the checklist prior to submitting the final design.
As the UE team started to learn more about the BESS design, agile changes or request were made to create a better product. This has affected the timely delivery of the project.	UE had to work with the supplier in finding a way to include the additional requirements.	UE to revisit the technical specification prepared for the pilot project and update it to capture the additional requirement.
Lack of visibility on supplier subcomponents made it hard for UE to keep track of all the materials being procured.	UE to work closely with the supplier in identifying long lead items and to ensure they are order as soon as possible.	For all the main components and long lead time items, it will be beneficial for UE to have point of contact with the sub-supplier.
The supplier did not have a defined procurement strategy, and this resulted in delaying placing the order for the BESS units. Supplier being a small business did not have any dedicated person responsible for procurement.	UE assisted in procuring some of the items for the supplier. e.g. CTs were procured by UE for the timely installation of BESS#1.	Supplier should provide a list of all long lead items and the proposed delivery timeframes. Supplier should provide a confirmation letter from their sub-supplier about their delivery timeframes based on the current situation. UE to request for bill of lading from the supplier.

Situation	Action	Recommendation – Future Projects
The supplier did not have a document control policy.	UE assisted with centralising documents and drawings in OneDrive.	Supplier to provide document control procedures, document revision procedures, document registers and document transmittal example.
Pilot projects which involve developing new technologies are very complex and require a lot of internal resources and time.	UE worked actively to manage unexpected issues.	Ensure cost and time contingency is taken into consideration when creating the project management plan (PMP).

Table 3 details the lessons learnt during the BESS system design.

Table 3: System design lessons learnt

Situation	Action	Recommendation – Future Projects
Security and reliability queries were raised overusing the service provider's modem and communications for retailer integration.	UE is currently managing this risk by using an access control document. The supplier needs to inform UE before taking control of the system.	In future BESS designs, the control and communications to individual devices will be from a UE issued modem which will be talking to the UE BESS control system over a private VPN network.
Supplier had remote read and write access to the grid protection relay. Setting changes could be made remotely from the SEL relay terminal.	UE changed the password on the SEL relays to mitigate this risk.	In future systems the protection relay will be locked for remote write access. Any setting changed will have to be done locally using UE approved service provider.
UE requested to have remote terminal unit (RTU) installed on the BESS which was not part of the original technical specification.	UE had to work with the supplier to accommodate this request.	UE needs to review the technical specification and BESS control strategy to understand whether an RTU unit is required for the future installation.
The current design did not measure and inform UE about the individual cell temperature. Only a max and min temperature reading was available to UE.	UE was not aware that the existing BMS only monitored the minimum and maximum temperature early in the design phase. UE captured this requirement as an improvement for the larger pilot.	In future, the supplier needs to provide a detailed specification of the battery management system (BMS) unit to UE. UE should also have direct contact with the battery and BMS manufacturer to understand that the products meet UE's expectations.
The protection philosophy submitted by the supplier did not meet UE protection expectations. This resulted in delays in approving the finals settings for the BESS systems.	UE worked with the supplier in changing some of the protection philosophy to meet UE standards. This resulted in multiple iteration and caused delays to project.	For future systems, UE will be requesting the supplier to have a dedicated protection engineer to prepare the protection report or get it done by an external consultant. UE will also be updating the technical specification document to clearly state the protection requirement for the BESS units.
In the current BESS design, the operation of the main Q2 breaker was not independent of the supply voltage.	This was design improvement identified by UE during the factory acceptance testing. UE did ask the supplier to implement the under-voltage shunt trip (UVR) method. In this way the breaker would go to its OPEN position when supply voltage is lost.	UE to review zone substation secondary standard and include this in the updated technical specification document.

Situation	Action	Recommendation – Future Projects
The current BESS pilot project had different voltage levels (240V, 24V and 12V DC) supplying the control and auxiliary systems.	UE asked the supplier to clearly label this in the engineering drawings and operational manual.	For future systems, UE to specify that all control and auxiliary supplies to be designed in one voltage level i.e. 24V DC.
Insulation monitor should be connected to the battery side and not the inverter side.	This will be captured as a lesson learnt from the pilot project.	In future, UE will have to be engaged in the design of the BESS system. UE will also be asking for regular design workshops/updates to identify these design issues at an early stage.

Table 4 details the lesson learnt during the construction and installation of the BESS units.

Table 4: Construction and Installation lessons learnt

Situation	Action	Recommendation – Future Projects
The lifting force was required to be applied directly above the eyebolts or should be at an angle greater than 45 degrees. This resulted in a large lifting distance between the top of the BESS and the crane. Hence an outage was required during the installation.	UE had to take an outage on the LV network to install the BESS unit. The number of customers affected was minimised by adding LV mid-section interrupters (MSIs) and back feeding customers from adjacent distribution substations. However, for future installation, UE needs to consider design improvements to install the system without an outage (live work installation).	Ensure the lifting lugs are welded to Australian standards. This needs to be included in the mechanical drawing provided to UE. Going forward, UE to do an audit on the design drawings and welding practise. Position of the top of the lifting apparatus (crane) needs to be within 1m of the top of the BESS unit. This will enable the BESS unit to be installed without LV outages in most situations. UE needs to ensure that the supplier submits a lifting plan prior to installation of the unit. In future, during mechanical enclosure design, an H bracket needs to be included to ensure that the lifting of the cabinet can be performed safely and with reduced clearance between the BESS and the top of crane. Also, UE needs to review the mechanical design of the cabinet to make installation process quick and simpler. The lifting mechanism of the BESS can also be externally on the side of the BESS to assist with clearances issues. UE needs to review the clearance between the cabinet and the LV overhead line before installation.
The circumference of the LV pole was uneven. This resulted in considerable additional time being spent in installing the BESS units.	Wooden plane was used to shave protruding knots, so that BESS can be installed safely. The service provider attended site to measure the poles installed to ensure the BESS would fit around the pole at the required mounting height.	For future installations if a new pole is required to be installed, then the service provider needs to make sure a straight pole is selected for the job. It is recommended that the service provider to do some measurement prior to the selection of pole to

Situation	Action	Recommendation – Future Projects
		ensure the BESS unit fits on the pole. Prior to installation the service provider should try a sample template demonstrating the BESS hollow sizing? Maybe include a standard specification in BESS technical document. Consider having a bigger circumference for the BESS design to ensure it fits uneven poles. Also, BESS mounting to have ability for minor adjustment.
It was noted by the testers during the factory acceptance testing that fork lugs were used instead of standard ring lugs. This resulted in additional work to change it.	UE worked collaboratively with the supplier to ensure the fork lugs were amended. This was a lengthy process as it had not been specified in the design requirements.	In future as part of the regular design meeting and reviews UE needs to check and confirm that ring lugs are utilised instead of fork lugs. Need to include this in the technical specification document.
Test links were missing on some inputs and the links were wired incorrectly i.e. not to the UE standard.	UE worked collaboratively with the supplier to include additional test links and rewire to “top and fall to close”. This was a lengthy process as it had not been specified in the design requirements. BESS 2 constructed slightly different to ensure improved design was considering.	Test links required to be wired from top and fall to close. Test links also required on all inputs. UE needs to reference this in the UE technical specification.
Lack of specification provided to wire RTU logic caused considerable re-work.	UE had to trouble shoot why the RTU was working, however, providing unexpected results. After confirming the truth tables, it was identified that two independent logic tables where been used independently by UE and the supplier. These tables were altered to match.	Adequate information needs to be provided by various stakeholders to the supplier to ensure they are wired correctly. Items being free issued need to have adequate documentation.
During the installation of BESS#2, the service provider had to take extra measures to ensure the cabinet remained waterproof during installation i.e. before installing the roof.	The service provider had to utilise tarpaulins on the BESS when it started to rain for spells. During rain, tarpaulins were installed, and work had to be stopped. Once rain had stopped, work proceeded again.	In the future enclosure design, UE needs to consider waterproofing of the cabinets, so that it will not affect the installation of the unit during wet/raining days. UE to specify in the technical specification document that consideration needs to be taken in the design stage to have the enclosure waterproof during transportation and installation. Potentially design a BESS which does not have a removable roof. This would mitigate the chance of water penetrating the BESS during installation and would also result in a more efficient installation.
Connection of the overhead LV provide time consuming to connect internally in the BESS.	The service provider had to install overhead LV service cable down the pole, through the BESS and then looped at the bottom to come	UE to explore the potential to install the overhead LV to external bushing mounted on the top of the BESS. This could reduce the

Situation	Action	Recommendation – Future Projects
	back through the underneath of the BESS.	requirements for connections and testing inside the BESS.
During the factory acceptance testing it was noted fan guards were not installed on the BESS.	Fans were protected by the roof installation.	UE to specify fan guards as a requirement in the technical specification.
Installing all nuts and bolts while up in a bucket truck deemed difficult in certain situations.	Multiple drills and sockets set had to be utilised to ensure access to all connection mechanism.	All nuts and bolts should be easily accessible, and the design should minimise the requirement for connections to be completed during pole installation. Tools to complete the install should be recommended i.e. flexible socket sets.
Significant vibrations were noted during testing.	Supplier ensured inverter and filter were mounted to the cabinet with rubber grommets in-between the metal frame.	UE to explore the idea of installing rubber sealing on the platform to minimise vibration. UE to specify in the technical specification the requirement for vibration dampening installation techniques.
Installing and aligning the BESS platform correctly deemed difficult due to small bolt holes predrilled in the platform.	The service provider had to include additional mounting blocks/spacers to ensure the bracket was aligned correctly.	UE to specify the use of slotted bolt holes rather than circular holes on the platform. This will allow adjustments to fit the BESS platform on poles more easily.

Table 5 details the lesson learnt during the testing of the BESS units.

Table 5: System testing lessons learnt

Situation	Action	Recommendation – Future Projects
The supplier test facility did not have capability to simulate all the network fault scenarios. The facility did not support AS4777.2 testing requirements. Supplier was not able to perform the required type tested specified in UE technical specification. Supplier did not have thermal devices or calibrated equipment.	UE worked with the supplier to ensure the testing capabilities were increased i.e. provided PT100 testing temperature testing unit.	UE needs to include test requirement as part of the technical specification. UE to include the requirement to have a load bank and single phase variac. Have meetings with the supplier prior to signing the agreement to confirm that the UE testing requirements can be performed at the supplier test facility.
The technical specification did not specify any mandatory routine testing. The supplier developed an ITP that did not meet UE's expectation.	UE worked with the supplier to ensure the testing requirements were addressed to UE requirements.	UE to make sure that the mandatory routine test required for the BESS will be specified in the technical specification document.
supplier did not have adequate test equipment to perform secondary injection testing.	UE instructed the service provider to confirm injection testing was satisfactory.	For future installations, UE will need to investigate the supplier test facility to validate their capability.
Supplier did not provide a testing procedure document prior to UE FAT testing. This made it hard for UE to perform or repeat test at the site.	For BESS #2, UE only attending witness testing once a defined FAT document was signed by the supplier and provided to UE.	For future installation, UE will request the supplier to develop test procedure document for all the specified mandatory test. This will be specified in the technical specification document and will

Situation	Action	Recommendation – Future Projects
Supplier did not perform or have a proper test procedure prepared to perform all the test mentioned in the ITP prior to witness testing with UE individuals. This had resulted in considerable amount of time being lost.		have to be provided to UE for review prior to starting the factory acceptance test.
Supplier lacked appropriate test resources and experience in utility test requirements.	UE worked with the supplier to ensure the testing requirements were addressed to UE requirements.	UE to specify the type of test required and the equipment's that will be required to perform the test in the technical specification document. For larger pilots, UE needs to understand supplier capability/experience in testing and their resource capabilities.
Supplier did not complete elementary wiring checks with the AS BUILD drawings prior to starting testing on the equipment.		In future, UE needs to ask for an appropriate test plan from the supplier which should include the ITP, test procedure and confirmation of wiring checks completed prior to starting testing on the equipment.
Supplier hesitant on completing multiple charge and discharge cycles		Provide the supplier with an estimation of testing days required and energy consumed.

Table 6 details the lesson learnt during the design and implementation of the network protection settings for the BESS units.

Table 6: Network protection design lessons learnt

Situation	Action	Recommendation – Future Projects
Neutral over-current (NOC) setting was changed remotely.	UE conducted a risk assessment prior to accepting the remote changes. To mitigate the risks, UE attended the supplier's factory during the remote access change and ensured the terminal was used to change the NOC value. This process was documented, and the BESS was physically tested again at the next available time.	Utilise additional testing equipment such as a variac to simulate the extremities on the UE network. Explore the options of having remote access via internal UE security. Disabled the option for remote access to the BESS.
BESS will not run 100% if the network is unbalanced.	Smart function implemented in the BESS that detects significant circuit imbalance and reduced the BESS output to ensure the BESS does not trip.	Highlight potential extremities of circuit imbalances and ensure this BESS is specified to work at extreme conditions. Potentially install 2 BESS on extremely overloaded circuits.
The supplier's design used the protection relay for their own form of metering (This can be still used). Protection relay and its protection functions need to be independent to any other control functions for the inverters.	UE had to work closely with the supplier to ensure all protection enquires were answered. UE created an answer form which identified all the uncertainties regarding the protection settings and enabled specific answer provided by the supplier to confirm validity.	In the future, the protection relay should be completely independent of the control functions. Three single-phase inverters can be used; however, this includes additional difficulties that may present additional problems. It is not also FAT as one unit until the BESS is tested.

Situation	Action	Recommendation – Future Projects
		Protection relay should not offer control to the inverter – Inverter control functions should not come from the inverter.
Network study was not performed for the original pilot requirements.	UE had to work closely with the supplier to ensure all our protection requirements were met.	UE to provide supplier network simulation and previous circuit studies to assist in protection requirements.
The supplier utilises system integrated components.	UE requested breakdown of all materials (BoM) to ensure access to each component in the event the supplier is no longer available.	Larger companies withdrawn from renewable energy technologies due to warranties not available when utilised in system integrators. Ensure system integrator company does not impact individual warranties of components.

Table 7 details the lesson learnt during the design and implementation of the control system for the BESS units.

Table 7: BESS control system design lessons learnt

Situation	Action	Recommendation – Future Projects
The supplier did not enable the SMART mode operation as discussed in the initial project start up meetings.	Analytics team had to build more functionalities to utilise all the capabilities of the BESS.	UE needs to set our expectation at the start of the project and agree with the supplier about what control systems will be available to UE. The supplier should also have a suitable working product before handing over the access to UE to build the control system.
Lack of information regarding the final product from the supplier resulted in creating confusion internally in UE.	UE requested documentation to highlight the capabilities, operating modes and requirements of the BESS.	The supplier should also have a suitable working product before handing over the access to UE to build the control system
Analytics team expected the open VPN solution could be used in the corporate zone. However, this was not the case which resulted in delays.	A virtual machine (VM) was created and a firewall project had to be initiated internally at UE to enable connection to the OpenVPN.	Control system architecture to be completed prior to large scale roll out.
The supplier outsourcing control system functionalities could cause unnecessary delays. e.g. in the pilot project the supplier used a third-party VPN service that they had little control resulted in delays in the project.	UE actively followed up the supplier rectification works, however, the supplier had to follow up with a third-party company based in Europe.	Request a list of third-party contractors that the supplier will be using.