Installation Integrity

CLEAN ENERGY COUNCIL

INSPECTIONS SUMMARY

ENERGEX MARKET BASED BATTERY TRIAL – STAGE ONE

MAY 2017

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1. Executive Summary

As a peak body for the clean energy sector, the Clean Energy Council (CEC) is working to ensure the strategic development of energy storage and the coordination of this emerging sector, raising awareness about best practice implementation, and engagement in policy and regulatory issues.

Numerous trials of BESS are occurring across Australia. These trials provide a unique opportunity to enable the continuous improvement of the storage sector. CEC was contracted by Energex to undertake compliance inspections of fifteen (15) solar PV with battery energy storage system (BESS) installations which are part of Energex's Market Based Battery Trial - Stage 1. The BESS installations include a mix of brands and configurations, with a focus on lithium ion battery technologies currently available on the market.

These independent inspections audited the PV systems and BESS to ensure compliance with relevant Australian Standards, industry guidelines, and network regulations. See Section 4: Inspection Scope and Process for the list of standards, and refer to CEC guidelines for when battery standards are applicable.

Non-compliances with standards and guidelines were identified at all sites. In addition, safety risk was identified on the original solar system at one site. Please note that, at the time of writing this report, 1 of the 15 Stage 1 installations was yet to be installed and inspected. Therefore this report only includes observations of the first 14.

The majority of non-compliances observed on Stage 1 BESS related to either manufacturers' installation instructions not being followed or system signage being incomplete or inaccurate. To ensure safety of BESS, installers need to thoroughly understand and comply with the manufacturer's instructions. Installers must also ensure that signage is installed that will effectively communicate safety procedures and precautions to occupants, contractors and emergency personnel.

The level of non-compliance identified through the audits highlights the need for change in installation practices to occur to ensure the quality and safety of battery systems. Based on the audits completed, the CEC recommends action in the following areas:

- Establishment of a BESS Registry
- Ongoing training and awareness
- Additional guidance on BESS safety signage
- Proactively check existing PV systems
- Set standards and protect consumers

This report summarises the issues identified during inspections of Stage 1 installations and the percentage of systems that were identified with the issues. Please note that this summary report includes only issues that were observed at more than one site as well as issues that represent a significant safety risk.

2. Introduction

The Clean Energy Council's Australian Energy Storage Roadmap highlights that energy storage technologies are a game changer for the Australian energy market, offering the prospects of greatly increased flexibility, reliability and efficiency in the delivery of power to consumers. Energy storage will complement the accelerated deployment of renewable energy in its various forms. As storage technology evolves and costs decline, the potential for storage technology in Australia is massive.

As a peak body for the clean energy sector, CEC is working to ensure the strategic development of energy storage and the coordination of this emerging sector, raising awareness about best practice implementation, and engagement in policy and regulatory issues.

Numerous trials of BESS are occurring across Australia. These trials provide a unique opportunity to enable the continuous improvement of the storage sector. CEC was contracted by Energex to undertake audits of BESS installed as part of their Market Based Battery Trial.

The objectives of CEC audits were to:

- provide a third party accredited audit of BESS installations to ensure compliance with relevant Australian Standards, industry guidelines and network regulations; and
- share findings and learnings from the audits with key BESS industry stakeholders.

This report summarises the findings of the audits and provides recommendations to inform industry/BESS stakeholders.

3. Energex Market Based Battery Trial

In conjunction with BESS manufacturers, Energex is running a Market Based Battery Trial with 15 of Energex's employees who already had a solar PV system installed. The trial aims to provide insights into how homeowners configure and use BESS; and the demand response provided by BESS during times of peak demand and high solar export. The trial will run for 3 years and will monitor the changes to customer load profiles during this time.

Six different brands of BESS are being installed as part of the trial. These include a mix of AC and DC coupled systems. All systems are AS/NZS 4755.3.5 demand response enabled, giving the network the ability to communicate to the BESS and activate demand response modes. All systems have lithium ion batteries. The systems are:

- Solarpowa Powasaver (LG Chem battery and Sungrow inverter);
- BG (LG Chem battery and Goodwe inverter);
- BYD mini (BYD battery and inverter);
- Samsung AIO and Reposit controller;
- Redback (pylontech battery, Redback inverter); and
- Panasonic residential storage system.

The trial participant sites were located across South East Queensland. The PV systems ranged in age from 3.5 years to less than one year old. BESS were installed between September 2016 and May 2017. All BESS installations were undertaken by CEC accredited installers.

4. Inspection Scope and Process

CEC contracted GLOBAL SUSTAINABLE ENERGY SOLUTIONS PTY. LTD. (GSES) to undertake audits of each of the 15 solar PV systems and BESS installed at the MBBT trial sties. The inspections occurred within a couple of weeks of the BESS installation. GSES is an authorised auditor for the federal government's Clean Energy Regulator, which has given them the necessary expertise to conduct these inspections on behalf of the CEC.

Each PV and BESS installation is checked for:

- Products installed listed on the CEC approved list,
- Compliance with relevant Australian Standards, including:
    - AS/NZS 3000 Electrical Installations
    - AS/NZS 4777 Grid Connection of Energy Systems via an Inverter
    - AS/NZS 5033 Installation and Safety Requirements for Photovoltaic Arrays
    - AS 2676 Installation and Maintenance of Batteries in Buildings
    - AS 3011 Electrical Installations – Secondary Batteries in Buildings
    - AS 4086 Secondary batteries for use with stand-alone power systems
    - AS/NZS 4509 Stand-alone Power Systems
- Compliance with CEC guidelines, including:
    - CEC Install And Supervise Guidelines For Accredited Installers: Grid-Connected Solar PV Systems
    - CEC Install Guidelines for Accredited Installers: Grid Connected Energy Systems with Battery Storage
- Correct system wiring at switchboard, multimode inverter and battery,
- Water ingress into any enclosures,
- Wiring inspection,
- Installation of correct signage, and
- System documentation.

The inspection process comprises:

- Roof inspection including a visual inspection of roof attachments, opening and inspecting all isolator enclosures and combiner boxes, inspecting wiring fixings, connection and protection
- Roof cavity inspection and all solar wiring between the array and inverter confirming correct conduit installation
- Inverter inspection by opening and inspecting all isolator enclosures and combiner boxes and inspecting wiring fixings, connections and protection

- System protection inspection including inspection of wiring fixings, connections, over-current protection, isolation and associated equipment ratings.

Inspection findings reports were created for each individual site, outlining the level of compliance and any rectification actions required. Each report included the following:

- **Inspection findings:** The technical outcomes of the inspection. This section lists all findings of system elements or installation practices which do not meet the associated compliance requirements. Recommended methods for corrective action were provided where required.
- **Inspection photos:** Photos taken during the inspection which correspond to any items listed under the previous section.

The reports were provided to system installers to assist in carrying out rectification work identified where required. To assess understanding and resolution of the issues identified, desktop audits were then completed on written responses and photos of rectifications work provided by the installers.

5. Results of Inspections

Non-compliances with standards and guidelines were identified at all sites[1]. In addition, safety risk was identified on the original solar system at one site.

The majority of non-compliances observed by GSES on Stage 1 BESS related to either manufacturers' installation instructions not being followed or system signage being incomplete or inaccurate. To ensure safety of BESS, installers need to thoroughly understand and comply with the manufacturer's instructions. Installers must also ensure that signage is installed that will effectively communicate safety procedures and precautions to occupants, contractors and emergency personnel.

The current BESS Australian standards are focused on lead acid BESS and therefore requirements for BESS with other battery chemistries must rely more heavily on manufacturers' instructions. The CEC's new BESS guidelines have helped to clarify which current Australian Standard requirements are applicable to all grid connected BESS (including non-lead acid technologies) and they provide vital guidance in the interim before *AS/NZS 5139: Electrical Installations – Safety of battery systems for use in inverter energy systems* is published.

System documentation was not sighted for 12 of the 14 sites inspected. This means that the inspector was not able to confirm that documentation met required standards and guidelines. Only one Material Safety Data Sheet (MSDS) for the battery and any other potentially hazardous materials installed was sighted. This was primarily due to trial participants not being home or forewarned of the need to have the documentation available for inspection.

Table 1 summarises the issues identified during inspections of Stage 1 installations and the percentage of systems that were identified with the issues. Please note that this summary report includes only issues that were observed at more than one site as well as issues that represent a significant safety risk.

[1] Please note that, at the time of writing this report, 1 of the 15 Stage 1 installations was yet to be installed and inspected. Therefore this report only includes observations of the first 14.

Table 1. Observed issues and frequency of occurrence

Issue Identifier	% of sites with issue	Issue Description	Installation (I) / Signage (S)	Issue Details
Battery system non-compliance				
GBATT4	50% (7/14)	The battery manufacturer's installation instructions have not been followed.	I	The BESS installations were checked against the manufacturer's installation instructions and some instructions were not followed. Adhering to manufacturer's instructions ensures the validity of the warranty and that products operate correctly and safely. GSES found that 64% of the Stage 1 installations inspected differed from manufacturer's instructions. The main cause for this issue was the location of the BESS. Some of the BESS were installed in locations which could easily be reached by children and the manufacturer's instructions specified that the product must be installed in a place that children cannot reach. This issue can usually be resolved by restricting access to the BESS with a locked barrier.
GBATT3	29% (4/14)	The clearance, ventilation and/or location of the battery system does not meet requirements at the time of installation.	I	Batteries have chemistry specific location and ventilation requirements to ensure safe operation conditions and longevity of batteries. GSES found that 29% of the Stage 1 installations inspected did not meet manufacturer's requirements. Of the installations found to be non-compliant, the reason for non-compliance was split between BESS being exposed to the elements, and BESS being installed in an enclosure without the manufacturer's specified ventilation clearance.
GBATT2	21% (3/14)	The battery system protection and/or isolation are not compliant.	I	Batteries are provided with switches to protect and/or isolate the battery system safely. GSES found that 21% of the Stage 1 installations inspected were found to have non-compliant isolation methods. The main cause of non-compliance was due to the battery main isolator not being readily accessible or identified.
GSIGN15	79% (11/14)	Battery voltage and/or short circuit current have not been displayed or are incorrect.	S	Displaying the Voltage and current of the batteries help identify the level of risk and required protection for emergency workers and contractors attending site. GSES found that these values were either missing or incorrect at 79% of the Stage 1 sites inspected. One cause for this issue is manufacturer not providing short circuit

Issue Identifier	% of sites with issue	Issue Description	Installation (I) / Signage (S)	Issue Details
				current ratings or equivalent values such as maximum fault currents, or internal resistance.
GSIGN11	64% (9/14)	A reflective sign with the letters "ES" and noting the battery chemistry, has not been installed at the meter box and main switchboard.	S	The reflective 'ES' sign and battery chemistry information at the meter box and main switchboard helps emergency workers to effectively identify the presence of an energy storage system and take appropriate actions. GSES found that this sign was missing or not meeting CEC guideline requirements. The main cause for non-compliance was the reflective 'ES' sign missing at the meter box and main switchboard.
GSIGN13	57% (8/14)	Emergency signage installed does not include safety procedures.	S	Battery chemistry specific safety procedures such as instructions for electrolyte burns and fire should be installed to provide instructions in the event of accidents. GSES found that 57% of the Stage 1 installations inspected were missing signage providing safety procedures. This may be due to there being no ready-made safety procedure signage on the market for the varied battery technologies currently available on the market, such as lithium.
GSIGN2	57% (8/14)	The shutdown procedure is incorrect or is not permanently fixed at the inverter or main switchboard	S	The shutdown procedure signage installed at the location of the switchboard or inverter allows correct and safe shutdown of equipment without relying on the presence of system documentation. GSES found that 57% of the Stage 1 installations inspected had incorrect or confusing shutdown procedure signage installed. Reasons for non-compliance varied, including installation sites with multiple and mismatching shutdown procedures, and sites where the shutdown procedure did not include wording required by Australian Standards. In the event of an emergency or simply for conducting maintenance, it is important that shutdown procedures are displayed and clearly communicate how to shutdown both the PV system and the BESS.
GSIGN14	29% (4/14)	Warning: Spark Hazard' signage has not been provided.	S	A sign reading 'Warning: Spark Hazard' is required at the batteries to inform personnel working on the system of the risk of sparks from improper connection or disconnection of equipment. GSES found that 29% of the Stage 1 installations inspected were not installed with

Issue Identifier	% of sites with issue	Issue Description	Installation (I) / Signage (S)	Issue Details
				this sign.
Existing PV system non-compliance				
GDC2.1.2	43% (6/14)	DC enclosures at the array do not have the required IP rating or are not suitably installed to prevent water ingress.	I	DC isolator enclosures house components which are required to isolate the PV system. Even a small amount of water getting into a DC isolator enclosure can cause can cause significant safety issues. It is thus important that the DC isolator enclosures installed have the required ingress protection (IP) rating and installed correctly to maintain this rating. GSES found that 43% of the Stage 1 installations inspected were not installed maintaining the enclosure's IP rating. The main cause of non-compliance was the lack of a suitable cable gland installed at cable entry into the enclosures.
GGENERAL5	43% (6/14)	There is inadequate clearance around the inverter in accordance with inverter manufacturer's recommendation regarding adequate space and ventilation	I	A clearance area around the inverter is specified by the inverter manufacturer to ensure adequate space for ventilation and cooling of the inverter. If the required clearance is not maintained, the inverter may overheat, attenuate performance and potentially void the inverter warranty. GSES found that 43% of the Stage 1 installations inspected did not maintain the inverter clearance area. Non-compliant sites found inverters installed close to objects or structures within the clearance area.
GDC1.2.1	21% (3/14)	The DC isolator at the inverter is incorrectly rated for voltage and/or current.	I	DC isolators are required to be rated as per Australian Standards to ensure that isolators installed can isolate the PV system under normal and fault conditions. GSES found that 21% of the Stage 1 installations inspected had underrated isolators installed.
GWIRING15	21% (3/14)	Not all electrical equipment is installed in accordance with AS/NZS3000.	I	All electrical installations, including PV systems, are required to meet the Australian/New Zealand Wiring Rules.

Issue Identifier	% of sites with issue	Issue Description	Installation (I) / Signage (S)	Issue Details
				GSES found that 21% of the Stage 1 installations inspected were not compliant with the Wiring Rules. The reasons for non-compliance included inadequate access to neutral links and inadequate ingress protection at the main switchboard.
GWIRING2	21% (3/14)	There are cables installed that are not securely fixed.	I	PV system cables are required to be securely fixed to minimise movement to prevent mechanical damage over time. GSES found that 21% of the Stage 1 installations inspected had cables or conduits which were not securely fixed. This issue was seen at the roof top and within the roof cavity.
GCEC1	14% (3/14)	Roof penetrations for the wiring system do not provide adequate sealing and waterproofing.	I	The roof penetration points of the wiring system present a risk for water ingress into the roof cavity and to the wiring system. GSES found that 14% of the Stage 1 installations inspected were found to have inadequate sealing of roof penetrations for the wiring system. The non-compliances were due to the lack of a suitable cable glands installed at cable entry into roof penetration point.
GCEC8	14% (2/14)	Roof penetrations for the array structure are not sealed or waterproofed to last for the life of the system and/or there are no details in the maintenance timetable.	I	The array structure attachment points on the roof present a risk for water ingress into the roof cavity. GSES found that 14% of the Stage 1 installations inspected were found to have inadequate sealing of roof penetrations for the array structure. The cause for non-compliance was tiles being raised by array structure fixing brackets.
GPROTECTION5.1	14% (2/14)	The PV array frame and modules earthing does not comply with standards requirements.	I	PV modules and array mounting systems are required to be earthed to prevent a build-up of voltage at the array. GSES found that 14% of the Stage 1 installations inspected to have earthing connection which did not meet standards requirement. The causes for non-compliance were associated with missing or incorrectly installed earthing washers.
GWIRING16.1	14% (2/14)	Wiring is not adequately protected from mechanical damage.	I	DC wiring must have sufficient mechanical protection to avoid damage to cabling. This is achieved by appropriate cable insulation and cable location. GSES found that 14% of the Stage 1 installations inspected had cables that were

Issue Identifier	% of sites with issue	Issue Description	Installation (I) / Signage (S)	Issue Details
				inadequately protected against mechanical damage.
GWIRING19	14% (2/14)	Not all DC connectors are of the same type and/or from the same manufacturer where they are married at a connection point.	I	DC connectors at a point of connection are required to be of the same type and from the same manufacturer to minimise the risk of fire from inadequate connection. GSES found that 14% of the Stage 1 installations inspected did not have matching DC connectors at some connection points.
GDC1.1.2	7% (1/14)	The DC enclosure at the inverter is not suitably installed to prevent water ingress and there are signs of water damage.	I	GSES found one site to have signs of water ingress, causing damage to components. Even a small amount of water getting into a DC isolator enclosure can cause can cause significant safety issues. To reduce the risk of this happening, purpose made enclosures and glands with appropriate ingress protection ratings must be used and they must be installed to manufacturer's instructions. It should also be part of the regular maintenance checks to confirm sound ingress protection is maintained.
GSIGN7.1	64% (9/14)	The fire emergency information is not displayed correctly.	S	The fire emergency information provides information on the solar PV system's voltage and current, which helps emergency workers and contractors attending site to identify the level of risk and required protection. GSES found that 64% of the Stage 1 installations inspected were found to be non-compliant. While the required signage was present at all sites, the non-compliant sites did not display the system's voltage and current in the way specified by the Australian Standard.
GWIRING13	29% (4/14)	The cabling/conduit is not adequately labelled.	S	Cabling and conduit of the PV system are required to be clearly labelled to help contractors identify any DC cables on site. GSES found that 29% of the Stage 1 installations inspected did not have adequate labelling on the PV system conduits installed. Solar labelling must be clearly visible every 2 metres.
GSIGN6	14% (2/14)	The inverter is not adjacent to the main switchboard and its location is not displayed on the main switchboard.	S	Inverter signage is required next to the main switchboard when the inverter is not adjacent to the switchboard, to assist emergency workers in isolating the PV system.

Issue Identifier	% of sites with issue	Issue Description	Installation (I) / Signage (S)	Issue Details
				GSES found that 14% of the Stage 1 installations inspected did not display this information at the required location.
GSIGN10	14% (2/14)	Multiple DC isolators are installed at the inverter and the correct warning sign indicating the need to operate all DC isolators to isolate the equipment is not present.	S	A warning sign is required if a PV system is installed with multiple DC isolators to inform the operator the presence of multiple DC isolators and the need to operate all DC isolators to isolate the PV array from the inverter. GSES found that 14% of the Stage 1 installations inspected did not have this sign installed where it was required.

6. Recommendations

The level of non-compliance identified through the audits highlights the need for changes in installation practices to ensure the quality and safety of battery systems. Based on the audits completed, the CEC recommends action in the following areas:

- Establishment of a BESS Registry
- Ongoing training and awareness
- Additional guidance on BESS safety signage
- Proactively check existing PV systems
- Set standards and protect consumers

Establishment of a BESS registry

Given the risk profile associated with BESS, it is critical that a registry of grid connected BESS be kept. Work is currently being done to understand the parameters of such a registry; the CEC is extremely well placed to assist with this initiative. It is the crucial that DNSP's, state and federal government bodies and industry bodies create a framework for capturing BESS data. Especially since, as installed BESS capacity increases, this market segment will be considered critical NEM infrastructure on aggregate.

Ongoing training and awareness

The inspection results summarised in this report demonstrate that there is a lack of understanding of applicable standards and a lack of understanding of product specific safety precautions. To resolve this issue, installers and designers of BESS should receive targeted training. Training is currently available from registered training organisations (RTOs) for grid connected PV systems with batteries, with training units endorsed by the Australian Industry and Skills Committee. This training is required for a storage (BESS) endorsement to be added to installer and designer CEC accreditation. Note that it is vital to receive this training even if training for standalone power systems has already been completed.

As products change and standards are updated, it is vital that the industry makes appropriate adjustments to keep up. Therefore in addition to initial targeted training, installers and designers need to receive ongoing training and feedback. One method of ongoing training currently available is through the ongoing professional development program as part of CEC accreditation. However, it is essential that the ongoing training be specific to BESS technologies and their requirements. For example it will be invaluable that training is provided on the new *AS/NZS 5139: Electrical Installations – Safety of battery systems for use in inverter energy systems* when it is published. In addition to this training, installers should also be given feedback through ongoing auditing of systems installed.

Additional guidance on BESS safety signage

The BESS signage varied considerably throughout the systems inspected. Installers need clearer guidance and standardisation on BESS signage, especially safety information specific to a battery type/chemistry. Note that AS/NZS 5139 may provide guidance on this, but until it is in effect installers need a clearer set of guidelines on how to display appropriate safety information for the battery system they are installing. Safety information can be gathered from manufacturer documentation but the clarity of manufacturer information varies between products. One option to assist with this is to develop an approved products list for BESS (as is currently done with PV modules and inverters), where BESS systems would be confirmed to meet applicable standards and have appropriate documentation. For example, BESS on this list could be confirmed to provide maximum fault current and safety equipment information.

Proactively check existing PV systems

The inspection results summarised in this report show all existing PV systems had defects which made them non-compliant with standards and guidelines. One safety risk was identified. Common defects included DC enclosures not having required IP rating, inadequate fire emergency information and inadequate cable and conduit labelling. When installing a DC coupled BESS, the installer is responsible for whole system compliance (PV and BESS). It is critical that installers are up to date with changes to standards. It is recommended that installers proactively check existing PV systems to ensure they are compliant and don't pose a safety risk.

Set standards and protect consumers

These recommendations are consistent with and complementary to those detailed in Section 4: Set standards and protect consumers' of the recently released CEC Report *Charging Forward: Policy and Regulation Reforms to Unlock the Potential of Energy Storage in Australia: Clean Energy Council Briefing Paper,* May 2017[2]. The regulation of installations and training, product standard, quality assurance, and retailing and after sales services, are all identified as key issues for ongoing performance, quality and safety of the BESS industry.

[2]Report available via CEC