Demand Management Case Study

Grid Energy Storage System

Grid Energy Storage System Trial

Introduction

AusNet Services was the first electricity distribution business in Australia to initiate a trial of a large scale battery energy storage system. The aim of the Grid Energy Storage System (GESS) trial was to build the knowledge, experience and capabilities required to capitalise on the expected benefits provided by grid-connected battery storage systems and prepare for the anticipated cost reductions and technical improvements of battery storage systems over time.

Fig 1: The AusNet Services Grid Energy Storage System, installed in Thomastown ***(Photo credit: ABB)***

Potential value

For Distribution Network Service Providers (DNSPs) such as AusNet Services, one of the main benefits of battery storage is the potential to help the network run more efficiently by reducing peaks in demand.

Reducing customers' use of electricity at peak times or shifting the usage to off-peak times is desirable, because it reduces the risk of the network becoming overloaded. In the long term this can also reduce or defer the need for networks to invest in new capacity that may only rarely be used (i.e. during periods of peak demand), and that would be paid for by customers through their electricity bills.

Battery storage also offers a number of other important benefits including the provision of higher network reliability and managing the impact of new energy technologies such as solar PV uptake.

The full range of potential benefits to both the network and customers includes:

- managing peak demand on the network and reducing the risk of associated customer outages;
- deferring network upgrades, therefore reducing network investment costs;
- offsetting operational costs such as hire of temporary generators during periods of peak demand;
- improving power quality through power factor and voltage level corrections; and
- supplying customers in islanded mode during outages.
- facilitating customer uptake of new energy technologies such as solar power by managing technical impacts

Implementation

In 2012 AusNet Services conducted a feasibility study for a GESS trial in terms of the costs, availability of technology and suppliers. After a formal and competitive tendering and assessment process, a contract was awarded to a consortium led by ABB Australia Pty. Ltd. including Samsung SDI as battery supplier to design and construct the GESS. The system included:

- **1MW/1MWh (nominal) battery system plus smart inverter:** stores energy in the lithium-ion battery bank and interacts with the network to charge or discharge the battery through an inverter that has control over the 4 quadrants of active and reactive power. An energy management system is programmed to control the behaviour of the overall system.
- **1MW (nominal) diesel generator:** effectively extends the capacity of the battery to provide full coverage of the peak demand period.
- **Balance of plant:** 3MVA 22kV/415V transformer kiosk, switchgear, measurement and SCADA RTU equipment.

The GESS facility as shown in Figure 2 is housed in seven containers, most of which are standard 20' shipping containers. It consists of 4 containers for the battery bank, 1 container each for the inverter, the generator and the switchgear, plus the 3MVA transformer. The GESS overall has a nominal power output capacity of over 2MW, capable of improving power quality and transition between grid connected and islanded modes. The containerised design facilitates mobility, offering the potential for the facility to be relocated to other areas on the AusNet Services network.

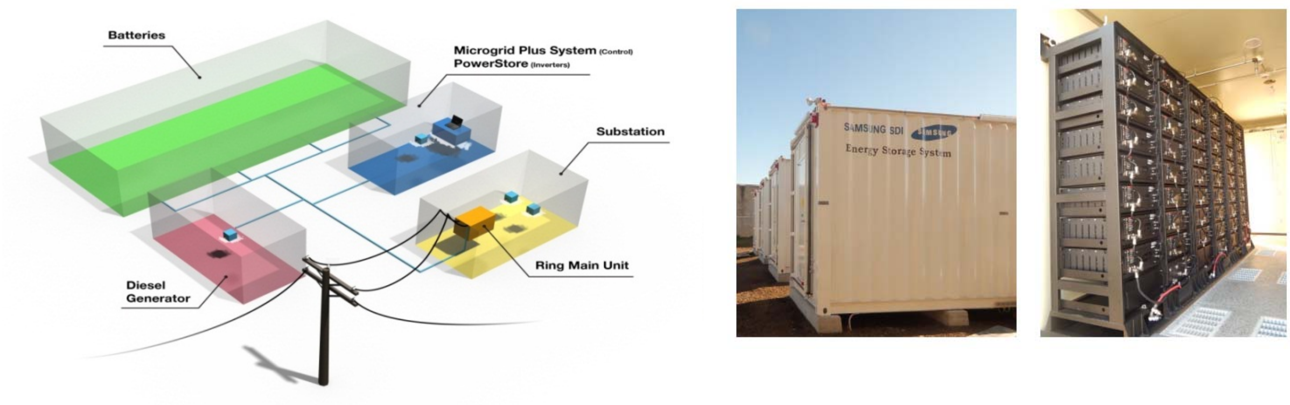

Fig 2: a) GESS system set up b) Samsung battery container and rack

Operating Scenarios

Peak lopping

A primary function of the GESS is to reduce peak demand on the local power line (feeder) by directly supplying customer loads at the end of the feeder. This is achieved by employing the peak lopping function, which has two variants, local peak lopping and feeder peak lopping.

Local peak lopping allows the power delivered to the downstream customers to be controlled. This is achieved by restricting the power delivered from the network to the downstream load to a pre-defined set point. The local peak lopping function controls the amount of power provided by the GESS to meet the extra downstream demand – refer example Figure 5.

Feeder peak lopping works in a similar manner by limiting the load demand on the entire feeder. The GESS uses the total feeder load and calculates the power required to meet the total demand whilst limiting the feeder demand, and injects the required power into the local network. This function has the capability to delay network augmentation and allow better utilisation of distribution assets.

Island mode

The islanding capabilities of the GESS were investigated by AusNet Services to improve system supply reliability in the case of network faults and outages.

Figure 3 shows the GESS in both grid-connected and island modes. In the event of a network outage, the GESS will island the downstream section of network by opening the upstream circuit breaker (shown in green). This creates an islanded micro-grid, which the GESS can supply until its energy reserves are depleted or the network outage is rectified. When network supply is restored, the GESS can re-connect to the grid and transfer supply back to network. Moreover, the batteries can begin recharging on a scheduled pre-set programmed time of day to be ready for an outage or other events.

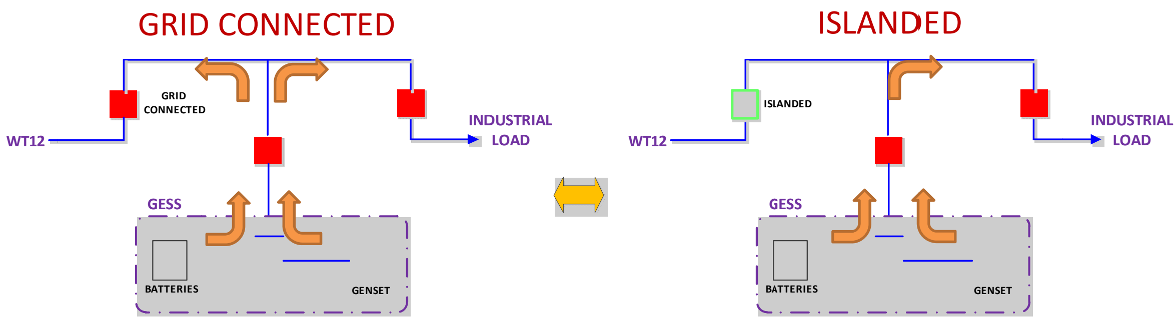

Fig 3: GESS network support modes for grid connected and islanded operation

There are 104 commercial and industrial customers downstream of the GESS that the facility can supply in island mode as shown in Figure 4.

Fig 4: Aerial view of the customers that can be supplied solely by the GESS in 'island mode'

Power Quality

Power quality from the GESS can be maintained by either one of the following two methods:

Voltage Support (Vdroop): Maintains the network voltage to within 3% of a predefined voltage set point (around 22kV in a typical distribution network). This is achieved by comparing the network voltage with the voltage set point. The difference is used to determine the amount of reactive power injected or absorbed from the grid by the Powerstore inverter to stabilise the network voltage.

Power Factor Correction (PF): Maintains the actual power factor of the system to a predefined set point by utilising the reactive components of the four quadrant PowerStore inverter.

Since neither of the above methods requires any active power the energy from the battery, the State of Charge (SoC) of the battery is conserved. During the summer trials, these two parameters were varied to test the quality of supply with and without peak lopping.

Results to Date

The bulk of the GESS trial testing phase was performed over two summer periods; 2014/2015 and 2015/2016. The tests are summarised below.

Summer Trial 2014/2015

The first tests were conducted in grid-connected mode to trial the following GESS functionality:

- Peak lopping in local mode
- Power factor correction
- Voltage droop control

Test results showed the system performing successfully. Ttwo examples of the tests performed in peak lopping and power factor correction modes are described below:

Peak lopping load to 3700kW

Peak lopping allows the downstream load on the local high voltage power line (feeder WT12) to be constrained to a pre-set level, in this case 3700kW, by discharging the battery at peak times. Overnight battery charging is also controlled so that this set-point is not exceeded. Different peak lopping set-points were tested to determine the level of network support that the system can reliably deliver.

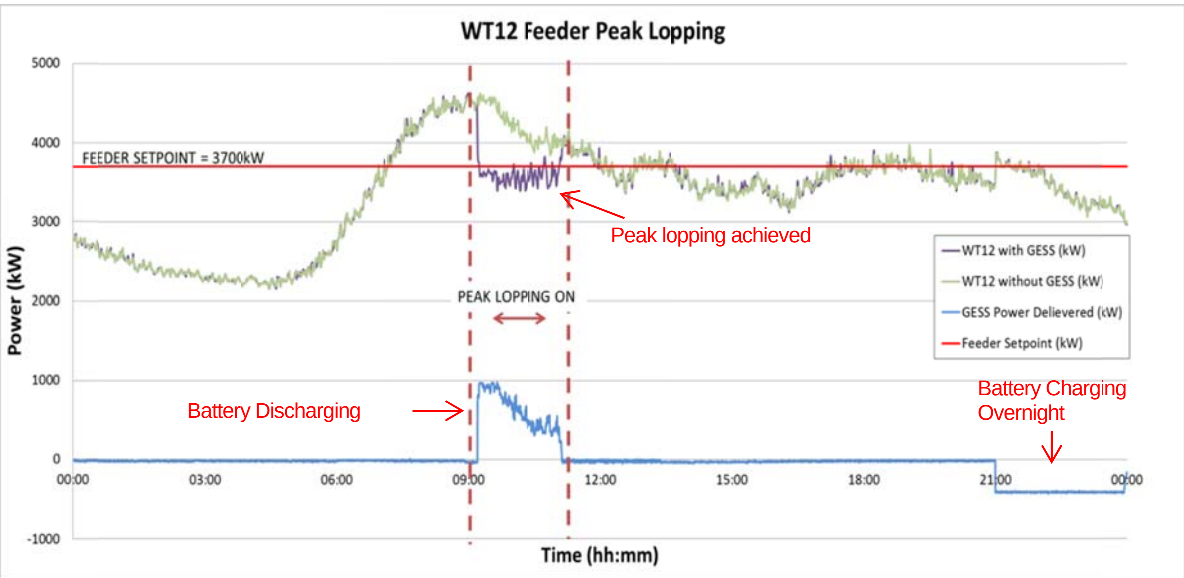

Fig 5: Example of local peak lopping with battery

Power Factor Correction to 0.95

Using the capabilities of the four-quadrant inverter, the GESS can maintain a defined power factor at the point of connection. This test shows the GESS exporting reactive power during periods of high demand in order to maintain a power factor of at least 0.95. Unlike peak lopping, power factor correction does not expend the battery. The GESS was in fact able to simultaneously provide peak lopping and power factor correction.

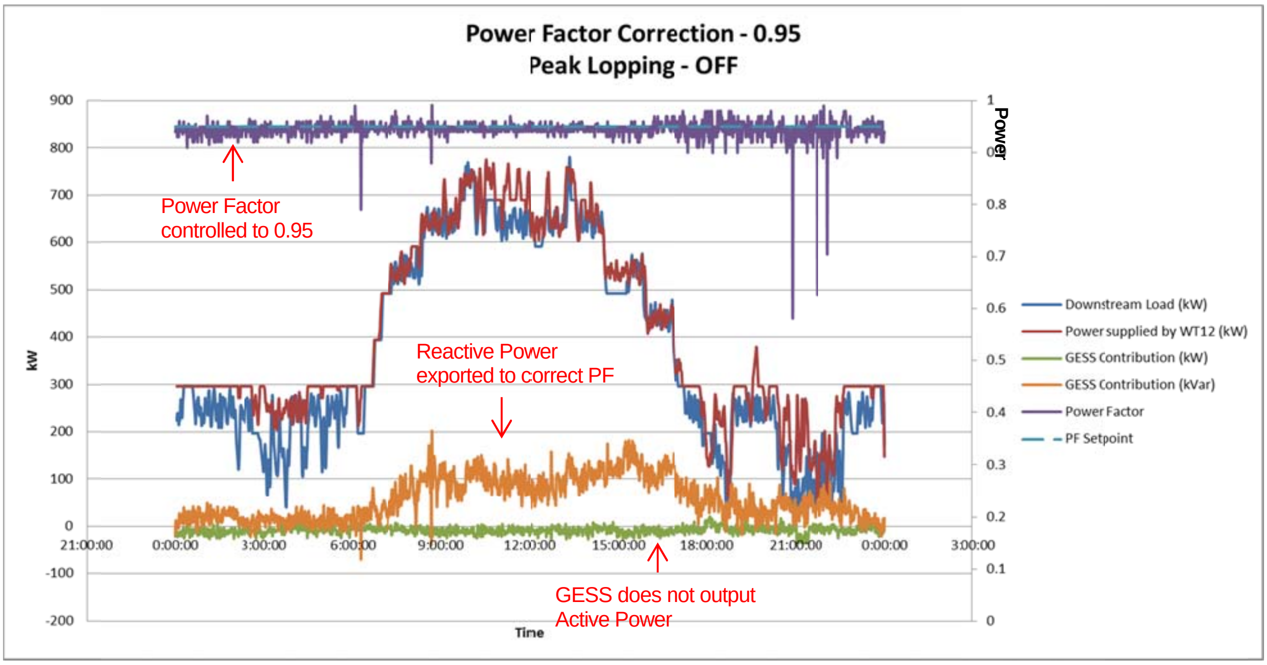

Fig 6: Example of power factor correction with peak lopping off

Summer Trial 2015/2016

The second trial focused on the following tests:

- Reliability testing via a series of morning and evening peak lopping tests.
- Power quality testing including assessment of power factor performance, voltage stability, flicker and harmonics.
- Island mode operation with multiple planned transitions to and from island mode.
- Black start testing, where the facility can bring customers back on supply after an unplanned network outage.

During the trial the GESS was successfully deployed to supply power to the downstream customers in micro-grid / island mode. This was a major milestone since this was the first time the GESS was utilised in a live network condition. The event is detailed below.

The GESS keeps customers on supply

On 2 February 2016, a network fault resulted in an outage on the WT12 feeder to which the GESS is connected. The fault was located upstream of the GESS and the AusNet Services Customer and Emergency Operations Team (CEOT – our control centre) initiated a recovery procedure to start up the GESS in 'island mode'. In this mode, the GESS can power the 104 commercial and industrial customers downstream of the facility. Islanding had previously been tested under trial conditions, but this was the first time it had been initiated in response to live network conditions.

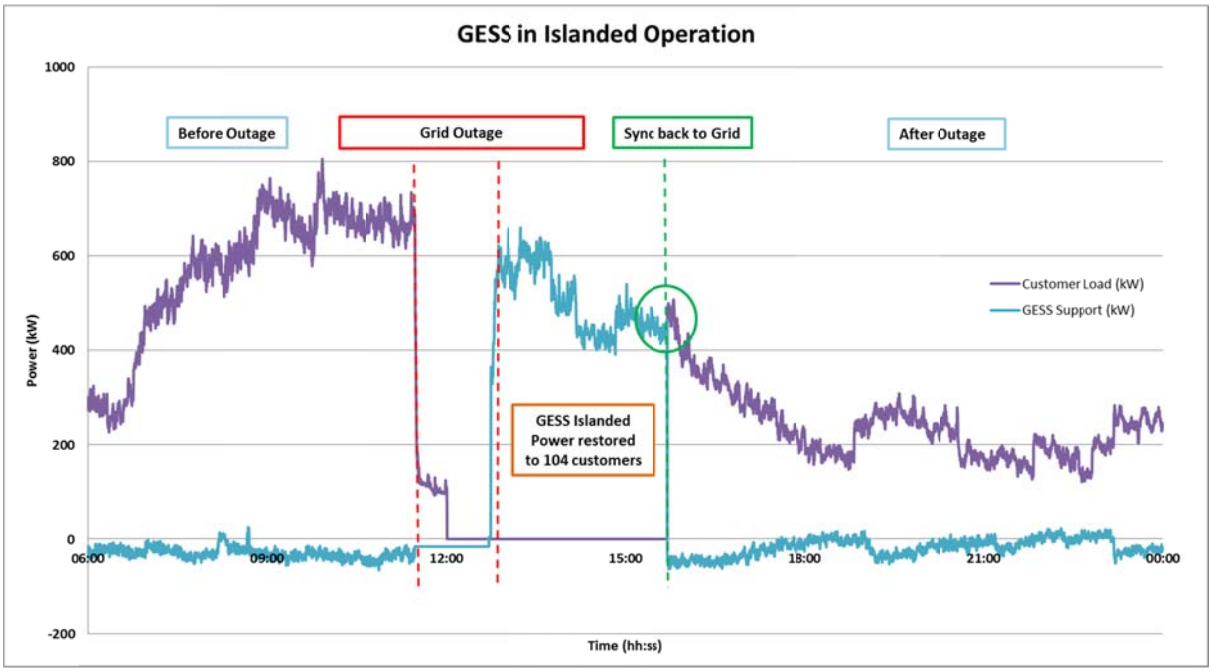

Fig 7: GESS in micro-grid operation

Shift Supervisor, Scotty Nimmo from CEOT, who was on duty at the time, said: "Being able to supply the 104 customers downstream from the GESS, in 'Island Mode', reduced the customers' outage by approximately 2 hours and 20 minutes. This was a great result for all the commercial customers affected as this fault was during normal business hours. This was also a great saving in customer minutes off supply and an absolute proof of concept with regard to being able to supply customers in island mode".

What Next

- The final test results have been analysed to determine the overall performance of the GESS and will be summarised in a final report;
- AusNet Services will consider opportunities to relocate the GESS to a more critical network location for the benefit of our customers.

Mission Zero: our safety vision

Safety was the number one priority throughout the life cycle of this project. Some of the key undertakings are listed below:

- A detailed "Safety in Design" document was created to address operational safety of the batteries. Design features include an advanced battery management system, fire suppression system and exclusion zone in case of total fire.
- Safe work methods, proper operating instructions, safe utility standard works practices and authorisation procedures were followed to make GESS project completely incident free.
- Three near miss events were reported during the project work which helped improve operational safety processes.
- The HV switchgear was altered to avoid arc venting from the top.
- Significants efforts were made to comply with environmental regulations, especially in regards to noise from the diesel generator.
- Staff from Melbourne Fire Brigade visited the site to enhance their familiarity with this new technology.