Battery Energy Storage Systems

Vector Limited

Independent Review of Lithium Ion Battery Lives

RZ033800-0001 | D

7 Sep 2017

Executive Summary

Vector engaged Jacobs to prepare an independent report outlining the expected life of Vector owned grid-connected utility-scale and behind-the-load residential Lithium Ion batteries depending on their mode of operation. The report focuses on a class of Lithium ion batteries that are typically provided by a number of manufacturers for stationary applications that require daily cycling of energy (e.g. for solar energy storage).

The current regulatory life span for "DC Supplies, Batteries and Inverters" in the ODV Handbook is set to 20 years, based on low usage backup lead acid batteries. This report is specifically focused on a class of batteries being utilised by Vector for network load management purposes at the zone substation level as well as at the residential level. These can be broadly characterised as follows:

- The batteries are based on Lithium ion chemistry (as opposed to lead acid).
- The batteries are part of an overall energy storage system (ESS) that is connected to the grid via a bi-directional inverter.
- The primary operational mode of the ESS is anticipated to typically involve daily discharging and charging of the batteries.

Battery life is typically defined as the number of full charge-discharge cycles before significant capacity loss. Battery manufacturers typically provide performance warrantees that warrant a minimum level of performance over a set period (in this case ten years), provided that the operational use of the system does not exceed pre-defined operational limits of the manufacturer.

At the end of the performance warranty period, while the ESS might still have a remaining technical life, albeit at a reduced capacity, it can no longer meet the functional and commercial objectives of its original purpose. At this point the ESS either needs to be replaced or supplemented with additional battery capacity.

Jacobs modelled the ten year duty cycle and throughput of both utility-scale network and residential Tesla batteries under a range of anticipated operational scenarios:

- 1 MW, 2.3 MWh Tesla Powerpack 1 ESS at a zone substation – monthly peak demand management vs. heavy usage to maximise utilisation.
- 3 kW, 6.4 kWh Tesla Powerwall 1 – maximise solar PV self-consumption, reserving some battery capacity for back-up, and solar storage plus network peak management.

Utility-Scale Energy Storage

Based on the expected functionality of the Tesla Powerpack 1 units on Vector's network (i.e. primarily for peak demand management), there is unlikely to be excessive duty cycles imposed on the batteries which would prematurely shorten their operational life / capacity. Likewise, the modelling showed that even if the batteries are utilised outside of peak demand months for other purposes on a regular basis they are not likely to exceed the throughput that would reduce the warranted performance, or shorten the warranty.

The primary driver of life for these batteries will therefore be driven by their warranted degraded performance. Once they have lost up to 30-50% of their storage capacity, their ability to meet Vector's functional requirements (i.e. the ability to contain load peaks at a specific site) will be significantly reduced, which will require either replacement of the battery, increasing battery capacity or investment in the network upgrade that the battery was helping to defer.

Based on this, the expected usable and economic life of a utility-scale Lithium ion battery energy storage system (such as the Tesla Powerpack 1) would be 10 years.

Residential Energy Storage

Like the grid-connected network batteries, the expected life of the Tesla Powerwall 1 units deployed to customers on Vector's network will be driven by their warranted degraded performance. This is potentially impacted by the operational mode and configuration they are used for. The typical usage scenarios considered by Jacobs resulted in battery throughput over ten years lower than the operational limits set by the manufacturer (i.e. the batteries would not be expected to degrade at an advanced rate and reduce life expectancy).

While a future scenario of solar self-consumption with overnight charging for peak demand management could potentially exceed this operating limit, in practice it is expected that the settings for grid based charging would be used sparingly to avoid excessive “solar spill” and therefore would be unlikely to exceed the manufacturer’s operating limits.

It is unlikely that the operating scenarios envisaged will prematurely age the batteries to less than ten years. However at the end of ten years, the reduced warranted capacity of the battery would mean that the home owner would likely to be exporting significant quantities of solar energy to the grid, so would be economically incentivised to replace the battery at this point.

Based on this, the expected usable and economic life of a residential-scale Lithium battery energy storage system (such as the Tesla Powerwall 1) would be 10 years.

Inverters

The life span of inverters is not impacted by the number of cycles of the batteries or solar panels that are connected to them. An inverter is a fairly well established electronic device for converting direct current electricity supply into alternating current supply, and vice versa.

There is no correct answer on inverter life span, but in normal operating environments, a good quality inverter such as the Dynapower PCS and SolarEdge inverters used by Vector that is regularly maintained should comfortably last between 10 and 15 years.

Conclusions

The warranted performance of the Tesla Powerwall was considered to be typical of those provided by manufacturers of Lithium batteries being utilised for similar purposes. While these warranted performance curves may be conservative compared to real world performance, they are bankable. That is, a developer seeking funding for a project incorporating these batteries can rely on the performance warranty, provided they are operating the batteries in the manner and in the environmental conditions specified in the warranty.

Based on the expected range of utility and residential applications that Vector are intending to use these batteries for, it is not expected that the batteries will be subject to excessive cycling that would shorten their warranted life span of ten years.

On the flipside, in situations where such batteries might be cycled a lot less due to a greater level of capacity being reserved for infrequent back up purposes, the impact of calendar aging processes on storage capacity will be more predominant. The total amount of storage capacity decline for a lowly utilised Lithium battery over ten years from calendar aging processes is not well understood but Jacobs anticipate that capacity loss could still be significant, particularly as a commercially focused utility such as Vector would seek to maximise the value obtained from a utility scale battery to benefit its customers. .

On this basis, Jacobs recommend the use of a ten year life span for regulatory purposes for both utility-scale and residential-scale Lithium batteries deployed by Vector.

As it is likely that the associated inverters would be replaced at the same time as the batteries in the network and residential systems above, a commercial lifespan of ten years for inverter would also be considered appropriate.

JACOBS

Important note about your report

The sole purpose of this report and the associated services performed by Jacobs is to provide a report on the expected lives of Lithium Ion batteries in accordance with the scope of services set out in the contract between Jacobs and the Client. That scope of services, as described in this report, was developed with the Client. This report is for Vector's regulatory compliance purposes and is not intended to be relied upon by third parties.

Jacobs derived the data in this report from information sourced from the Client (if any) and/or available in the public domain at the time or times outlined in this report. The passage of time, manifestation of latent conditions or impacts of future events may require further examination of the project and subsequent data analysis, and re-evaluation of the data, findings, observations and conclusions expressed in this report. Jacobs has prepared this report in accordance with the usual care and thoroughness of the consulting profession, for the sole purpose described above and by reference to applicable standards, guidelines, procedures and practices at the date of issue of this report. For the reasons outlined above, however, no other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in this report, to the extent permitted by law.

This report should be read in full and no excerpts are to be taken as representative of the findings. No responsibility is accepted by Jacobs for use of any part of this report in any other context.

This report has been prepared on behalf of, and for the exclusive use of, Jacobs' Client, and is subject to, and issued in accordance with, the provisions of the contract between Jacobs and the Client. Jacobs accepts no liability or responsibility whatsoever for, or in respect of, any use of, or reliance upon, this report by any third party.