

Relectrify Second-Life Battery Trial

Lessons Learnt Report

November 2023



The ReVolve® commercial and industrial scale battery storage system



The views expressed herein are not necessarily the views of the Australian Government, and the Australian Government does not accept responsibility for any information or advice contained herein.
This Project received funding from ARENA as part of ARENA's Advancing Renewables Program.

Project Overview

The ReVolve® by Relectrify represents a groundbreaking advancement in energy storage, uniquely merging Relectrify's cell-level control technology, known as CellSwitch™, with battery packs reclaimed from nine Nissan LEAF electric vehicles. Each ReVolve provides an effective capacity of 120 kWh and power of 36 kW per modular block. This project, which is supported by ARENA, aims to validate the feasibility and cost-effectiveness of using second-life batteries for energy storage in Australia and beyond.

In March 2023, the ReVolve achieved a significant milestone by becoming the first cell-level control product of its kind at commercial and industrial scale to be certified to stringent International Electrotechnical Commission (IEC) standards. It is also the first integrated stationary battery energy storage product using repurposed second-life EV batteries to be certified for on-grid deployment in Australia.

The initial installations of the ReVolve have been successfully completed at several customer locations. These include Nissan's aluminium casting facility in Dandenong South, Victoria; Colormaker Industries, a boutique paint and tint producer in Sydney's Northern Beaches; and Innovative Mechatronics Group, known for supplying electronic and mechatronic components to automotive aftermarket and original equipment manufacturers.

ReVolve® certifications learnings

Relectrify undertook a pioneering certification journey for the ReVolve, navigating unforeseen challenges and complexities. It's the first time that a commercial and industrial scale storage product, using cell-level control to generate AC output without a conventional inverter, has been certified to the internationally recognised IEC standards. It is also the first stationary battery energy storage product using repurposed second-life EV batteries to have been certified for on-grid deployment in Australia.

Key challenges

- **Geographical Limitations:** The absence of battery management system (BMS) testing labs in Australia restricted us to US, Asia, and Europe options. COVID-19 presented additional challenges by limiting face-to-face interactions with our chosen US certification partner.
- **Unique Product Design:** Relectrify's novel integration of the BMS and the inverter posed a significant challenge since components and subsystems that would usually be tested and certified individually by separate teams could not be isolated and treated independently. For instance, for conventional systems, a BMS would be tested in

isolation in a thermal chamber to evaluate its performance in hot and cold conditions. Since our technology is connected directly to the battery cells we needed to engineer a way to test our system as if it were a conventional one. This process was further complicated by the need to test under diverse and challenging grid conditions, such as rapid voltage and frequency shifts.

- **Critical Component Lists:** Each set of functionality required separate ‘critical component lists’. These lists detail the safety-critical components used in the construction of a conventional product. Due to the overlapping nature of our technology – the inverter and BMS and batteries being interconnected – the list of critical components became a unique challenge. If a component of one of the lists would change, the list would then need to be approved by all of the testing teams. This happened on more than one occasion.

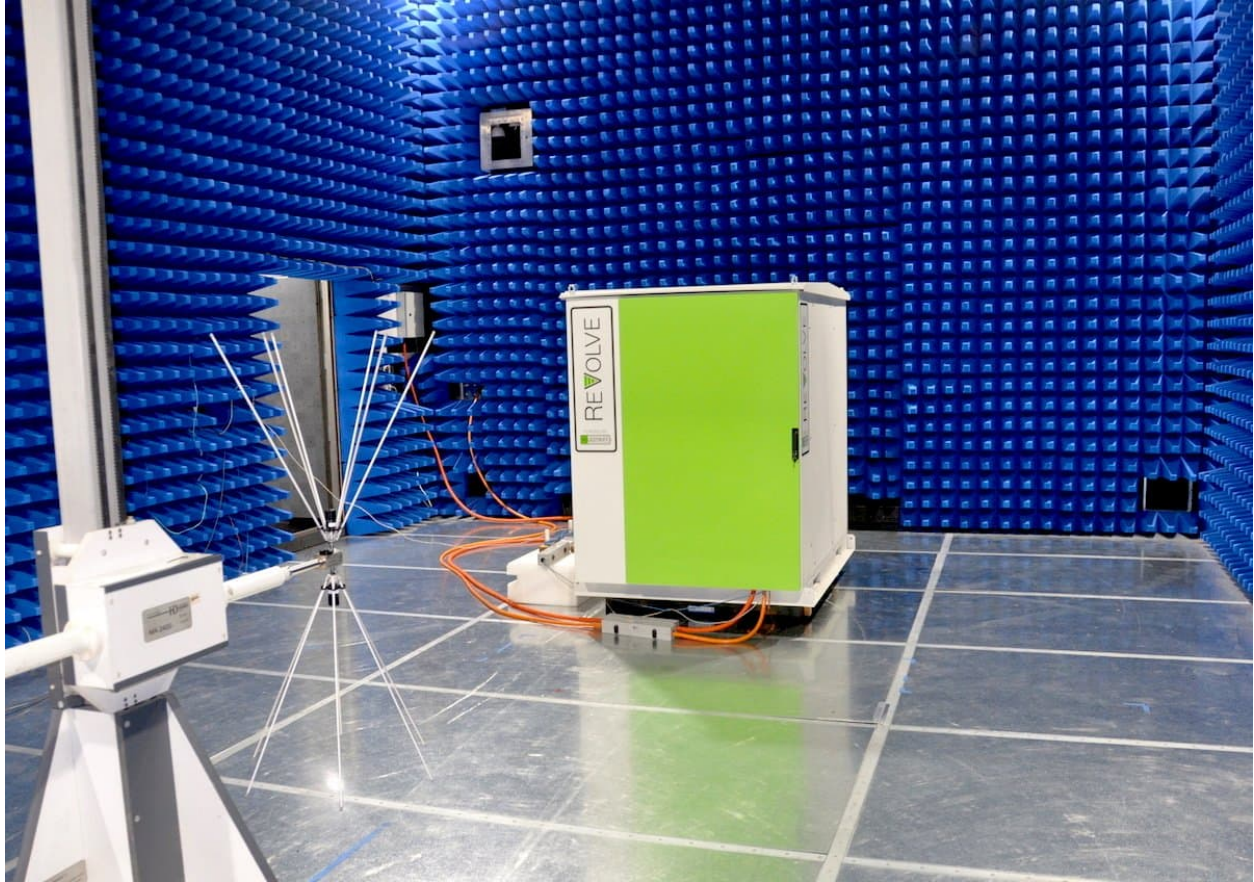
Response

Leverage US Partnerships: We sought quotes from a number of certification houses and ultimately went with a US-based company due to an existing relationship with Dynamic Manufacturing, our customer and partner based in Illinois. Dynamic Manufacturing offered to build and test the ReVolve unit at its US-based facility and then transport it to our chosen certification institute. We shipped items directly to Dynamic Manufacturing from Australia and had some parts delivered domestically within the US.

In-house Grid Simulator: The need to replicate the certification body's test system on-site in Melbourne led to the innovative decision to convert one of our ReVolve units into a grid simulator. This approach not only offered significant cost savings compared to commercial grid simulators but also enhanced the ReVolve’s grid-forming capabilities, a crucial aspect for operating in complex microgrid environments.

The adaptation presented its own challenges, requiring the development of specialised software to override grid-tied constraints and incorporate real-time parameter adjustments and automated operation sequences. This intricate task demanded additional resources but was successfully executed by our skilled team. The most demanding aspect was fine-tuning the grid simulator's performance to handle abrupt phase and frequency shifts without compromising stability. This involved multiple development and testing cycles, fostered by a collaborative effort across our software, testing, data, and systems teams.

The creation of an in-house grid simulator not only met our immediate testing requirements but also provided valuable insights into the ReVolve’s capabilities and its value in demanding microgrid applications. Additionally, the integration of logging and automation features enabled efficient and remote regression testing, significantly reducing resource expenditure for each software update and facilitating the swift resolution of issues during the certification process.



Electromagnetic compatibility (EMC) testing of the ReVolve unit in an anechoic chamber

Key Lessons

- **Early Preparation:** In retrospect, we initiated the certification prematurely. We have learned to perform as many of the certification tests as possible in house before proceeding to external certification. Our grid simulator now allows us to run many of the complicated grid and inverter tests in-house and we have also built out test environments for the BMS and battery safety tests.
- **Preliminary Research:** Significant time was spent interpreting testing standards and developing approaches to accommodate our new technology. A deeper initial understanding of the standards could have streamlined this process. Furthermore, we realised that we need to guide the test agency with more upfront guidance on the novel aspects of our technology.
- **Design for Compliance:** We now understand that we can't rely on a design that has many methods to catch a fault unless at least one method meets functional safety standards. This has resulted in significant design changes that we can now use going forward.

- **Second-life Certifications:** Battery certifications are required even for second life cells. The process is faster and easier if the batteries already have all the required certifications and we have access to that documentation. These documents should be obtained upfront for any future product certifications.
- **Functional Safety:** This requires significant overhead and involvement early in the design and development phase. For example, we needed to select new microprocessors that were suitable for functional safety. EMC testing includes functional safety elements and should be planned for upfront and included in EMC testing.

In summary, we embarked on the certification journey for a world-first product, not knowing how long it would take or how complicated the process would be. We're on the other side of certification now and have learned valuable lessons along the way. Beyond facilitating ReVolve sales and installations, the certification process has paved the way for our customers and partners to integrate our cell-level control technology into their energy storage products. We can help test our customers' new products using our test beds and grid simulator; and we have the capability to verify that new products can pass major certification tests before we commence the formal process. Through the parallel testing, we learned how to simplify, optimise and create efficiencies for the next generation of products utilising Relectrify's technology.