Relectrify

2020/ARP023

Relectrify Second-Life Battery Trial

Final Report (Public)

March 2025 | www.relectrify.com | Lead author: Tom Godwin

Acknowledgement & disclaimer

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Executive summary

The Second-Life Battery Trial was a pioneering project to develop and demonstrate a modular 36 kW / 120 kWh second-life battery energy storage system (BESS), showcasing Relectrify's advanced cell-level battery management and inverter technology, known as CellSwitch®. The resulting product, named ReVolve®, integrates retired Nissan Leaf electric vehicle (EV) battery packs with CellSwitch to create a self-contained battery unit that can directly output AC power without a conventional inverter.

This trial, which ran from late 2020 to early 2025, was supported by ARENA and marked a world-first in certifying an 'inverterless' battery system. Key goals and outcomes from the trial included:

1. **Demonstrate technology readiness**

   By the end of the project, the CellSwitch-based ReVolve system was fully certified and deployed in real-world settings. The team also gained significant product development and deployment experience, which is being applied to upcoming Relectrify products.

2. **Reduce storage costs**

   Using second-life EV batteries in combination with CellSwitch led to meaningful reductions in storage costs in comparison with similar new battery systems available during the trial period.

3. **Validate second-life performance**

   Field deployments confirmed that second-life batteries managed with CellSwitch can still deliver strong performance in stationary applications. The ReVolve units maintained high availability (most above 98% uptime) and were able to extract significantly more usable energy from aged battery packs than a traditional system could. In one case, an increase of over 20% in usable capacity was observed from a set of particularly degraded Nissan Leaf cells. This performance effectively overcomes the "weakest cell" limitation of conventional battery architectures.

4. **Evaluate second-life economics**

   The trial revealed that the economic benefit of second-life batteries was narrower than anticipated, due to factors like limited supply of used EV packs, high logistics costs, and rapidly falling prices of new batteries.

5. **Lowered adoption barriers**

   Through rigorous independent certification and real-world demonstrations, the trial built confidence in the safety and reliability of second-life storage. Relectrify offered a standard 4-year product warranty on the trial units and was transparent about expected battery life, to help alleviate worries about longevity and risk. These measures, combined with the environmental appeal of reusing EV batteries, helped early adopters embrace the technology despite shorter warranty terms than brand-new systems.

Overall, the trial demonstrated that retired EV batteries can contribute meaningfully to the clean energy transition. ReVolve units were deployed across sites in Australia, New Zealand and Japan, delivering over 240 MWh of stored energy to support solar integration, peak demand reduction, EV charging, and other applications. Alongside technical success, the trial revealed practical challenges in areas such as certification, supply chain, and customer perception.

Project overview

Trial timeline

The trial encompassed the end-to-end development of the ReVolve battery system – from design and prototyping, through certification, to deployment and operation at customer sites in Australia, New Zealand and Japan. Commencing in late 2020, the project unfolded over about four and a half years and was structured in three phases:

Milestone 1 - Product development (late 2020-2021)

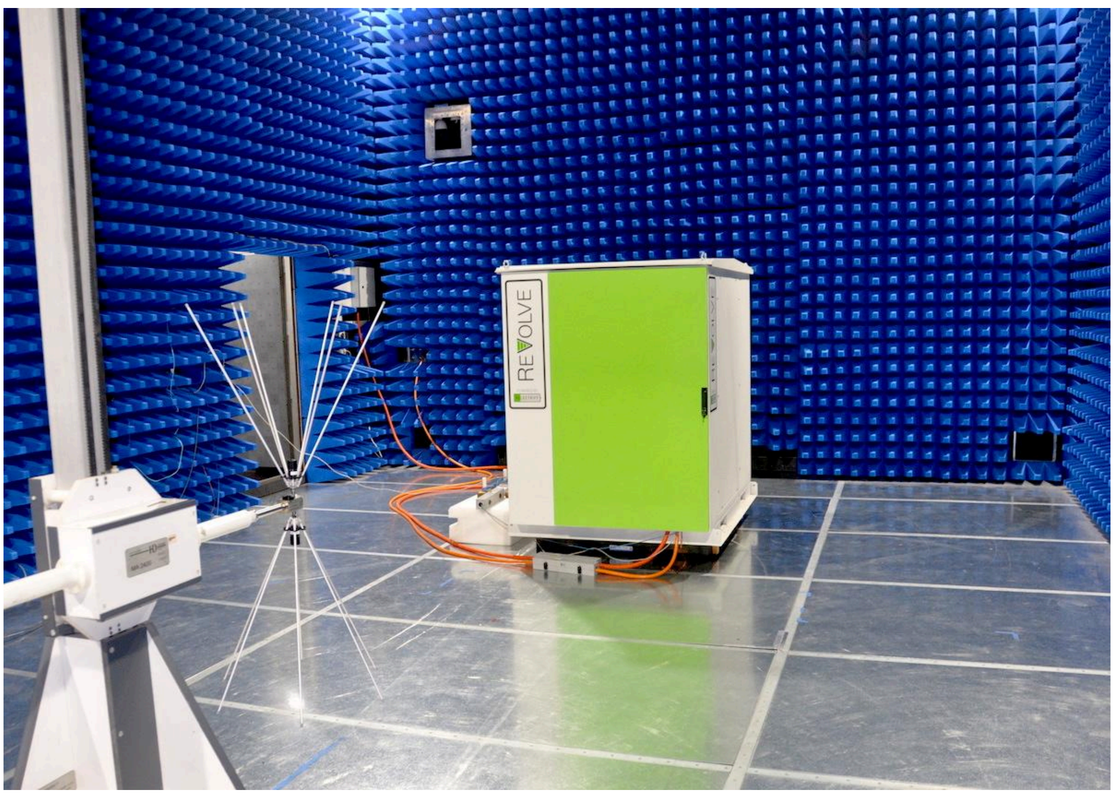
Relectrify completed the initial design and development of the 120kWh / 36kW ReVolve, integrating its CellSwitch battery control technology with second-life Nissan Leaf battery packs. A prototype unit was built and remotely commissioned in collaboration with Counties Energy, a New Zealand electricity distributor, yielding early insights that drove design improvements (for example, the cooling system was enhanced to minimise cell degradation).

By 2021, Relectrify publicly unveiled the ReVolve and initiated the formal certification process, targeting relevant Australian and international standards (such as AS/NZS 4777 for grid connection and IEC 62619 for battery safety). The company also secured initial pre-orders from commercial customers in anticipation of a certified product.

Milestone 2 - Certifications and initial deployments (2022-2023)

This phase focused on navigating a first-of-its-kind certification journey and beginning pilot installations. By early 2023, the ReVolve had achieved all required safety and grid compliance certifications, becoming the first second-life BESS with cell-level control to meet globally recognised standards (including AS/NZS 4777.2:2020, IEC 62619, and others). With certification in hand, Relectrify commenced customer installations.

With certification complete, Relectrify commenced customer installations. Eight ReVolve units (~960 kWh aggregate) were deployed in the initial rollout. Notable early deployments included one at Nissan's aluminum casting plant in Victoria (as part of Nissan's sustainability initiative to reuse EV batteries on-site) and one at an environmentally focused paint manufacturer in Sydney (using the ReVolve to maximise solar self-consumption and cut peak grid demand). Relectrify also bolstered its team during this period, bringing in experienced industry personnel to support project delivery and market adoption of the new product.



Milestone 3 - Final deployments and trial completion (2024-early 2025)

In the final phase, the remaining trial units were delivered and installed, concluding the demonstration fleet. This included five additional ReVolve systems in New Zealand through collaborations with local utilities (Counties Energy and Meridian Energy) to support use cases such as EV charging hubs and community renewable energy projects. By the end of 2024, the full fleet of trial units (15 in total across three countries) was installed, and the project focus shifted to monitoring performance and extracting lessons.

The ReVolve

The ReVolve is a self-contained battery energy storage system designed for commercial, industrial, and small utility applications. Each unit repurposes nine second-life EV battery packs (from Nissan Leaf cars) and is equipped with Relectrify's CellSwitch® BMS+inverter electronics, all housed in an outdoor-rated enclosure. In the trial, units were installed in a variety of settings, indoors and outdoors, ground-level and on raised platforms.

Unlike conventional battery systems that require a separate inverter, the ReVolve's CellSwitch architecture combines power electronics and advanced control software to manage each cell individually. By dynamically selecting which cells are active at any moment, the system can generate AC power directly, without a traditional inverter, while also maximising both usable energy and battery lifespan.

The ReVolve received all certifications required for the Australian market, making it a world-first certification for an 'inverterless' battery platform:

- **Inverter**: IEC 62477-2; IEC 62477-1
- **Batteries**: IEC 62040
- **Functional safety**: IEC 62619; IEC 60730; IEC 62109
- **Grid connection**: AS/NZ 4777.2; EMC: AS61000-6-3

Findings and Outcomes

Second-life battery performance

Using second-life batteries brings inherent technical challenges due to the variability in individual cell performance, such as state of health (SoH) and internal resistance. These variations stem from differing usage histories and significantly affect how a battery pack performs. In series-connected packs, the cell with the lowest performance often sets the system limits, reducing overall capacity and efficiency.

SoH and resistance variation

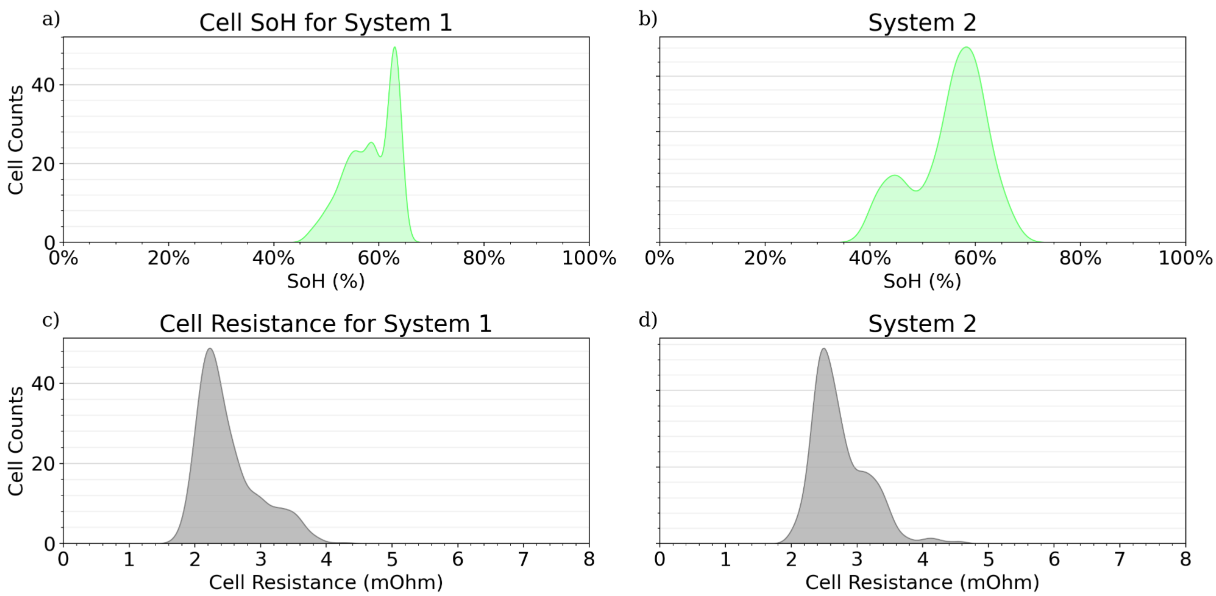


Fig. 1. Distribution of Cell SoH (a-b) and Cell Resistance (c-d) from different second-life battery packs.

Data from ReVolve systems show substantial variation in SoH and internal resistance among cells in second-life EV battery packs. In some cases, SoH differed by up to 32% between cells. Conventional systems struggle with this disparity, as weaker cells hit voltage limits sooner, capping usable capacity. While cell binning (grouping cells with similar characteristics) can mitigate this, it is resource-intensive and limited by cell availability.

Internal resistance also varied by up to 2.63 mΩ, causing uneven heat generation and performance. This leads to challenges for passive balancing systems, which can result in persistent SoC imbalances over time.

Initial SoC variation

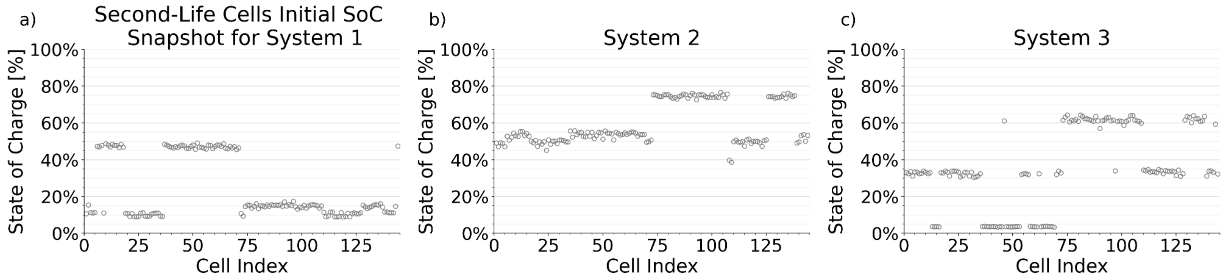


Fig. 2. Data showing significant imbalance in initial SoC of second-life battery packs (a-c)

Balancing the state of charge across cells in a battery pack is a common challenge in lithium-ion battery systems. In conventional battery manufacturing, initial conditioning is a key step that ensures all cells start at a uniform SoC before they are assembled into packs. This process involves charging or discharging individual cells to compensate for the system's limited ability to balance cells with significant charge differences once in operation.

This issue is more challenging with second-life cells as the initial condition of the cells is dependent on their usage and storage histories. Fig. 2 illustrates an example of newly commissioned battery packs with more than 120 cells sourced from different EV battery packs. It shows that the initial SoCs can be grouped into several clusters with significant differences. Converging to a balanced state from this initial condition will be difficult for a conventional system, typically, a pre-balancing step is needed to harmonise SoC before integration into packs.

CellSwitch

Relectrify's CellSwitch technology addresses these challenges by managing each cell individually. The following subsections present how CellSwitch improves the performance of second-life packs using operational data.

Managing the energy flow to each cell

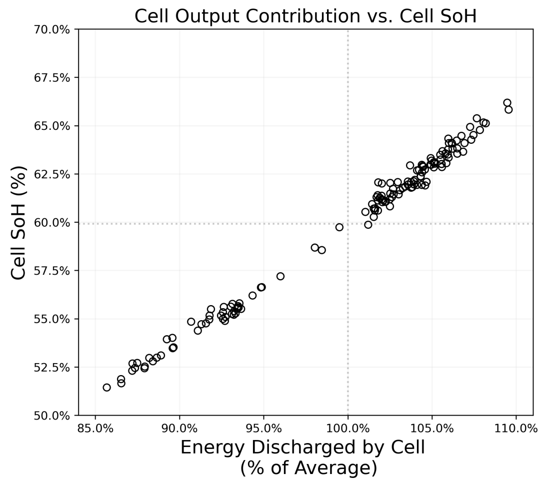


Fig. 3. Relative cell contribution to the system discharge capacity vs. cell SoH. The benchmark is the average output energy.

Fig. 3 illustrates how CellSwitch dynamically manages energy flow at the cell level, enabling each cell to be utilised to its maximum capacity. The data is drawn from a discharge cycle in a pack with a ~15% variation in SoH between the weakest and strongest cells.

In conventional systems, all cells are used equally, so the weakest cell limits overall performance. In contrast, CellSwitch adjusts usage according to each cell's condition. The graph shows a clear linear relationship between SoH and energy contribution, demonstrating how CellSwitch optimises system output by prioritising healthier cells.

Extracting more energy from a second-life battery pack

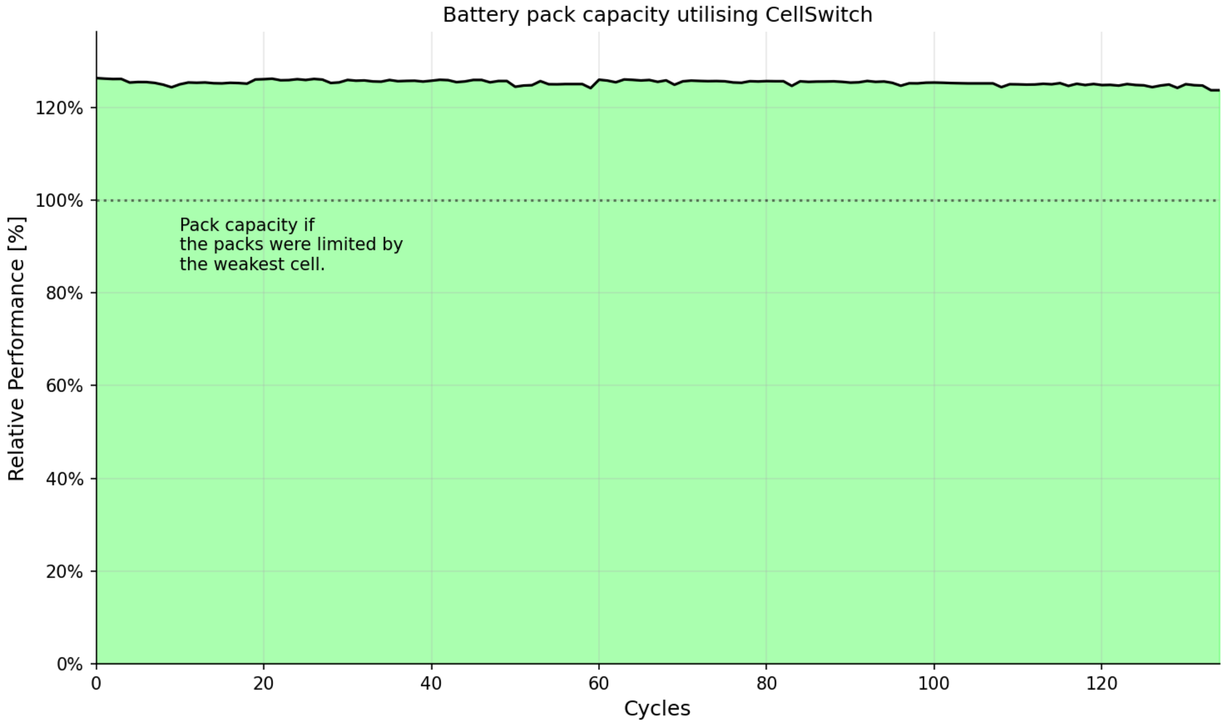


Fig. 4. Relative discharge capacity of a battery system over multiple cycles using CellSwitch technology. The benchmark represents the theoretical discharge capacity of the same battery pack when managed by a passive BMS operating at 100% Depth of Discharge (DoD).

Fig. 4 shows discharge energy data from a second-life battery pack managed by CellSwitch over 130 continuous cycles. The energy output is expressed as a percentage relative to the theoretical capacity of the same pack if constrained by its weakest cell.

Field data from a deployed ReVolve indicated a more than 20% increase in usable capacity compared to a conventional system. The scale of this improvement depends on the level of variation in SoH and internal resistance within the pack. Greater variation leads to greater capacity gains with CellSwitch.

Balancing a highly unbalanced pack

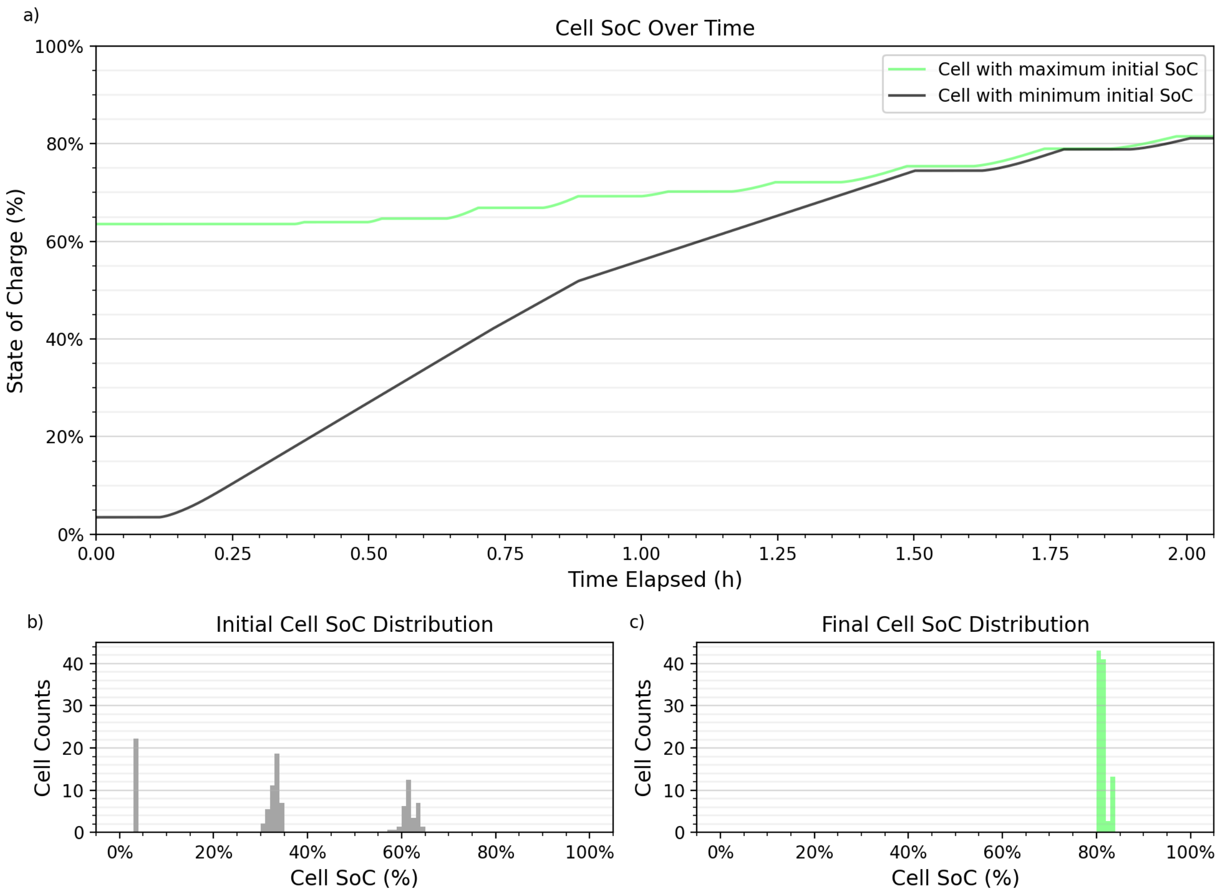


Fig. 5. Analysis of cell balancing in a newly assembled second-life battery pack over a two-hour charging period. (a) SoC trend of the cells with the highest and lowest initial SoC during charging. (b) Initial SoC distribution of all cells in the pack before charging. (c) Final SoC distribution after the two-hour balancing process.

The initial conditioning required to balance second-life battery packs is a crucial step in conventional systems due to their limited ability to correct large SoC imbalances. CellSwitch eliminates this requirement by dynamically managing cell selection during normal operation. Instead of relying on pre-conditioning, it adjusts the charging and discharging cycles of individual cells to bring the pack into balance. Cells with lower SoC are given priority during charging or are discharged less frequently, while higher SoC cells contribute more during discharge cycles.

Fig. 5 demonstrates CellSwitch's ability to balance a highly unbalanced pack. In this example, the system resolved an SoC spread of over 50% between the highest and lowest cells within just two hours. The comparison between the initial (Fig. 5b) and final

(Fig. 5c) SoC distributions illustrate the highly unbalanced initial state within the battery pack and the effectiveness of CellSwitch balancing.

Beyond initial balancing, CellSwitch also prevents imbalance from building up over time. By continuously adjusting how each cell is used, it maintains balance during everyday operation, removing the need for passive balancing during idle periods and simplifying the integration of second-life cells.

Bypassing problematic cells

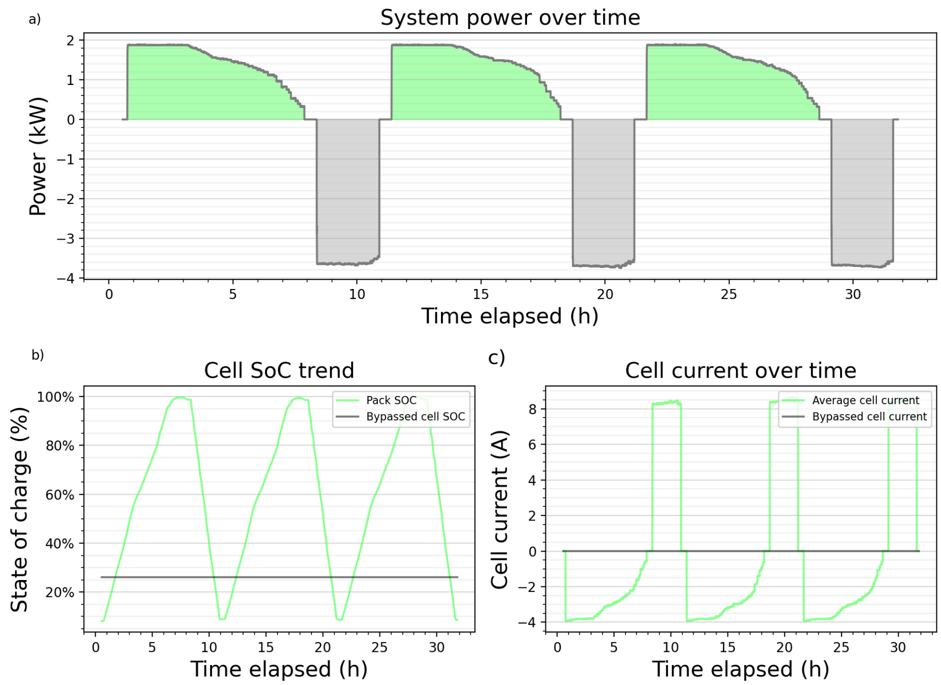


Fig. 6. System operation with a bypassed cell using CellSwitch technology. (a) Demonstrates the system completing multiple charge and discharge cycles while a cell remains bypassed. (b) and (c) illustrate that the bypassed cell remains inactive, neither charging nor discharging, while the rest of the system continues normal operation.

The ability to bypass faulty or underperforming cells is a major advantage for battery systems. In conventional architectures, a single cell failure can trigger a full system shutdown, leading to unplanned downtime. CellSwitch addresses this by enabling the system to electrically isolate problematic cells while continuing normal operation.

Fig. 6 illustrates this functionality in an internal test where one cell was intentionally bypassed. The system continued to operate normally over a 32-hour period, completing multiple charge and discharge cycles without disruption.

As shown in Fig. 6(a), the system's power profile remained stable, indicating that bypassing a single cell did not disrupt overall performance. In Fig. 6(b), the pack SoC fluctuated as expected in response to power cycling, while the bypassed cell's SoC remained fixed at around 25%, confirming that it was no longer contributing to the system. Fig. 6(c) further illustrates this by showing zero current flow through the bypassed cell, while the remaining cells continued to operate as intended.

This test highlights the robustness and flexibility of CellSwitch in real-world applications. By selectively bypassing failing or degraded cells, the system can maintain efficiency and extend operational life without requiring immediate maintenance or replacement. In practical deployments, this capability could significantly reduce maintenance costs and downtime, particularly in applications such as renewable energy storage, grid support, and electric vehicles, where battery reliability is critical.

Harmonic control

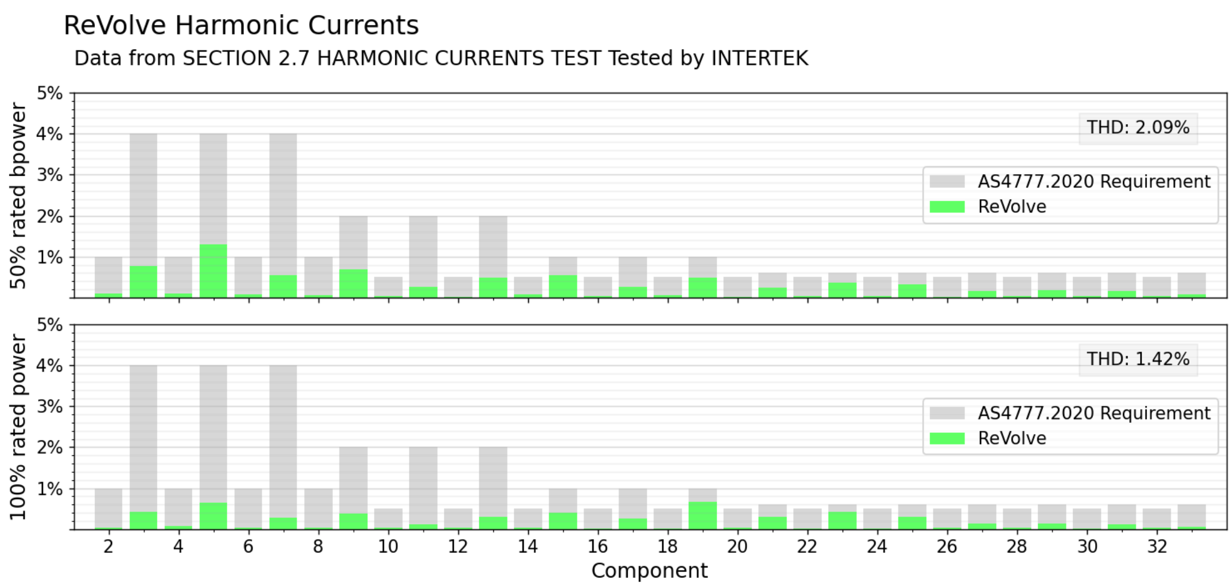


Fig. 7. Harmonic current limit test results for the ReVolve battery system, conducted by Intertek to assess compliance with regulatory standards.

Harmonics in electrical power systems are sinusoidal signals with frequencies that are integer multiples of the fundamental frequency - 50 Hz or 60 Hz, depending on the power grid. Harmonics distort electrical waveforms and degrade power quality. Excessive harmonics can lead to overheating of electronic systems due to increased heat generation and can cause the malfunction of protective equipment, such as the tripping of circuit breakers. To prevent such issues, the Australian grid code (AS4777.2:2020) specifies an allowable limit for the harmonics on the current waveform that is generated by grid-connected inverters.

Fig. 7 illustrates the harmonic currents generated by the ReVolve system, compared against the AS4777.2:2020 regulatory limits at 50% and 100% rated power. This test was conducted during the ReVolve's certification process in January 2023 to evaluate its compliance under varying load conditions.

The results demonstrate that the ReVolve complies with the AS4777.2:2020 standard, with all harmonic components remaining below the specified limits at both rated power levels, ensuring safe and stable operation within grid-connected environments.

CellSwitch Summary

In summary, by actively managing each cell, CellSwitch technology overcomes the principal performance limitations of second-life batteries (SoH differences, resistance differences, and initial imbalance). This results in more usable capacity, better efficiency, and improved reliability compared to what would be achievable with a conventional BMS architecture. Internal testing indicated that a CellSwitch-managed pack can deliver close to its theoretical maximum capacity even with cells of varying health (approaching the benchmark of a perfectly balanced pack at 100% depth of discharge). This represents a notable efficiency gain and maximises the value extracted from second-life cells.

ReVolve

Having addressed how CellSwitch enables second-life packs to function effectively, we now turn to the actual field performance of the ReVolve systems deployed in the trial. The analysis below covers the key performance metrics of these systems, based on ~15 months of operational data collected up to March 2025.

The operational data presented reflects six units deployed under typical customer conditions, which we believe offers a representative view of field performance within the scope of the trial.

Usage profiles and energy throughput

By March 2025, the deployed ReVolve units have collectively delivered over 240 MWh of energy with a combined 49,600 hours of runtime. Fig. 8 shows the progression of energy throughput from October 2023 to March 2025.

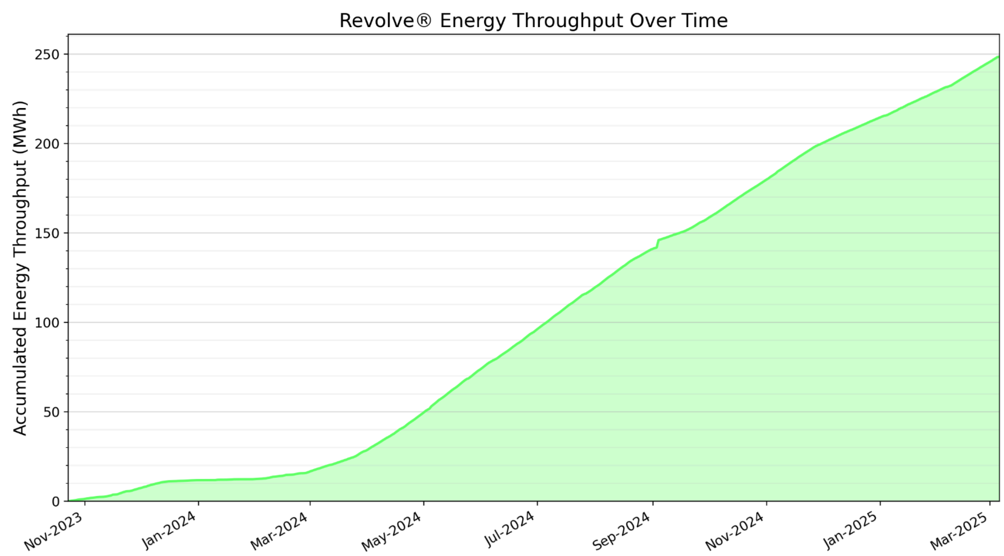


Fig. 8. Total energy throughput of all ReVolve®s installed at customer sites.

The deployed systems fell into two general categories: scheduled operation and demand-responsive use. In scheduled applications, units followed predictable daily cycles, such as morning solar charging and evening discharge, which supported clear performance tracking. Demand-responsive units operated in response to site-specific conditions or irregular loads, leading to more varied cycling but still enabling aggregated analysis of system behaviour.

Table 1. Summary of total energy throughput and run time of six ReVolves deployed on five different sites.

Use case	Description	Commissioned in	Total runtime (thousands of hours)	Energy throughput (MWh)
1	Solar shifting and demand charge reduction	2023	10.5	47.9
2	C&I application 1	2023	8.1	63.7
3	EV charging in net metering mode	2024	19.2	24.4
4	Peer-to-peer sharing	2024	8.3	86.9

5	C&I application 2	2024	3.5	21.0

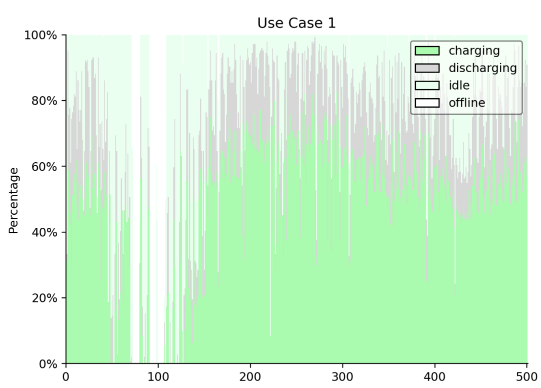
Fig. 9. Daily activity profile for the five different use cases.

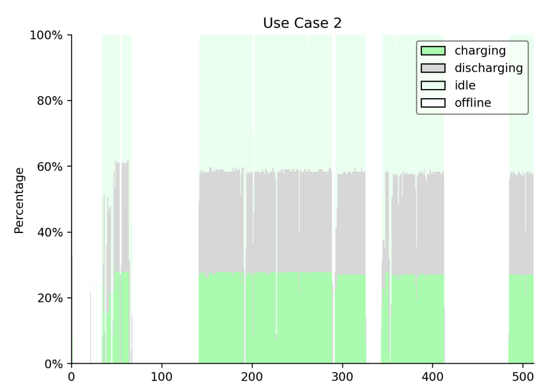
Fig. 9 shows the typical daily load demand profiles for the five different use cases. In scheduled operation, the system follows a fixed, repeating pattern of charging and discharging at specific times each day. These schedules are defined by customers based on site conditions and are repeated daily to optimise energy usage. Use cases 2 and 4 fall into this category.

Demand response, in contrast, involves the system reacting to external signals in real time to determine whether to charge or discharge. An example is use case 1, where the unit supports solar shifting and demand charge reduction. In this scenario, the system charges when excess solar energy is available and discharges when site demand exceeds solar generation. Use case 3, where the system operates in net metering mode for EV charging, also falls under demand response. Here, the unit discharges whenever an EV connects to charge, helping to reduce grid consumption, and charges when site conditions allow.

Use case 5 represents a hybrid approach, combining elements of both scheduled operation and demand response. The system follows a nighttime charging schedule but operates in net metering mode during the day, dynamically adjusting its discharge to support the site's energy needs.

Fig. 10 below provides a detailed analysis of the usage patterns of these units by illustrating the proportion of time each unit spends charging, discharging, idling, or offline. The uptime diagram visualises these operational states over time, with the horizontal axis representing the number of days since commissioning and different colours representing different operation states.





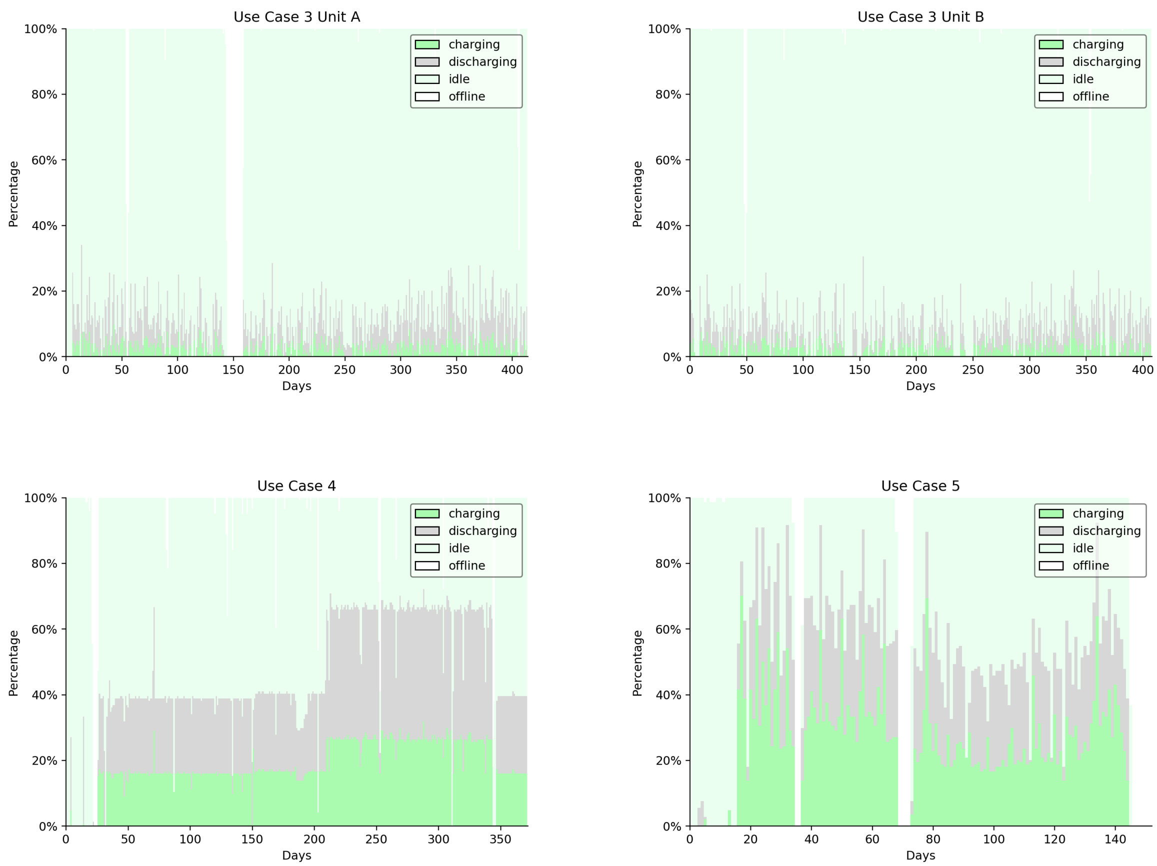


Fig. 10. Uptime graph showing the proportion of time each unit spends charging, discharging, idling, or offline, categorised by use case.

Similar to Fig. 9, the distinction between scheduled operation and demand response use cases is clearly reflected in the uptime data. Units in use cases 2, 4, and 5 follow a consistent operational pattern, with variations occurring primarily due to schedule adjustments. A notable change is observed in use case 4 around day 200, where the system's charging and discharging behavior shifts.

In contrast, the demand response use cases (use cases 1 and 3) display distinctly different daily usage patterns. Use case 1, deployed for solar shifting, demonstrates high utilisation, as the site consistently experiences periods of surplus and deficit solar energy. Over time, a seasonal trend is emerging, with usage patterns aligning with seasonal variations in solar availability.

Use case 3, which supports EV charging infrastructure, shows a low utilisation rate, with both units spending the majority of their time idling. This suggests that demand for EV charging at the site is relatively low.

Fig. 10 also highlights periods where some units remained offline for extended durations. A more detailed discussion of these downtime events is provided in the uptime and availability analysis later in this report.

Analysis of the different usage patterns establishes the context for how these units are being used in the field and are also essential for analysis of the system's efficiency.

Uptime and availability

The reliability and availability of the deployed ReVolve units were evaluated using three key metrics: runtime, uptime, and availability rate.

Table 2. Uptime and availability rate statistics.

Use case	Description	Total runtime (thousands of hours)	Total uptime (thousands of hours)	Availability rate (%)
1	Solar shifting and demand charge reduction	10.54	10.48	99.43
2	Peak demand reduction	8.14	7.44	91.42
3	EV charging	19.25	19.14	99.41
4	Peer-to-peer sharing	8.30	8.17	98.39
5	C&I	3.31	3.27	98.63

- **Runtime** measures the total operational hours of each unit from its installation and commissioning to the cutoff date (March 2025), excluding downtime caused by non-technical factors.
- **Uptime** represents the total hours a unit was powered on and available for operation.
- **Availability rate** is calculated as the ratio of uptime to runtime, providing a measure of the unit's overall reliability and readiness for use.

Table 2 presents these metrics for the five use cases. Some offline periods were excluded from the runtime calculation, as they were unrelated to system performance. Four of the five use cases maintained an availability rate above 98%, with most downtime attributed to internet connectivity issues rather than system failures.

For use case 2, the availability rate was lower (91.4%) due to an extended downtime event in September 2024, when a fuse replacement took over two weeks to complete. This single incident significantly impacted the unit's overall availability, despite its otherwise consistent operation.

Degradation

The degradation of lithium-ion battery packs is commonly assessed by analysing capacity fade in individual cells. This evaluation was conducted on the two ReVolve units with the highest energy throughput - use cases 2 and 4. A random sample of cells was selected from each unit, and their SoH was estimated by taking the ratio of the accumulated charge and the change in SoC during their charging cycles. The equations below describe the method used for these estimations.

$$SoH\ (\%) = \frac{Capacity_{available}}{Capacity_{nominal}}$$

$$Capacity\ (Ah) = \frac{Accumulated\ charge}{Change\ in\ SoC} = \frac{\sum_{t=0}^{t=T} i_{ave} * dt}{|SOC_{t=T} - SOC_{t=0}|}$$

Fig. 11 displays the SoH estimates with a linear degradation model, which projects the annual degradation rate for cells within these units. As noted earlier, both use cases follow a scheduled operation profile, completing one full cycle per day.

The linear model indicates that the degradation rate for these two units falls within the range of 2.0% to 3.0% per year, aligning with expected degradation rates for battery energy storage systems.[1] A broad SoH distribution, ranging from 40% to 70%, is also evident, further highlighting the significant variability in second-life cells being managed by the ReVolve system.

[1] J. Figgener et al., "Multi-year field measurements of home storage systems and their use in capacity estimation," Nat Energy, vol. 9, pp. 1438–1447, 2024, doi: 10.1038/s41560-024-01620-9.

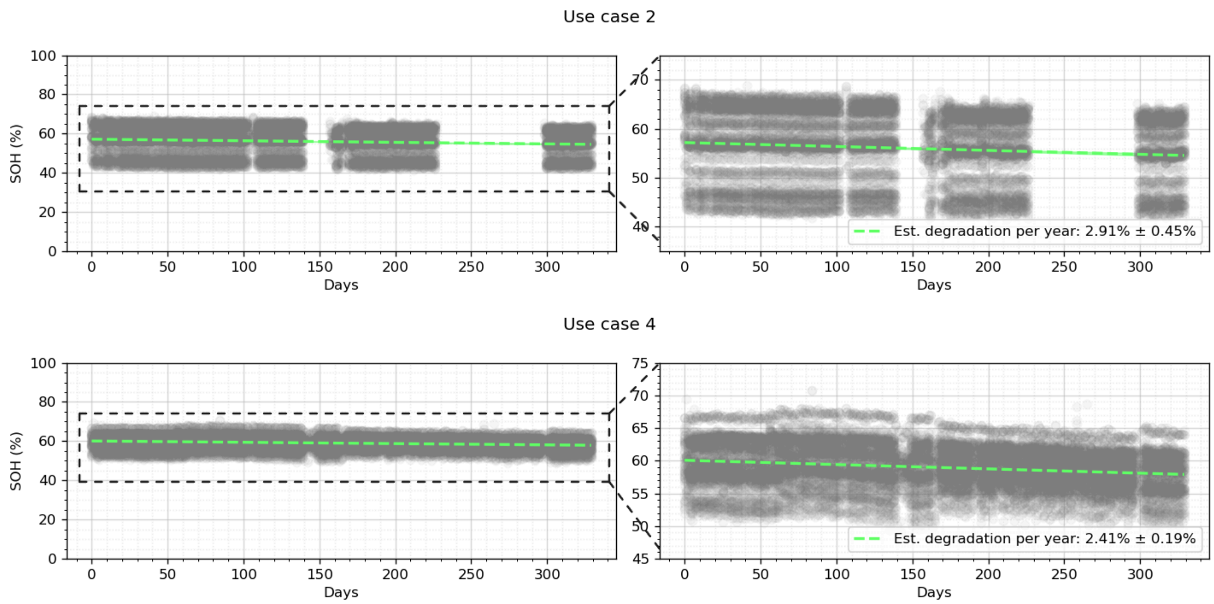


Fig. 11. SoH estimates for packs in use case 2 and 4 with linear degradation rate estimates.

ReVolve Summary

This section explored the operational performance of deployed ReVolve units, focusing on energy throughput, uptime, availability, and battery degradation. The analysis showed that the five use cases collectively delivered approximately 240 MWh of energy. These use cases were categorised into scheduled operation, where the system follows a daily charging and discharging pattern, and demand response, where the system reacts dynamically to real-time signals.

The availability analysis revealed that most ReVolve units maintained an availability rate above 98%, with only one unit recording a lower rate of 91.4% due to an extended downtime period for parts replacement.

Finally, an evaluation of battery degradation focused on the two units with the highest energy throughput. By estimating SoH for a sample of cells and applying a linear degradation model, the annual capacity fade rate was determined to be 2.0% to 3.0%, consistent with expected degradation rates for battery energy storage systems.

Grid connection experience

Relectrify's experience navigating grid connection requirements highlights the complexity of engaging with Australia's fourteen Distribution Network Service Providers (DNSPs), each of which maintains its own embedded generation guidelines. These are typically updated regularly and are primarily designed with residential, low-voltage systems in mind. Overlaying this are state-specific regulations that can override or add requirements. For example, Queensland, Victoria, and South Australia mandate remote disconnect functionality for embedded generation, while New South Wales does not. In practice, such obligations tend to apply more heavily to small-scale residential systems than to commercial solutions like Relectrify's ReVolve.

A particular challenge emerged during certification, when one DNSP revised its guidelines partway through Relectrify's application process. This change delayed connection approvals for ReVolve systems in that distribution area. The experience highlighted the importance of adopting a more proactive and structured approach to regulatory change. Looking ahead, Relectrify may benefit from nominating an internal regulatory lead or engaging specialist consultants to monitor evolving requirements and maintain alignment with strategic goals and resource availability.

Further complexity arose from certain DNSPs requiring Clean Energy Council (CEC)-listed inverters for systems under 200 kW. In one case, a DNSP declined to grant an exemption for the ReVolve despite other networks in both Australia and New Zealand accepting the same system under identical certification documentation. In another case, this challenge was resolved by appealing directly to the distributor, successfully arguing that the site was connected to the high-voltage (HV) network, where CEC listing was a preference rather than a strict requirement. The distributor accepted the ReVolve certificates in this instance. While the CellSwitch component was not explicitly cited, the broader regulatory framework proved to be a hurdle in finalising post-commissioning customer connection agreements.

A major obstacle to obtaining CEC listing arose from the CEC's strict requirement that AS4777.2 inverter testing be conducted by a JAS-ANZ-accredited laboratory. While Relectrify's IEC certificates for the ReVolve (Method 3) were acceptable, the lack of a suitable JAS-ANZ-accredited testing facility created a bottleneck. Relectrify's only viable option was an ILAC-MRA-accredited lab rather than a JAS-ANZ-accredited one, and the CEC declined to make any exceptions. This posed a particular challenge because the ReVolve is a small-scale, commercial-and-industrial (C&I) second-life system that doesn't neatly align with conventional CEC guidelines. Some electricity distributors mandated CEC product listing for battery connections regardless of whether the installation was residential or C&I, further compounding this issue.

One illustrative example of these regulatory constraints was compliance with flammability standards in the CEC's Best Practice Guide. While Relectrify already factored in flammability standards in the design of its electronics, wiring, and enclosures, the AESC second-life battery cells had been tested against more stringent EV standards and demonstrated a decade of real-world performance. Nonetheless, Relectrify was required to conduct additional glow-wire testing to meet different interpretations of the standard, resulting in significant cost and effort for a single component.

The key takeaway from this experience is that regulatory and grid compliance must be treated as a continuous and proactive function when bringing novel technologies to market. Building internal expertise in grid standards has proven valuable for Relectrify, and the selective use of external consultants could further streamline compliance as regulations evolve. By actively monitoring DNSP-specific requirements and anticipating regulatory changes, Relectrify can better integrate these into product design and approval pathways from the outset.

Product certification

Achieving product certification for the ReVolve proved to be one of the project's more significant technical hurdles, due to the system's unconventional design. The ReVolve merges functions of a battery management system and- inverter functionality, which did not fit neatly into existing certification categories. Industry standards and certification test procedures were not written with such an integrated device in mind. As a result, Relectrify faced challenges in both testing and regulatory interpretation.

During certification testing, Relectrify discovered that the usual strategy of testing components in isolation was insufficient; the CellSwitch platform had to be evaluated as part of a whole-system behavior. One concrete difficulty was the accreditation mismatch mentioned earlier: Relectrify's chosen test laboratory was accredited to certify battery systems to IEC standards, but Australian authorities (Clean Energy Council) required that the inverter portion be certified by a JAS-ANZ accredited body. This led to an unexpected gap where the ReVolve, despite meeting IEC requirements, was not initially recognised under Australian inverter certification lists. The resolution involved additional testing and coordinating with a different accredited body, causing delays in the project timeline.

From these experiences, Relectrify gained a clear understanding of what will be required for smoother certification in the future. First, engaging early and often with certification bodies and regulators is vital. By educating them about the CellSwitch-based architecture, misclassifications can be avoided. The company has since developed stronger relationships with testing agencies to ensure there's a shared understanding of how systems like the ReVolve should be categorised. Second, Relectrify learned to design with certification in mind: for example, where standards require certain safety requirements, those need to be built into the product from the beginning (e.g. not relying on multiple independent over-voltage protection methods).

In the end, the ReVolve secured all the required certifications, including AS/NZS 4777.2:2020 for grid connection and the AS 62040 / IEC 61000 series for safety and EMC.

In the process, Relectrify not only achieved compliance for the ReVolve but also built valuable in-house expertise that will make certifying future products more efficient. The next generation of CellSwitch-enabled systems will benefit directly from these lessons, enabling faster certification and a shorter path to market.

Installation experience

Deploying the ReVolve units at customer sites (as well as moving them between facilities for tests) provided valuable feedback on practical installation and handling. Several areas of improvement were identified through this hands-on experience, and many have already been addressed in Relectrify's next-generation system.

Transportation & handling

The ReVolve was designed with an integrated steel skid base and forklift/crane lifting points to facilitate shipping. Even so, the trial showed that more detailed guidance was needed for logistics. Written instructions alone were not enough; in several cases Relectrify had to provide additional verbal and pictorial guidance to trucking companies to ensure the units were handled correctly

Vibrations during long-distance transport caused a few minor component issues upon arrival, prompting Relectrify to implement post-transport inspection procedures. One particular challenge was the ReVolve's weatherproof hood (an external cover for outdoor installations): it was necessary for ingress protection (IP rating), but it proved somewhat prone to cosmetic dents during shipping and handling.

Installation Site Requirements

All ReVolve installations adhered to the relevant installation standard (AS/NZS 5139 for battery installations), supplemented by Relectrify's own site guidelines. Despite this, many commercial/industrial sites presented real-world challenges not fully anticipated at design stage. Space constraints were common: often the unit had to fit in tight electrical rooms or crowded plant areas. In a couple of cases, installers chose to mount ReVolve units on raised steel platforms – this protected the units from forklift traffic and made wiring easier, but it introduced new considerations (e.g. ensuring the platform could support the weight and that vibration from the platform didn't introduce electrical noise).

Some sites struggled with providing the recommended clearances around the unit, which are important for maintenance access and airflow. For example, sufficient front clearance is needed to service the electronics and air conditioning module; when space was limited, it became harder to perform maintenance tasks. Learning from this, Relectrify adjusted its guidance to be more prescriptive about minimum clearances and even redesigned aspects of the next-gen product so that all regular service access is from the front side only (minimising the required footprint and access area). The overarching lesson is that real installation environments can differ greatly from ideal conditions, so flexible and clear installation guidelines are essential, and product design should account for less-than-ideal site layouts.

Commissioning

Relectrify's commissioning tests for the ReVolve were suitable for most sites, but some required greater flexibility to accommodate site-specific limitations. In cases where battery output power was restricted by the connection agreement, full-power testing was not possible. Future products will incorporate a commissioning procedure that allows for site-specific adjustments, with change requests reviewed and approved by Relectrify.

The commissioning process for the ReVolve units generally went smoothly, but there were a few instances that required flexibility. Relectrify's standard commissioning procedure involves testing the unit at full power to verify performance (e.g. a full-load discharge test to measure system response and efficiency). At some customer sites, however, the grid connection agreement imposed export limits or other restrictions that prevented a full-power test. In these situations, Relectrify engineers had to adjust the commissioning plan – for instance, performing a partial-power test or extending the test duration at a lower rate to gather equivalent data.

The need for such adaptations highlighted that a one-size-fits-all commissioning checklist might not work for every site. To address this, Relectrify is developing a more flexible commissioning procedure for future products, including a formal process to approve site-specific modifications to the test plan without compromising validation. This ensures that commissioning can be completed satisfactorily even if site conditions impose certain limits, and it avoids unnecessary strain on either the equipment or the customer relationship during the installation phase.

Metering

An unexpected area that demanded attention was the integration of external site metering with the ReVolve's control system. The ReVolve relies on an external meter (installed at the customer's main switchboard) to measure grid import/export in real time when operating in certain modes (such as an import and export target of zero to minimise grid usage.). While metering itself is outside Relectrify's core expertise, the trial revealed that supporting the metering setup was important for a successful deployment. Challenges encountered included: very long cable runs between the meter and the ReVolve unit causing signal attenuation, electrical noise on the communication line in industrial environments, incorrect wiring of CTs (current transformers) on site, and issues with meter programming. These factors occasionally led to delays in commissioning or suboptimal initial performance until resolved.

Relectrify's engineers often had to assist in troubleshooting these metering issues, effectively stepping beyond the product's boundaries. The lesson learned is that partnerships with metering and electrical specialists are valuable. Furthermore, improvements in documentation (e.g. clearer wiring diagrams for installers, recommended validated meters) have been made to reduce the chance of metering mishaps.

Maintenance and modular design

Finally, the trial provided insight into how the ReVolve could be made easier to maintain. The initial ReVolve design did incorporate maintainability features learned from earlier prototypes – for example, it has dedicated service switches and a layout that allows access to major components. However, servicing a system of this nature still proved to require highly skilled technicians (often Relectrify's own engineers) for certain tasks.

One clear improvement area is increasing modularity. Major components should be designed as independent, replaceable units to eliminate the need for intricate disassembly and reassembly. This is particularly relevant for battery modules, where the current design requires enclosure removal, disconnection of cell boards and wiring, and partial disassembly of module stacks to access a faulty unit. Such repairs are best handled at Relectrify rather than on-site. Future products will allow battery modules and cell boards to be disconnected and swapped with minimal effort.

Internal cabling also requires simplification. The existing design includes multiple communications cables and connectors, increasing the risk of connectivity issues if connectors are not properly seated or if cables are inserted incorrectly. Flat printed circuit cables could also slide underneath their connectors, creating the appearance of a proper connection when they were not fully engaged. Future CellSwitch designs should reduce connector complexity and ensure foolproof assembly. Cooling system cabling should also be rerouted to avoid pinch points that could lead to failures.

Finally, maintenance procedures should be structured so that qualified tradespeople, rather than Relectrify engineers, can perform routine servicing. Electronics should be integrated with battery cells as modular components that can be replaced without requiring delicate handling of cell terminals, torque settings, circuit boards, or flexible printed cables. Next generation products will prioritise robust, simplified maintenance procedures to reduce complexity and minimise service demands. This will reduce overall service costs and downtime for customers and will allow Relectrify to scale up deployments without a commensurate increase in support burden.

Overall, the installation and operational experience from the trial has directly fed into product improvements. By observing and documenting issues encountered in transport, installation, integration, and maintenance, Relectrify has been able to refine its designs and guidelines.

Regulatory

Relectrify's CellSwitch-based BESS encountered a unique regulatory challenge: it did not fit neatly into existing equipment categories for certification and compliance. Most electrical safety and grid connection regulations assume a clear separation between a battery system (with its BMS) and an inverter. Because the ReVolve merges these functions, regulatory bodies initially struggled to classify the system. This was evident in the certification stage, as described earlier, and it also has implications for how the product is viewed by regulators and industry programs (such as approved product lists, incentive schemes, etc.). In essence, the regulatory framework was designed for traditional battery systems, and the ReVolve's innovation pushed its boundaries.

During the trial, one concrete consequence of this misalignment was the delay caused by differing interpretations among testing authorities. At one point, a certification body was unsure whether to test the ReVolve as an inverter or as a battery system, leading to certain tests being redone and a longer overall certification timeline. This had direct commercial impact: a few early customers grew concerned about the uncertainty and timing, and ended up canceling their pre-orders to pursue more conventional solutions. Although Relectrify eventually resolved the certification issues, this episode highlighted how regulatory uncertainty can translate to market risk for innovative technologies.

Beyond certification, the project did not encounter major regulatory barriers in terms of tariffs or market rules, largely because the deployments were behind-the-meter and focused on self-consumption (solar shifting, peak shaving) rather than market trading or ancillary services. However, looking forward, if Relectrify's systems were to participate in revenue streams like frequency control ancillary services (FCAS) or other network services, there may be additional regulatory hurdles or registration complexities to navigate.

One lesson is that persistent dialogue with regulatory authorities is important when introducing an unconventional product. By being part of working groups or standards committees (where possible), Relectrify can help shape future standards that accommodate cell-level power electronics or second-life batteries more explicitly.

Customer value proposition

From the outset, the ReVolve was designed and positioned to meet the needs of C&I customers looking for behind-the-meter energy storage. The system targeted several primary use cases for these customers:

- **Solar shifting**: Capturing excess solar PV generation during the day and storing it, then discharging in the evening or other peak periods to offset grid consumption. This helps businesses maximise on-site solar usage and reduce peak-time energy costs.

- **Peak shaving**: Discharging the battery to reduce high demand spikes, thereby lowering demand charges on electricity bills. By smoothing out the load profile, customers can achieve cost savings on network tariffs.

- **Sustainability & circular economy**: Using second-life EV batteries gives the ReVolve a unique environmental appeal. It extends the life of batteries that would otherwise be recycled or discarded, reducing e-waste and the embodied energy per cycle of the batteries. Customers with corporate sustainability goals find this attribute adds intangible value (like carbon footprint reduction and positive storytelling around resource reuse).

These use cases can often be value-stacked, meaning a single ReVolve installation might deliver multiple benefits simultaneously. For example, a unit could perform daily solar shifting and also be available to shave the occasional afternoon peak, thus enhancing the overall return on investment. In principle, stacking uses improves the business case. However, throughout the trial, we observed that prospective customers tended to carefully weigh these theoretical benefits against some practical considerations unique to second-life systems (discussed below).

Quantitative economics

When evaluating proposals, C&I customers commonly focused on metrics such as the Levelised Cost of Storage (LCOS – essentially the cost per kWh delivered over the system's life) and the projected payback period. These metrics account for the system price, expected lifetime (cycles/years), operating costs, and any differences in warranty or performance relative to standard solutions:

- **Cost per kWh (LCOS)**: Many customers performed a cost analysis including purchase price, installation cost, and maintenance, divided by the expected energy throughput (over, say, 6–8 years of operation).

- **Payback period**: Customers examined how many years it would take for energy cost savings (from solar self-consumption and demand charge reduction) to recoup the system cost, often comparing this against doing nothing or using a new battery alternative.

In the portfolio of early ReVolve sales, the system generally showed a competitive LCOS for customers who placed a high value on sustainability. In several cases, the modeled cost-per-kWh over the system's life came out within 5–10% of an equivalent new-battery BESS project. For those customers, this small premium (or near-parity) was acceptable given the environmental benefits. It should be noted that this margin was highly sensitive to external factors: the cost of obtaining second-life batteries, international shipping rates (which spiked during COVID-19), and foreign exchange rates could all swing the economics. For example, when ocean freight costs doubled or tripled in 2021–2022, it eroded much of the cost advantage of using second-life batteries (this is addressed in Market Opportunity below).

Typical payback periods for ReVolve installations ranged between 4 to 7 years. Some customers, particularly those treating the project as a pilot or demonstration of new technology, were willing to accept a longer payback (even beyond 7 years) due to their commitment to environmental and innovation goals. Others, especially those with purely economic drivers, expected paybacks in the 4–5 year range and were less inclined to stretch that for the sake of sustainability alone. This underscored that while the ReVolve could meet the economic criteria in favorable scenarios, the financial case was sometimes marginal and depended on incentives or intangible benefits to push it over the line.

Customer perspective

Target market and early adopters

The ReVolve was strategically positioned to appeal primarily to early adopters within the C&I sector, particularly organisations with strong sustainability mandates or innovation programs. Interest was particularly high across manufacturing, energy retailer, agriculture, community energy and local government/community sectors. These customers were drawn by several aspects of the offering: the fact that the system gave a second life to EV batteries (aligning with circular economy values), the novelty of Relectrify's cell-level control technology (which promised improved performance), and the local (Australian) manufacturing aspect of the product. In essence, the ReVolve appealed to customers who were not only looking for an economic energy storage solution but also a story and impact they could stand behind.

Second-Life BESS characteristics - Asset life and warranty

A prominent concern among prospective buyers was the expected lifetime of the second-life battery system and the associated warranty. Customers are accustomed to new battery systems coming with warranties of 6 to 10+ years. With the ReVolve being built from used batteries, many customers initially sought similar warranty terms, which was challenging. Typically, EV manufacturers do not extend any warranty once a battery is removed from the vehicle, and as a third-party repurposer, Relectrify had to define its own warranty provisions.

Relectrify decided to offer a standard 4-year warranty on the ReVolve units (covering the entire system, independent of the original EV batteries' age). This warranty period was a balance between demonstrating confidence in the product and acknowledging the uncertainties of second-life cell longevity. However, Relectrify's shorter warranty was still noted as a disadvantage relative to new systems offering 10-year warranties.

To address this, Relectrify engaged in transparent discussions about realistic second-life performance. The team provided analysis to justify the expected life of ~6-8 years for the system. They also pointed out that a shorter warranty did not necessarily mean the system would reach the end of its useful life sooner, but rather reflected the unknowns beyond that period. Educating customers on why a second-life system couldn't reasonably carry the same 10-year guarantee as a brand new one was part of the sales process.

By setting honest expectations and backing it with data, Relectrify's approach helped with customers who were motivated by sustainability. They were more understanding that an innovative, sustainability-focused solution might come with different terms.

Motivations - financial and environmental

The motivation to consider the ReVolve typically boiled down to two main drivers: financial savings and environmental impact.

On the financial side, as discussed, customers evaluated the ReVolve for its potential to cut energy costs (via solar self-consumption and demand charge reduction). The trial deployments confirmed that in the right scenarios, the ReVolve can indeed deliver solid financial returns. All customers looked at the "dollars per kWh" metric; in this respect, ReVolve generally showed robust viability, often comparable to new systems when subsidies/incentives were not in play for either. However, where incentives or very low financing costs were available for conventional systems (or where a competitor offered aggressive pricing), Relectrify had to rely on its differentiators beyond price.

The environmental motivation was often the decisive factor for early adopters. Several customers explicitly chose ReVolve because it aligned with their organisational values around sustainability. The idea of giving EV batteries a second life was compelling as it demonstrated leadership in circular economy practices and innovation. These customers were willing to accept a slightly longer payback or a bit more risk because the project delivered environmental credence.

Preferred business models

During customer engagements, Relectrify explored various business model options (direct purchase, leasing, energy-as-a-service, etc.). The trial phase revealed that most customers preferred outright purchase of the equipment, especially given its relatively moderate size/cost in the context of their operations. Some customers did arrange their own financing or loans to fund the purchase, indicating that an opportunity might exist for Relectrify to facilitate financing to make projects easier. For example, if a customer could finance the system with repayments equivalent to the energy savings or revenues from energy trading, it essentially becomes cash-flow neutral or positive from day one.

Market opportunity

The trial provided a candid look at the market opportunity for second-life battery systems, revealing both significant interest and significant challenges.

On one hand, there is a clear environmental and conceptual appeal to reusing EV batteries for stationary storage. Governments and businesses are increasingly focusing on sustainability and circular economy initiatives, which creates a supportive narrative for second-life batteries. We saw genuine excitement from stakeholders about the prospect of reducing waste and lower-cost storage through reuse. Furthermore, the involvement of large international utilities in our trial (in NZ, US, JP) demonstrated that major players are willing to pilot and prove the technology, potentially paving the way for larger orders down the track.

On the other hand, the project highlighted major challenges that currently limit the profitability and scalability of second-life battery products:

Supply constraints and cost of used batteries

The availability of used EV batteries in the quantities and consistency needed for production is quite limited today. EV adoption is growing, but relatively few EVs have reached end-of-life so far. Moreover, automakers like Nissan view their used batteries as assets; some have internal programs to repurpose or resell them, which keeps prices high. For example, a Renault-Nissan Energy Services executive, estimated that Nissan

Leaf batteries could last 22 years, which is 10 to 12 years longer than the average life of the vehicle itself.[2] As long as this supply situation persists, the core premise of second-life (cheaper batteries) is undermined. The project had to continuously seek battery sources, importing packs from overseas when Australian supplies ran short. This patchy supply chain made planning difficult and added expense (as sometimes we paid a premium to secure packs in time).

Shipping challenges

Tied to the supply issue is the challenge of physically moving used batteries to where they are needed. During the trial, Relectrify had to import used Leaf packs from the US and Japan to supplement local packs. Shipping used lithium batteries is complicated - they are classified as dangerous goods, which means many carriers refuse them, and those who accept them impose strict conditions and paperwork. We encountered multiple instances of shipments stuck at ports or turned away by carriers despite prior arrangements.

The COVID-19 pandemic exacerbated the logistics woes: freight costs surged, and shipping schedules became unreliable. At one point, a container of used battery modules spent months in transit limbo, incurring storage fees and delays. The net effect was a sharp increase in logistics cost, which at times reached US$20–40 per kWh shipped, whereas the project had originally expected shipping to be under US$10/kWh. Such high logistics costs eat directly into any cost advantage of second-life batteries. They also introduce uncertainty in lead times for delivering products to customers.

Regulatory and safety compliance overhead

As discussed in the regulatory section, second-life batteries introduced additional complexity in certification. Also, because the EV packs were not originally made for stationary use, extra testing had to be done on certain components. This added unexpected cost and time. While these are manageable on a project scale, they indicate that a second-life product might always carry some extra overhead in engineering and compliance, compared to using batteries purpose-built for stationary storage. It's possible that as the market matures, regulatory adjustments (or standard exemptions) could reduce this overhead, but in the trial it was a factor.

Market outlook

While the trial highlighted several challenges, it also helped sharpen Relectrify's commercial strategy. The company recognises that under current conditions, second-life battery products face an uphill battle to compete with new batteries on cost and

[2] Automotive News, Nissan looks for ways to use long-lasting EV batteries, 2019: [Link]

convenience, and given scarcity of predictable supply, it is difficult to rely upon to build a sustainable business.

As a result, Relectrify is shifting its immediate focus to applying its CellSwitch technology with new battery cells. This approach offers more predictable supply chains, simplified certification pathways, and faster time to market. Importantly, it also lays the foundation for a self-generated pipeline of second-life batteries. By designing ‘first-life’ products today, Relectrify creates the opportunity to reclaim and redeploy its own battery packs in the future, enabling a closed-loop model and unlocking truly low-cost energy storage solutions over time.

This is not a departure from the second-life vision, but rather a phased strategy. The company remains strongly positioned to re-enter the second-life market at scale when conditions improve. As battery supply chains mature, standardisation increases, and the EV sector approaches saturation, the availability of high-quality second-life cells is expected to grow substantially. Relectrify’s proven technology and early-mover experience place it in a strong position to lead in that market.

Conclusion

The Second-Life Battery Trial successfully demonstrated that retired EV batteries can be repurposed into a functional, safe, and reliable energy storage product when combined with advanced control technology. The project met its technical objectives: the CellSwitch-equipped ReVolve systems were fully certified and performed reliably in the field, delivering over 240 MWh of energy across various sites. These deployments proved that second-life cells, when actively managed at the cell level, can provide strong performance and manageable degradation, effectively bridging many of the technical gaps between used and new batteries.

At the same time, the trial provided clarity on the current limitations of the second-life battery business case. The anticipated cost advantages of second-life batteries were largely offset by challenges in battery supply, logistics, and additional compliance overheads. In practice, limited availability of used batteries, high transport and handling costs, and extra certification effort meant that second-life solutions offered only a marginal benefit over new batteries under 2020–2025 conditions.

The knowledge and experience gained from this trial have strengthened Relectrify's market position. The data and success from diverse trial sites (including international utility partners) provide a strong reference for entering new markets and winning customers for the next generation of products. Relectrify is therefore well placed to lead in both today's battery storage market and the future second-life battery sector as it matures.

Glossary

Acronym	Description
ARENA	Australian Renewable Energy Agency
AS/NZS	Australian/New Zealand Standard (joint standards issued by Standards Australia and Standards New Zealand)
BESS	Battery Energy Storage System
BMS	Battery Management System (controls battery monitoring and safety)
C&I	Commercial and Industrial
CT	Current Transformer (device for measuring electric current, used in metering)
DNSP	Distribution Network Service Provider
EMC	Electromagnetic Compatibility
EV	Electric Vehicle
FCAS	Frequency Control Ancillary Services
HV	High Voltage
IEC	International Electrotechnical Commission
JAS-ANZ	Joint Accreditation System of Australia and New Zealand (accreditation body for certification labs)
LCOS	Levelised Cost of Storage (average cost per kWh of energy discharged over the lifetime of a storage system)
SoC	State of Charge (the current charge level of a battery cell or pack, as a percentage of its capacity)
SoH	State of Health (measure of a battery cell's remaining capacity relative to when it was new)