Darlington Point Energy Storage System

Operations Report #1

Project Name:	Darlington Point Energy Storage System
Contract Number:	2020/ARP05
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Darlington Point Energy Storage System has received funding from ARENA as part of ARENA’s Advancing Renewables Program.

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Executive Summary

Edify Energy (Edify) has developed the Darlington Point Energy Storage System (DPESS) which is a 25MW / 50MWh Battery Energy Storage System (BESS) system located adjacent to the 275MW Darlington Point Solar Farm in NSW. DPESS comprises advanced grid forming inverters with the ability to provide system strength services to the NSW electricity network. The performance of the plant is being verified through an agreed Testing Plan. This Testing Plan was developed in consultation with Transgrid and AEMO and includes a combination of power system studies, commissioning tests, and ongoing performance monitoring. The findings of the Testing Plan and any other key learnings will be disseminated through further knowledge sharing outputs.

This Operations Report is part of the Knowledge Sharing Deliverables under the ARENA Funding Agreement and is the first of four twice-yearly reports covering the technical and commercial performance of DPESS over the first two years of operation.

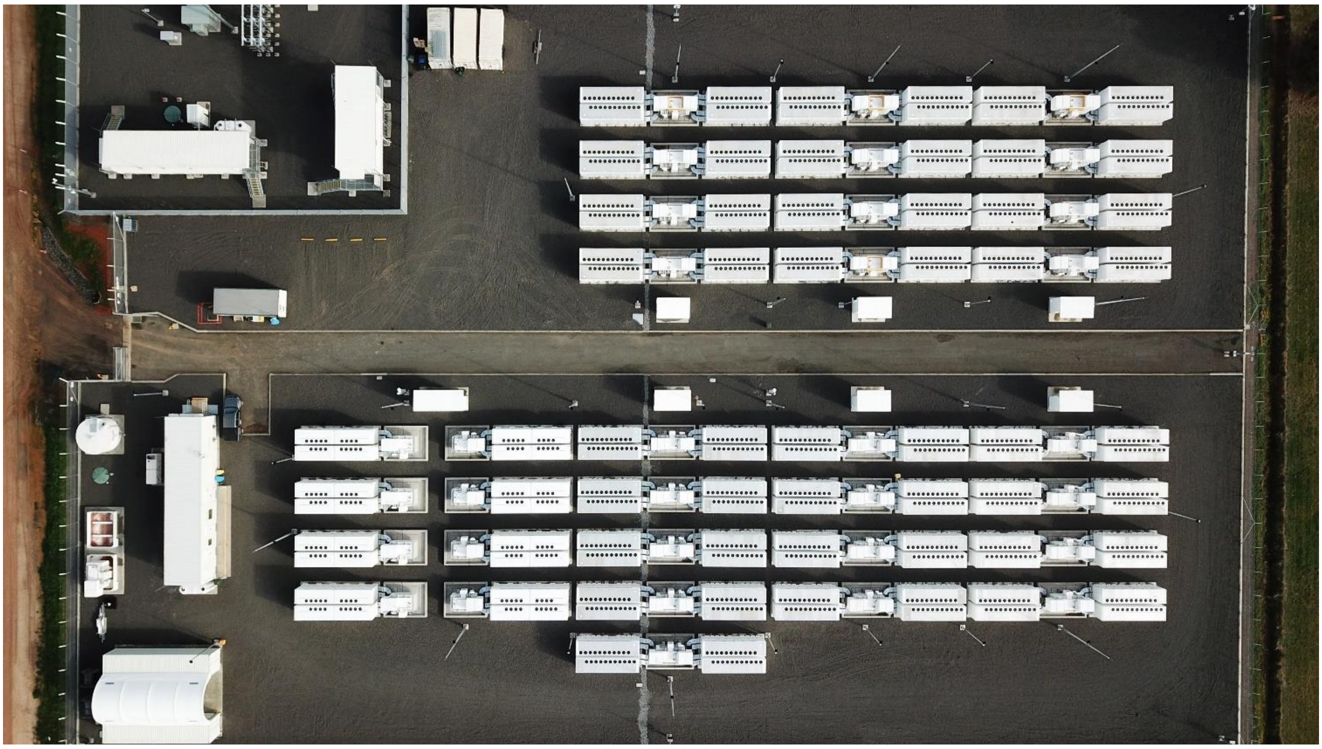
DPESS achieved commercial operations on 29 September 2023. This Operations Report focusses on the first six months of operations to 31 March 2024 and considers:

- Charging behaviour, including participation in various energy markets;
- Technical performance;
- Financial performance;
- Safety and environmental performance; and
- An overview of testing performed as specified in the above Testing Plan.

1 Project details

1.1 Project overview

Edify developed the DPESS project which is a 25MW / 50MWh BESS located adjacent to the 275MW Darlington Point Solar Farm in NSW (also developed by Edify). DPESS commenced construction in July 2022, completed construction in May 2023 and began commercial operations in September 2023.



DPESS connects to Transgrid's 132kV network at Darlington Point Substation and has advanced inverters set to 'grid forming mode' (also known as 'virtual machine mode'), which can provide system strength services to the grid.

1.2 Project objectives

DPESS principally aims to demonstrate that a BESS with advanced inverters can reduce the cost of connecting variable renewable energy projects to weak grids by offsetting (fully or partially) the need for synchronous condensers (or other reactive plant) in future projects.

DPESS aligns with the objectives and desired outcomes of ARENA's Advancing Renewables Program (ARP)[1] as successful completion of DPESS will contribute to technical, regulatory and commercial outcomes that are of high priority for ARENA. DPESS will contribute to all five of the ARP objectives and outcomes, which are:

a) reduction in the cost of renewable energy;
b) increase in the value delivered by renewable energy;
c) improvement in technology readiness and commercial readiness of renewable energy technologies;
d) reduction in or removal of barriers to renewable energy uptake; and
e) increased skills, capacity and knowledge relevant to renewable energy technologies.

BESS projects using advanced grid forming inverters offer several key benefits to the electricity network, as follows:

a) **Provide system strength services and reduce the need for synchronous condensers**: BESS projects with advanced grid forming inverters provide system strength (i.e. frequency and voltage stabilisation, fast disturbance event response, etc.) with much faster response times than other energy storage or generation technologies. These services can allow nearby renewable energy projects to operate with fewer constraints or without constraints to their output, increasing the value of these projects and improving the utilisation of the network. By providing these services, BESS projects with advanced grid forming inverters can remove the need for synchronous condensers or other measures to be installed with renewable energy projects. Synchronous condensers are complex and expensive

[1] https://arena.gov.au/assets/2017/05/ARENA_ARP_Guidelines_FA_Single_Pages_LORES.pdf

machines. Therefore, removing the need for such machines significantly reduces the cost and risk profile associated with connecting renewable energy projects in weak grids.

b) **Multi-use technology**: BESS projects with grid forming inverters can also provide all the beneficial services that have been observed and well reported from other BESS projects (such as charging during periods of low demand / price, dispatching into high demand / volatile price periods and providing market ancillary services) making them a multi-use market and technical service technology, in contrast to single purpose technologies such as synchronous condensers.

These benefits combine to support the further commercialisation of BESS and advanced grid forming inverter technology, further development of renewable energy projects and increased economic, environmental and social benefits to Australian consumers.

BESS technology is relatively new and as such there are significant learnings from every project. Key learnings to date from DPESS are detailed in the following section. These learnings are already being applied to other renewable energy and BESS projects in Australia.

1.3 EnergyAustralia as operators

The revenues of DPESS are wholly captured in a long-term Battery System Services Agreement (BSSA) between DPESS and EnergyAustralia. The BSSA entitles EnergyAustralia to full operational rights over DPESS, as they relate to charge and discharge decisions in both energy and FCAS markets. Accordingly, EnergyAustralia is the beneficiary of all market-linked revenues from DPESS, which it receives in exchange for making fixed payments to DPESS.

The BSSA also provides EnergyAustralia with battery performance, availability and reliability commitments, subject to operational constraints, mainly relating to the implications of cycling frequency on warranted performance.

The battery purchase agreement provides DPESS with performance, availability and reliability commitments from Tesla.

1.4 Project update and status

The project achieved Commercial Operations on 29 September 2023. At this point in time the project was permitted to operate commercially by the Network Operator and AEMO following the successful completion of the R2 testing program. The BESS also completed performance testing to demonstrate the storage capacity and round-trip efficiency. Since this time the BESS has been operating commercially.

Generators in the NEM are now required to submit a separate registration package to register to provide Frequency Control Ancillary Service (FCAS). This is a change from the previous process where registration in these markets was included in the generator registration. DPESS was registered to provide FCAS services from 20 November 2023. Participation in the new 1s Lower and 1s Raise FCAS markets commenced from 29 February 2024 with the delay due to the need for additional SCADA points and metering to be tested. The additional SCADA points for 1s Lower and 1s Raise were not considered in the initial SCADA list agreed with AEMO, as these were agreed and tested prior to the final design and commencement of this market. This should be considered for future projects.

With the introduction of the 1s Raise and 1s Lower FCAS markets a higher resolution of meter readings was also found to be required. This resulted in the need for a change in the power quality meter model which is a learning for future projects intending to participate in these markets.

2 System strength performance

2.1 Purpose of the Testing Plan and Flagship Report

The goal of the Testing Plan is to assess the ability of batteries with advanced inverters to provide system strength and to increase the renewable energy hosting capacity if the network. This will be demonstrated through modelling of various scenarios in the wide area network model to assess how the facility impacts on the stability of the network. The Testing Plan also includes onsite validation of the performance of the plant relative to the modelled performance. The third aspect of the Testing Plan is to assess the actual response of the plant to network disturbances.

2.2 Progress against the Testing Plan and Flagship Report

2.2.1 Onsite testing for model validation

The onsite testing of the plant was incorporated into the R2 testing program for the generator. The testing included the following tests to demonstrate the response of the plant:

- Voltage step tests;
- Frequency response tests;
- Active power step test;
- Reactive power step test;
- Partial trip test; and
- External voltage disturbance test.

The outcomes of the testing found that there was good alignment between the predicted response of the plant and the onsite test results. A sample of these results will be included in the Flagship Report.

There was no revision of the modelling required to align with the actual performance. This is expected but is important as the Testing Plan will assess the impact of the plant in fault conditions in a modelling environment and the results validate that the outcomes of this assessment can be relied upon.

2.2.2 Performance during actual network events

The most material actual network event which has occurred since the commencement of operations of the project was on 13 February 2024 at approximately 1308 hrs (Australian Eastern Standard Time). The event was well reported and has been detailed by AEMO in their preliminary incident report[2].

The incident was initiated by the simultaneous tripping of the Moorabool (MLTS) – Sydenham (SYTS) No. 1 and two 500kV lines following the failure of a number of 500kV towers due to extreme weather. This resulted in the loss of approximately 2,690MW of generation and caused load shedding.

The event caused a disturbance at the location of DPESS which involved frequency dropping to below 49.7Hz and a voltage drop of more than 6% at the worst case.

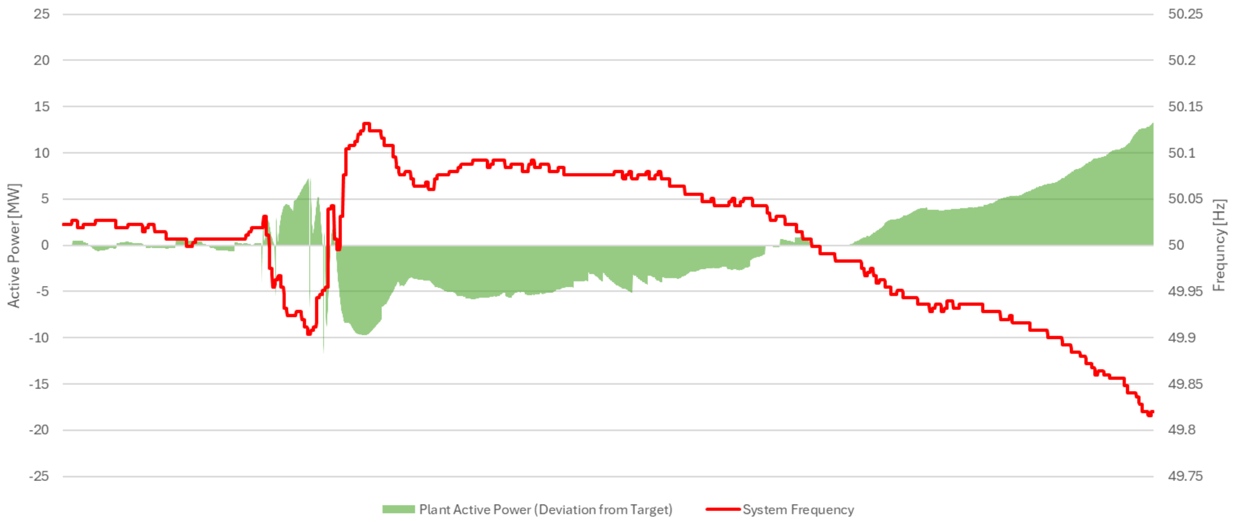
DPESS itself was offline prior to the event for unrelated reasons. DPESS however was built as part of a larger group of facilities including the Riverina Energy Storage System 1 (RESS1) and the Riverina Energy Storage System 2 (RESS2). These BESS' are also using Tesla Megapack technology and also utilising grid forming controls with identical settings to DPESS. All three BESS are co-located but are separately registered facilities each with its own connection point. As such, the response of the neighbouring RESS2

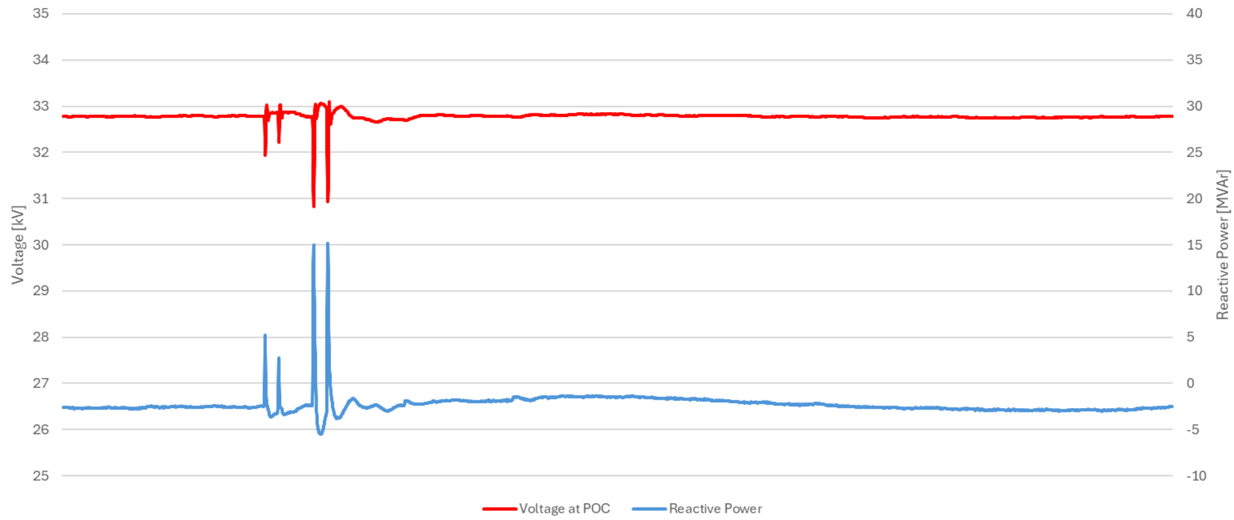
[2] https://aemo.com.au/-/media/files/electricity/nem/market_notices_and_events/power_system_incident_reports/2024/preliminary-report---loss-of-moorabool---sydenham-500-kv-lines-on-13-feb-2024.pdf

generator was able to be analysed to assess the grid forming BESS response. The key observations of the RESS2 response are as follows:

- The BESS rode through the event and continued normal operation, providing active and reactive power responses to the changes in voltage and frequency.
- There were multiple voltage disturbances during the event and in each case the BESS responded with the response being initiated in less than 20ms from the time of the disturbance. This speed of response to disturbances is a key feature of the advanced inverters where they respond almost instantaneously to voltage due to the grid forming controls.

The following figures shown the active power (deviation from target) vs frequency and reactive power vs voltage response of the facility for the event respectively.





This event and others will be analysed further in the Flagship Report but the initial findings are consistent with the expected performance of the BESS.

2.2.3 Assessment of provision of system strength

The assessment of the provision of system strength will be demonstrated in the wide area network model where the ability to stabilise renewable generation and a comparison to synchronous condensers will be undertaken. This assessment is ongoing and will be reported on in the Flagship Report.

2.2.4 Improving stability in southwest New South Wales RIT-T

In 2022 Transgrid published a RIT-T – Project Assessment Conclusions Report for Improving Stability in Southwest New South Wales[3]. This report considers a number of network and non-network options to alleviate constraints on line 63 which were introduced in May 2020 to limit power flows in order to manage risks to system stability. The findings of this assessment were that the presence of advanced grid forming inverters at DPESS (and the neighbouring RESS1 and RESS2 projects) will allow these BESSs to contribute to system stability and partly alleviate this constraint. The BESSs providing a network service was identified as part of the preferred solution as an interim option until a new transmission interconnection could be built.

Transgrid published a further update in December 2023[4] where it was identified that the BESSs could be used as a longer term option avoiding or deferring the need for investment in the transmission line.

In making this assessment Transgrid has undertaken modelling in the wide area network model to assess the impact of the BESSs on system stability. The fact this solution has been identified as preferred is a validation of the project contributing to system strength.

We expect to be able to update further on this in the Flagship Report when a revision of the constraint is expected to be in place.

[3] https://www.transgrid.com.au/media/tinisujc/transgrid-pacr_improving-stability-in-sw-nsw.pdf
[4] https://www.transgrid.com.au/media/4xun0spy/notice-of-change-to-non-network-option-to-improve-stability-in-southwest-new-south-wales.pdf

3 Technical performance

3.1 Energy throughput and round-trip efficiency

DPESS has exported a total of 6,249MWh for the 6-month period to March 2024. This is on average 34.15MWh per day relative to the beginning of life storage capacity of 50MWh. This is a cycle rate of lower than 1 cycle per day.

The total imported energy over this same period was 7,367MWh resulting in a total round-trip efficiency (RTE) of 85%. It is noted that this is an all-inclusive RTE at the point of connection and includes all BoP losses as well as standby losses when the BESS may be idle. RTE is generally tested via a bespoke charge and discharge test which excludes these standby losses resulting in a higher RTE. This test will be conducted only at the end of year one.

Table 1 summarises the charge and discharge cycle outcomes for the 6-month period to March 2024. A charge and discharge cycle of 1 per day is represented by an 8.33% capacity factor. On average, the table below shows the BESS discharged less than 1 cycle per day for the 6-month period to March 2024.

Table 1 Charge and discharge cycle summary: October 2023 to March 2024

Parameter	October	November	December	January	February	March	6-month period
Charge energy (MWh)	775	1,061	967	1,472	1,547	1,545	7,367
Discharge energy (MWh)	596	888	812	1,267	1,345	1,342	6,249
Discharge capacity factor	3.3%	4.8%	4.5%	6.8%	7.2%	7.7%	5.7%
Total RTE%	77%	84%	84%	86%	87%	87%	85%

Table 2 and Table 3 outlines the BESS' participation the various FCAS markets

Table 2 Percentage of intervals enabled for FCAS: October 2023 to March 2024

Product		Oct-23	Nov-23	Dec-23	Jan-24	Feb-24	Mar-24
Lower	Regulation	0.00%	21.45%	100.00%	99.80%	99.99%	97.93%
	Delayed	0.00%	39.82%	100.00%	99.80%	99.98%	98.05%
	Slow	0.00%	39.82%	100.00%	99.80%	99.98%	98.05%
	Fast	0.00%	39.82%	100.00%	99.80%	99.98%	98.05%
	Very Fast	0.00%	0.00%	0.00%	0.00%	53.43%	97.96%

Product		Oct-23	Nov-23	Dec-23	Jan-24	Feb-24	Mar-24
Raise	Regulation	0.00%	21.45%	100.00%	99.79%	99.91%	94.68%
	Delayed	0.00%	39.82%	100.00%	99.79%	100.00%	98.01%
	Slow	0.00%	39.82%	100.00%	99.79%	100.00%	98.01%
	Fast	0.00%	39.82%	100.00%	99.79%	100.00%	98.01%
	Very Fast	0.00%	0.00%	0.00%	53.43%	91.72%	0.00%

Table 3 Average MW enabled for FCAS: October 2023 to March 2024

Product		Oct-23	Nov-23	Dec-23	Jan-24	Feb-24	Mar-24
Lower	Regulation	0	9.48	11.73	12.29	11.32	9.27
	Delayed	0	5.09	4.89	4.87	4.79	4.65
	Slow	0	5.1	4.88	4.93	4.83	4.71
	Fast	0	5.1	4.87	4.86	4.8	4.61
	Very Fast	0	0	0	0	0.87	3.78
Raise	Regulation	0	8.56	9.57	11.18	9.95	9.61
	Delayed	0	5.03	4.91	4.97	4.99	5.01
	Slow	0	5.03	4.91	4.97	5.02	5.01
	Fast	0	5.03	4.95	4.98	5	5.02
	Very Fast	0	0	0	0	4.57	6.55

3.2 Energy degradation

The estimated full pack energy of the system has gradually decreased from 51.2MWh to 50.2MWh over the 6 months to date for the system indicating a degradation of slightly less than 2%. This however is an estimate value only by the BESS and it is necessary to undertake a full charge and discharge test to determine the true energy capacity of the BESS. This test will be conducted only at the end of year one.

3.3 Availability

The availability for DPESS has been lower than expectations in the reporting period, with an average availability of 93% over the period. There have been a few early teething issues with the plant relating to communications between site devices which have since been resolved and it is expected that availability will increase in the next 6-month period.

Table 4 Availability: October 2023 to March 2024

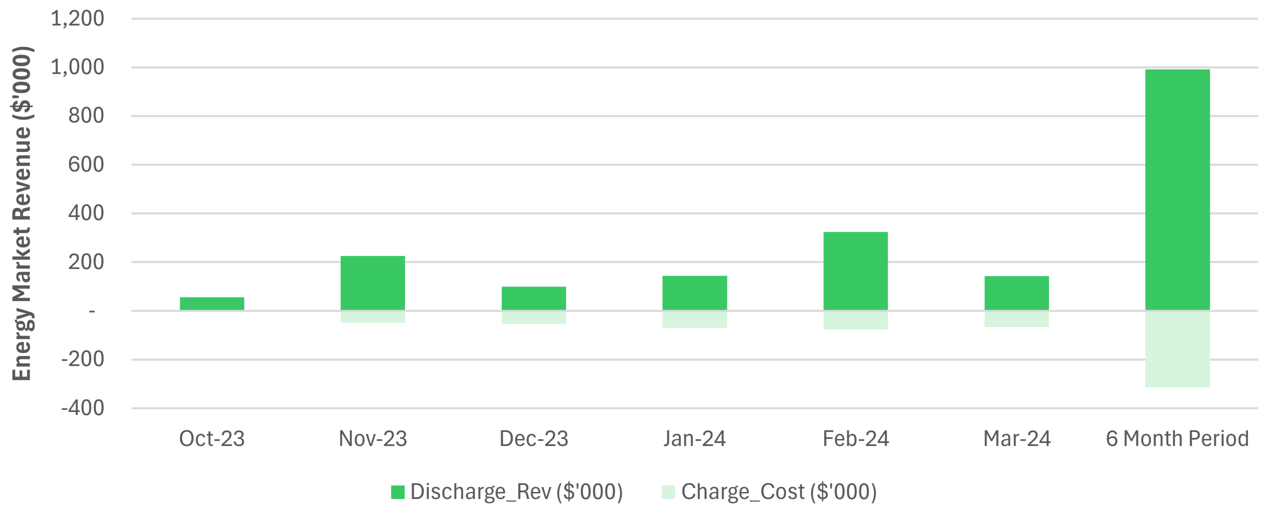
Parameter	October	November	December	January	February	March	6-month period
Availability	99.9%	96.9%	80.1%	95.4%	96.9%	90.7%	93.3%

4 Financial performance

As noted earlier, DPESS commenced commercial operations on 29 September 2023. DPESS was registered to provide FCAS services from 20 November 2023 and participation in the new 1s Lower and 1s Raise FCAS (VFFCAS) commenced from 29 February 2024.

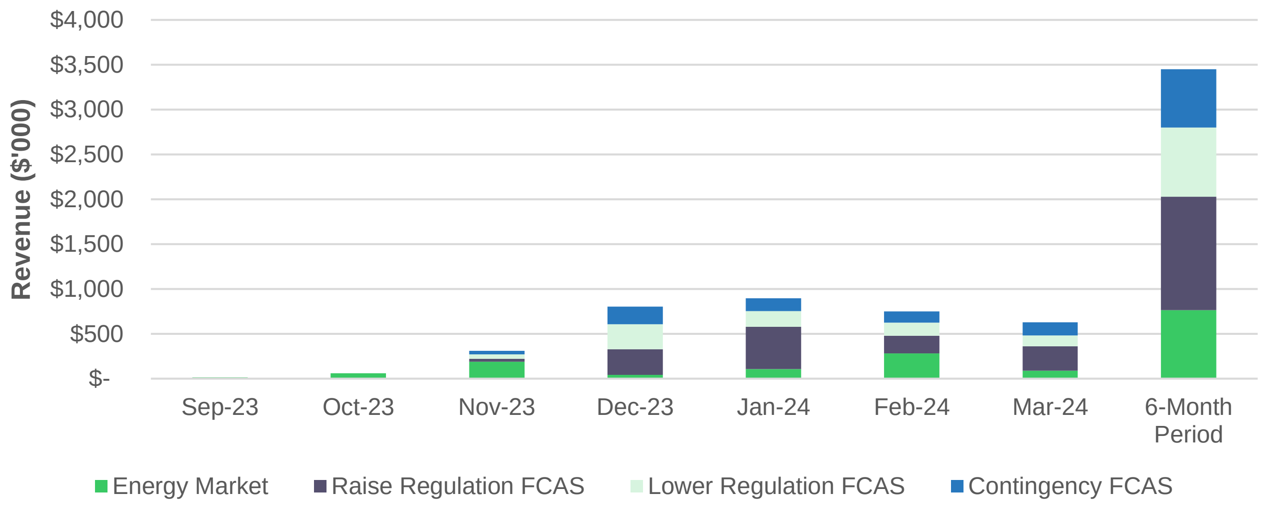
The average discharge price for DPESS between October and March was $155.17/MWh, with an average charging price of $40.29/MWh.

Figure 1 Energy Market Revenue and cost per month



The chart (see Figure 2) displays the monthly energy market margins and the value captured from various FCAS markets as they became operational. The regulation markets have significantly boosted the overall revenue across all FCAS segments.

Figure 2 Financial performance of DPESS in different Markets



From an energy market perspective, Figure 3 and Figure 4 outline the average operational profile of DPESS and Figure 5 shows trading interval prices in NSW respectively. As can be expected, DPESS operations have largely mirrored the trends in energy market prices. Typically, it discharges during the morning and evening peak periods when prices are highest and charges during midday when prices are often negative.

Figure 3 DPESS charge MW during the day per month (per 5-minute Trading Interval)

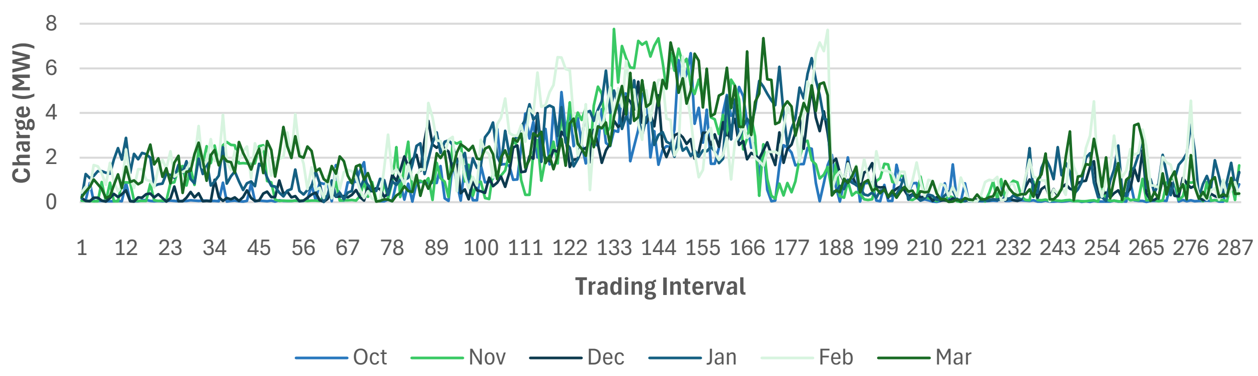


Figure 4 DPESS discharge MW during the day per month (per 5-minute Trading Interval)

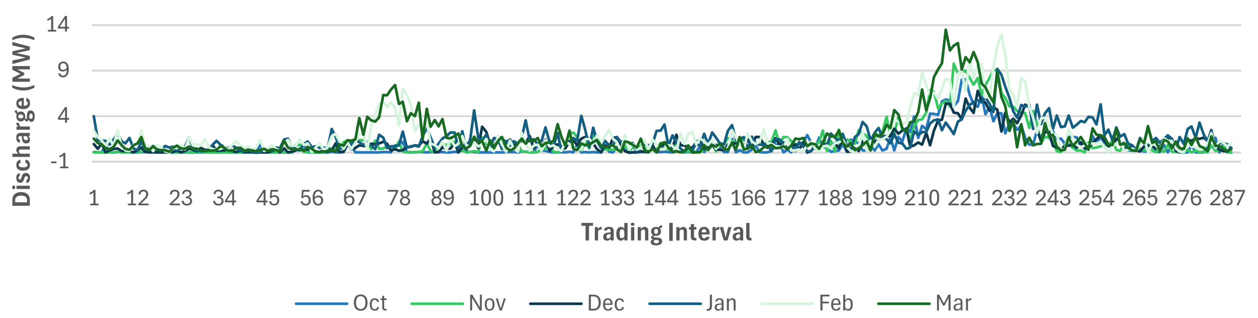
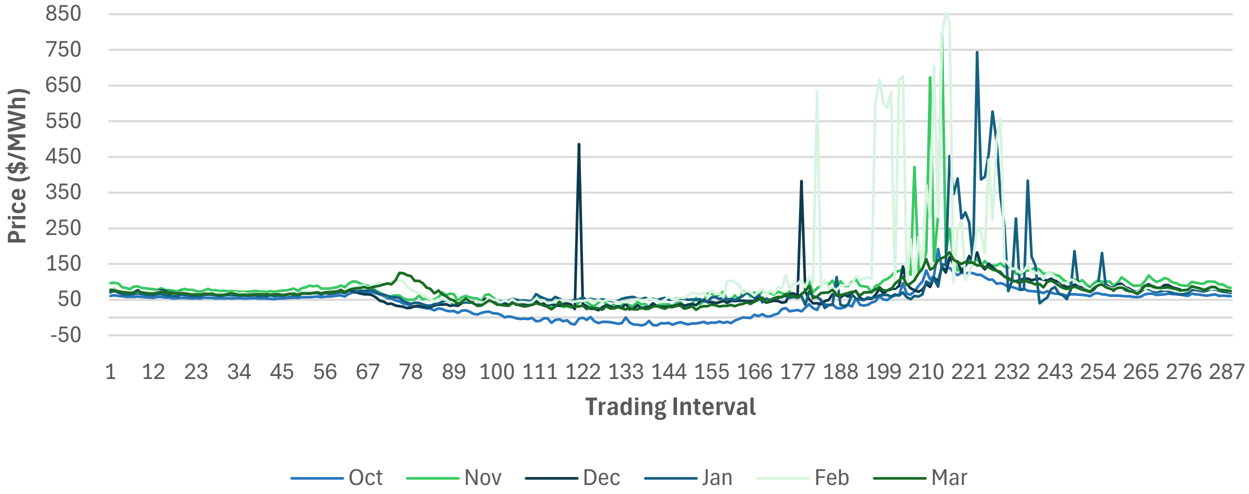


Figure 5 NSW RRP during the day per month (per 5-minute Trading Interval)



5 Safety and environmental performance

DPESS recorded no safety or environmental incidents in the 6-month period to March 2024. This is not unexpected due to the nature of the facility as well as the workplace health and safety policies adopted on site. As a company, Edify is always targeting zero incidents for the sites under our management.

The operations and maintenance contractor responsible for oversite of safety on the site has safety procedures in line with good industry practice. This includes ensuring that correct isolations are in place for works to be undertaken and using lock-out procedures to prevent unintended re-energisation. The O&M contractor reviews the work plans of any contractor doing works on the site.

The safety record of the facility reflects the inherent safety architecture aspects of the battery system that includes:

- Individual cell testing prior to module assembly to ensure flawed cells are not introduced into the battery system;
- Battery units are fully sealed to prevent thermal spread and have dedicated management systems that monitor individual cells to ensure they are operated within safe parameters;
- Batteries are contained in weather-proof steel enclosures with monitoring and operation optimised to reduce the risk of cascading failure of pods;
- Compliance with national and international safety standards; and

Exceedance of standards related to fire safety and propagation resistance to thermal runaway within individual cells.

6 Glossary of Terms

Acronym	Meaning
AEMO	Australian Energy Market Operator
ARENA	Australian Renewable Energy Agency
ARP	Advancing Renewables Program
BESS	Battery Energy Storage System
BSSA	Battery Storage Services Agreement
DPESS	Darlington Point Energy Storage System
Edify	Edify Energy Pty Ltd and its related entities
FCAS	Frequency Control Ancillary Services
FFR	Fast Frequency Response
NEM	National Electricity Market
O&M	Operations and Maintenance
Project	DPESS
RESS1	Riverina Energy Storage System 1
RESS2	Riverina Energy Storage System 2
RRP	Regional Reference Price
RTE	Round-Trip Efficiency
SCADA	Supervisory Control and Data Acquisition
SOC	State-of-Charge