Evaluation of ARENA's VPP Portfolio

Final Report

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Australian Government
Australian Renewable Energy Agency
ARENA

CutlerMerz

This report was commissioned by the Australian Renewable Energy Agency (ARENA). The report presents the findings of the CutlerMerz, which was prepared to provide an overall evaluation of ARENA's demand response portfolio in terms of the value provided to ARENA's stakeholders and the energy industry more generally and to identify lessons learned which may be applied to future programs.

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To the best of ARENA and CutlerMerz's knowledge, no actual or perceived conflict of interest exists between project personnel and the individual funding recipients assessed within the evaluation. While CutlerMerz has previously conducted reports, evaluations and other work for ARENA, CutlerMerz has not received any grant funding from ARENA.

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Acronyms and Abbreviations

Term	Definition
AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
API	Application Programming Interface
ARENA	Australian Renewable Energy Agency
AS	Australian Standard
CEC	Clean Energy Council
DELWP	Department of Environment, Land, Water and Planning
DER	Distributed Energy Resources
DNSP	Distribution Network Service Provider
DSO	Distribution System Operator
FCAS	Frequency Control Ancillary Services
IEC	International Electrotechnical Commission
IED	Intelligent Electronic Device
IEEE	Institute of Electrical and Electronics Engineers
NZS	New Zealand Standard
PV	Photovoltaic
SA	South Australia
SAPN	South Australia Power Network
SCADA	Supervisory Control and Data Acquisition
VPN	Victorian Power Networks
VPP	Virtual Power Plant

Executive Summary

Background

As the penetration of renewable energy continues to make inroads into Australia's energy system, novel ways to manage the delivery of secure, affordable, sustainable and reliable electricity are required. Australia has embarked on a distributed energy transformation where distributed energy resources (DER) could provide 13% to 22% of total underlying annual new energy consumption by 2040[1]. The challenge remains on how to maximise the benefits to consumers who invest in DER technologies whilst ensuring the power system remains secure, reliable and affordable for all consumers.

Virtual Power Plants (VPPs) are being developed with support from the Australian Renewable Energy Agency (ARENA) to meet this need. VPPs an aggregation of resources (such as decentralised generation, storage and controllable loads) coordinated to deliver services for power system operations and electricity markets, traditionally provided by centralised power plants.

Since 2014, ARENA has been investing in VPPs to support the growth of technical expertise and development of commercial models to increase their scale and sophistication. ARENA's VPP portfolio consists of 11 projects located in four states. These projects vary from high volumes of individual plants operation within Australia's National Electricity Market (NEM), to a limited number of systems operating in islanded microgrid environments.

With most of the 11 projects now completed or nearing the end of their contract, ARENA has engaged CutlerMerz to undertake an evaluation of the portfolio of projects in terms of the value provided to ARENA's stakeholders, the energy industry and the wider public as well as to identify lessons learned which may be applied to future programs.

Evaluation Summary

Overall, CutlerMerz considers that the ARENA funding of its portfolio of VPP projects was appropriate, effective, and efficient.

There is clear evidence that the portfolio of projects is appropriate in meeting ARENA's legislative objectives and contributing to the expected results set out in the performance framework. The funding helped support the development of a portfolio of projects that increased the competitiveness of VPPs and the renewable energy technologies supporting them. Similarly, ARENA deployed funding to support the supply of hardware and actively increased the supply of renewable energy in Australia. Additionally, the portfolio supported projects within both industry and universities, and in doing so, helped drive collaboration and knowledge sharing.

Although the evaluation highlights that the projects were appropriate in the most part, there remain areas for improvement. Firstly, there was no clear overarching strategy for how and why ARENA selected the VPP projects as appropriate. The amount of private sector capital mobilised could have been larger. This is reflected in the leverage ratio of ARENA to private sector funding falling below the target in 6 of the 11 projects.

The portfolio of projects was effective in validating VPP technologies and testing the VPPs' ability to access market benefits. In part, this was achieved through ARENA's funding strategy of progressively investing in VPP projects rather than a single funding round. This meant that support was available for technology innovators when required in a rapidly changing market. This allowed projects to learn from one another over time. It is suggested that such a strategy was effective for VPPs due to their inherent technical complexity, complex stakeholders' interactions and the early stage in which ARENA commenced supporting VPP projects. IF ARENA elected to support VPP technologies later in their development curve in Australia, then a single funding round may have been appropriate.

Importantly, the projects validated the ability of VPPs to access and effectively participate in Frequency Control Ancillary Services (FCAS) markets and provide network benefits. The outcomes of the test FCAS market, has informed

[1] AEMO (2020) 'Integrated System Plan', https://aemo.com.au/-/media/files/major-publications/isp/2020/final-2020-integrated-system-plan.pdf?la=en&hash=6BCC72F9535B8E5715216F8ECDB4451C

the development of AEMO's Market Ancillary Services Specification (MASS)[2] which we estimate has brought forward access to the FCAS market for VPPs by approximately 3 years.

As would be expected, ARENA's funding was focused on South Australia where the uptake of DER is high, network and system issues from high penetration renewable energy are emerging, and the need for VPP technologies is the greatest. The outcome was an organic accumulation of funding subsidies for batteries, allowing customers to "shop around for home battery installations. It also meant a build-up of expertise in the state, which need not be problematic, so long as the learnings from the state are actively shared across Australia.

The use of funding to deploy behind the meter batteries and integrate with network VPP software was viewed by some stakeholders as having provided an unequal advantage to certain VPP operators. In this context, and moving forward, a concerted effort should be made to ensure the benefits and lessons are shared broadly.

The evaluation of the VPP portfolio validated that ARENA's coordination of the portfolio was efficient resulting in high levels of satisfaction from the funding recipients relative to level of investment. In particular, ARENA's flexibility to adjust to the dynamic changes in the projects proved valuable to the funding recipients.

Overall, while the program was efficient and effective, few direct quantifiable benefits were able to be identified. Markets for VPPs remain in the very early stages and are not yet operational without government support. This is partly due to the costs of battery storage which remains prohibitively high for wide-scale investment by individual customers. Notwithstanding, the evaluation identified that the trials have likely brought forward the potential for VPPs to participate in FCAS markets by approximately three years, owing to the specific investment in developing and testing of this particular service. Other benefit streams, and network benefits in particular, remain largely inaccessible to VPPs.

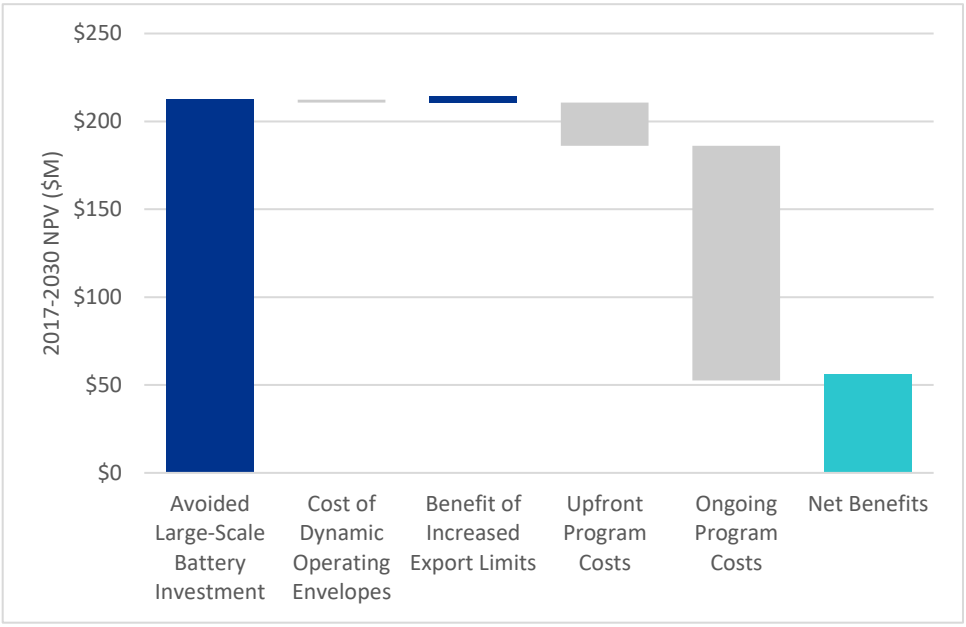
A quantitative cost benefit assessment (CBA) was undertaken specific to the key portfolio outcome of bringing forward an FCAS market for VPPs by three years as well as co-benefits of increasing export limits for behind the meter DER. Importantly, where VPPs can effectively participate in FCAS markets, it may avoid the capital cost of deploying large scale batteries to provide FCAS services. The avoided cost of large-scale battery investment accounts for the majority of the total benefits, with the benefits of increased export limits only marginally providing additional benefits in comparison[3]. Overall, the resulting Benefit Cost Ratio (BCR) comparing the total benefits of bringing forward VPPs by three years to the total costs over the modelled period is 1.35[4].

[2] AEMO (2020) 'Market Ancillary Service Specification', https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2020/primary-freq-resp-norm-op-conditions/market-ancillary-services-specification---v60.pdf?la=en&hash=4E46BE456C8D1DEAF12D0FF922DE4DBA

[3] We note that applying dynamic operating envelopes would have additional benefits that are not included in this CBA, including reduced curtailment of solar PV customers that are not participating in a VPP and increasing hosting capacity within the network to allow additional take up of distributed energy resources.

[4] We note that there are additional costs that are not quantified and thus not included in this CBA, please see Section 5.5 for more information.

Figure 1 – NPV of VPP Costs and Benefits from 2017 to 2030 (With ARENA Funding Scenario)



Evaluation Against Criteria

For the purposes of the evaluation, CutlerMerz identified a suite of evaluation criteria in terms of the appropriateness, effectiveness, and efficiency of the portfolio of projects, the outcomes of which are provided in Table 1 below.

Elements of the appropriateness evaluation did not fully meet the criteria. As no overarching strategy was in place, it is challenging to identify why each of the projects were selected as appropriate and what technical and commercial gaps each project was due to fill. Additionally, leveraging investment from the private sector could have been improved.

Similarly, elements of the portfolio design were inadequate for all effectiveness criteria to be fully met.

Importantly, the efficiency with which the portfolio was delivered fully met the evaluation criteria.

Table 1 – VPP Portfolio – Evaluation Summary

Appropriateness	
Overall, the VPP projects assessed are appropriate in terms of meeting ARENA's legislated objectives	Fully meets the criteria
Overall, the VPP projects assessed are appropriate in terms of meeting ARENA's Performance Framework	Partially meets the criteria
Overall, the frequency of reporting required (milestones, finances and knowledge sharing) under the funding agreement was appropriate	Fully meets the criteria
Effectiveness	
The VPP projects captured the broad range of value streams available to VPPs	Partially meets the criteria
A qualitative assessment suggests the technology readiness level (TRL) of the VPP technology has progressed as a result of the ARENA funding	Fully meets the criteria
A qualitative assessment suggests the commercial readiness index (CRI) of the project technology has progressed as a result of the ARENA funding	Fully meets the criteria
The funding provides 'good' coverage of the DER Technology Integration Functional Framework functional areas which are applicable to VPPs	Fully meets the criteria
Overall, the knowledge sharing activities enhanced the competitiveness of renewable energy technologies	Fully meets the criteria

Overall, knowledge sharing activities better informed the public about renewable energy technologies and the role they can play in Australia's energy transition	Fully meets the criteria
Overall, ARENA's responsiveness to communications with funding recipients was effective	Fully meets the criteria
Overall, the timeliness of the milestones / progress report assessment process was effective	Fully meets the criteria
Efficiency	
The total net benefits /MW VPP capacity delivered appears to be efficient relative to benchmarks	Partially meets the criteria
Portfolio participants (including funding recipients, DNSPs and AEMO) believe that the projects were efficiently delivered by ARENA	Fully meets the criteria

Recommendations

Appropriateness

- There was no documentation to suggest that ARENA had an overarching strategy to guide development of ARENA's VPP portfolio and justify how and why VPP projects were selected as appropriate. This resulted in funding recipients being uncertain on how their project 'fit' within the broader VPP strategy. Although this report notes that developing a clear 'roadmap' is challenging in developing technologies such as VPPs it could provide certain advantages.
    - A VPP strategy may better guide ARENA in electing projects that resolve VPP technical or commercial gaps. In doing so, more appropriate projects may be selected resulting in more effective delivery to meet ARENA's legislative and performance objectives.
    - A VPP strategy will inform funding recipients and the wider market. The benefit of doing so will help flag the projects with which they can gain learnings. Importantly, it will also allow the broader market to develop products and solutions to meet the technical and commercial knowledge gaps. Similarly, as technology solutions to enable microgrids continue to evolve, a guiding strategy for investment in impactful microgrid technologies will be beneficial for both ARENA and future funding recipients.
    - The evaluation identified the benefits workshops and industry steering groups provided knowledge sharing and guiding industry. ARENA has continued to improve in helping steer these knowledge sharing requirements in its contracts with funding recipients. It is recommended that ARENA continue to identify and leverage the knowledge sharing activities and maximise value such as the workshops and industry steering groups.
- As VPPs' are a developing technology, ARENA must balance investment in less commercially mature projects that require a higher percentage of ARENA funding with more commercially mature projects that attract a higher percentage of private sector investment. When electing which projects to invest, it is recommended that ARENA balance investment with commercial maturity to help attract an appropriate level of investment from private sector. Developing a risk / cost KPI may be a more appropriate metric than the 'project leverage' KPI presently used by ARENA.

Effectiveness

- This report notes that although the ARENA funding has made great strides in the development of technologies and commercial models to enable VPP, some clear barriers remain. Notably the findings of this evaluation suggest that there is inherent conflict of thought between how network businesses and AEMO believe VPP's should be managed. AEMO will continue to work towards a centralised bidding platform yet networks may be resistive to such a model. To effectively transition the market to a single and uniform model, ARENA may play a role in helping identify technologies and projects that help support a common bidding and governance framework.

- Another challenge for the industry will be standards for operability to ensure platforms for VPP aggregation are technology agnostic. That is, to help ensure all technologies and platforms can be integrated with one another. Doing so shall help maintain an open market in which companies can participate, generate competition and drive down prices for consumers. Although no solution is provided here, ARENA should be cognisant of continuing to provide funding to projects that support technology interoperability.

- The VPP projects resulted in a disproportionate percentage of funding in South Australia. Though appropriate for the time, ARENA should consider how to share the learnings from South Australia to efficiently support the update of VPP's in other jurisdictions.

1. Introduction

1.1 Background

With an aim to improve the competitiveness of renewable energy technologies and increase the supply of renewable energy, the Australian Renewable Energy Agency (ARENA) has in recent years funded innovative trials of virtual power plants (VPPs). A VPP broadly refers to a group of resources that are coordinated using software and communications technology to deliver services traditionally performed by a conventional power plant. In Australia, grid connected VPPs focus on coordinating rooftop photovoltaic (PV), battery storage and controllable load devices.[5]

With most trials now completed or nearing the end of their contract, ARENA has engaged CutlerMerz to undertake an evaluation of the appropriateness, effectiveness and efficiency of its VPP portfolio.

1.2 Objectives and Scope

The objectives of this assignment are to:

- Evaluate the appropriateness of ARENA's VPP portfolio by the extent to which the trials contribute to ARENA's legislative purpose and to the expected results set out in ARENA's Performance Framework.
- Evaluate the effectiveness of ARENA's VPP portfolio in advancing the technology and commercial maturity of Distributed Energy Resources (DER) and their full technical and market integration. This includes evaluating, both qualitatively and quantitatively, the potential impact of broad take up of the VPP technologies trialled as well as modelling projected benefits from ARENA's portfolio of VPP projects under reasonable scenarios.
- Evaluate the efficiency of ARENA's co-ordination with the Australian Energy Market Operator (AEMO) and State governments as well as the efficiency in terms of inputs and outcomes.

The scope of this assignment is the evaluation of ARENA's VPP portfolio which includes a sample of six VPP projects and five microgrid projects. Each project's high-level scope and their associated ARENA funding page is given in Table 2 below.

[5] ARENA, 2019: https://arena.gov.au/projects/aemo-virtual-power-plant-demonstrations/

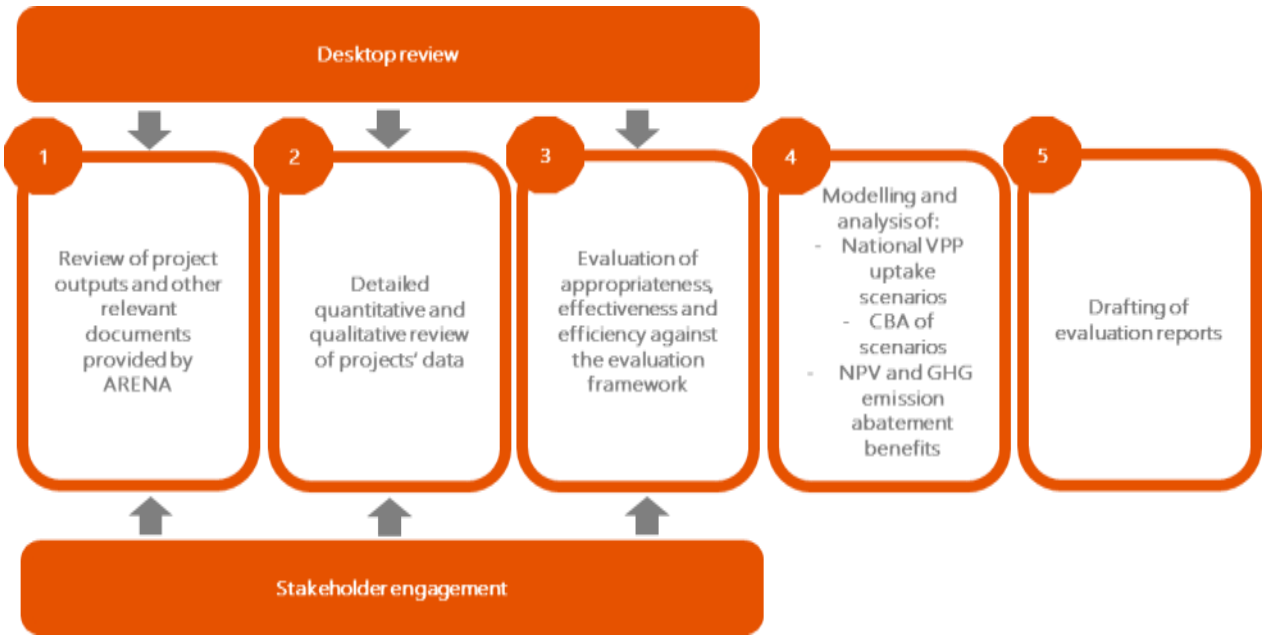
Table 2 – High Level Project Scope

Project Type	Project	High Level Project Scope	ARENA Project Page
NEM VPP	AEMO's Virtual Power Plant Demonstrations	Delivering operational data from VPPs to AEMO, and providing an evidence base to inform changes to regulatory settings or AEMO operational processes	AEMO
	AGL's Virtual Power Plant	Network of 1000 cloud-controlled residential premises that operates as a 5 MW VPP	AGL
	Ergon's New Residential Solar PV and Battery Model	Demonstrated a commercial and operational model for providing grid-connected solar PV and battery storage systems for 33 systems in three Queensland towns	Ergon
	SAPN's Advanced VPP Grid Integration	Standardised Application Programming Interface (API) to enable dynamic export limits	SAPN
	Simply Energy's Virtual Power Plant	6 MW of residential energy storage, with ten commercial businesses networked to deliver a further 2 MW of demand response capacity.	Simply Energy
	Tesla's Virtual Power Plant	Deployment of behind the meter batteries to test aggregation of batteries as an operating VPP	Tesla
Microgrid VPP	Curtin University's Solar PV in Strata Residential Developments	Behind the meter energy management in apartments	Curtin
	Horizon Power's Business Model Pilot Phase 1	Exploring the most economically efficient ways to design and manage a future grid to maximise solar energy contributions	Horizon Power
	Indra Monash's Smart City	Monitoring and control of distributed energy resources to access market benefits	Monash
	LO3 Energy's Latrobe Valley Microgrid Feasibility Study	Feasibility study into blockchain enabled marketplace for peer-to-peer energy trading	LO3
	Synergy's Solar and Storage Trial at Alkimos Beach Residential Development.	Developing, deploying, and testing a new energy retail model for community-scale battery storage	Synergy

1.3 Approach

The approach to the evaluation followed the five-step process shown in Figure 2.

Figure 2 – Evaluation approach



As part of the stakeholder engagement step, we interviewed representatives for each of the sample projects, with the exception of Ergon Retail who declined the interview request. Additionally, we conducted meetings with ARENA staff, AEMO, the Australian Energy Market Commission (AEMC) and the Australian Energy Regulator (AER).

Qualitative data pertaining to the portfolio of projects was provided by ARENA and examined to assist in clarifying the appropriateness, effectiveness and efficiency by which the portfolio of projects was delivered.

1.4 Structure of this report

The report is structured in five parts:

- Section 1 – Introduction: sets out the objective, scope and approach to the review.
- Section 2 – VPP Portfolio Evaluation: presents the project and program evaluation frameworks as well as the outcomes assessment.
- Section 3 – VPP Portfolio Evaluation (Qualitative): present the detailed qualitative analysis of the portfolio of projects and their appropriateness, effectiveness and efficiency.
- Section 4 – Trial Impact Evaluation (Quantitative): presents the modelling assumptions and results, showing projected benefits of ARENA's funding under reasonable scenarios.
- Section 5 – Summary and Recommendations: summarises the findings and recommendations of this evaluation as well as any next steps.

2. VPP Portfolio Evaluation

2.1 Evaluation framework

An evaluation framework was developed to evaluate options in terms of how well they meet certain criteria.

Two tables were developed and used as the basis for developing three core deliverables:

- Table 11 was used to evaluate each of the individual VPP projects. The project specific evaluations are captured in Section 0.
- Table 8 was used as the evaluation criteria for the ARENA VPP portfolio as a whole. The results of Table 11 is rolled up and incorporated into Table 8 to represent the final summary of the portfolio evaluation.

The criteria were designed to take into consideration the three criteria to evaluate the portfolio through appropriateness, effectiveness, and efficiency:

1. Appropriateness – The extent to which the portfolio of projects contributes to ARENA's legislative objectives and ARENA's performance Framework.
2. Effectiveness – Evaluates the extent to which the intended outcomes are being achieved.
3. Efficiency – Evaluates the extent to which inputs are minimised to achieve the activities objectives and outcomes.

3. VPP Portfolio Evaluation (Qualitative)

The evaluation of the VPP portfolio of projects is set out below in terms of appropriateness, effectiveness and efficiency.

3.1 Appropriateness

The evaluation of the appropriateness of the portfolio of VPP projects is described below in terms of alignment with ARENA's legislative objectives and Performance Framework.

3.1.1 Legislative alignment

ARENA has two core legislative objectives, which are to improve the competitiveness of renewable energy technologies and to increase the supply of renewable energy in Australia[6]. Overall, project objectives aligned with these objectives. The ARENA-funded projects have driven innovation in VPP management and helped demonstrate value streams that can be obtained from VPPs. These projects have enabled increased integration of renewable energy sources, helping improve the technologies' competitiveness.

One aspect which could have helped bolster alignment to ARENA's legislative objectives, was an overarching strategy or roadmap towards funding for VPPs. Some funding recipients expressed through the interviews that having a roadmap to work towards would have helped them to better shape projects to meet ARENA's expectations for VPP development. Having such a roadmap would have also tied projects together, so that the relationship between each project was understood and helping clarify how each project can learn from one another.

VPPs, however, are a nascent and complex concept which may not have been mature enough to fit under an overarching strategy until recently. ARENA's funds have promoted the first VPPs in Australia, that would most likely otherwise not have proceeded at sufficient scale. These first steps produced sufficient insights and developments in the VPP space that, should ARENA continue funding VPP projects in the future, a VPP roadmap would be warranted.

3.1.2 Adherence to ARENA's Performance Framework

ARENA's 2020-21 to 2023-24 Corporate Plan[7] sets out performance measures against two key activities:

1. Provide financial assistance to Australian scientists, innovators, and businesses.
2. Increase collaboration and knowledge sharing to make information and data available to a diverse audience and help increase the spread of ideas.

With respect to the first activity, the provision of funding was allocated to projects which sought to drive innovation in VPP management and demonstrate value streams from VPPs. Feedback throughout the interviews and data gathering was that the ARENA funding helped test a range of VPP technologies and business models within both universities and

AEMO's Feedback

Without the ARENA funding, the demonstrations would not have taken place, and the level of ARENA funding enabled AEMO to provide considerable support that helped VPPs understand the capabilities required to participate in the VPP Demonstrations and FCAS markets. Participants in the AEMO project noted that the program was a good forum to develop their VPP capability, fast-tracking their technical and commercial development. AEMO also noted the value of the operational visibility that participating VPPs provided to help AEMO understand how VPPs operate and respond to energy price signals.

[6] Australian Renewable Energy Agency Act 2011, https://www.legislation.gov.au/Details/C2017C00266
[7] ARENA (2020) 'ARENA Corporate Plan', https://arena.gov.au/assets/2020/06/2023-2024-arena-corporate-plan.pdf

the private sector. As such, the investment assisted in developing the technical and commercial readiness as discussed in Section 3.2.

ARENA's corporate plan sets out a target leverage of 1:2 to 1:3 where leverage is defined below. Leverage provides the ratio of dollars invested in a project by all other sources for every $1 of funds invested by ARENA.

$$Project\ leverage = \frac{Total\ project\ cost - ARENA\ funds\ committed}{ARENA\ funds\ comitted}$$

Although funding provided financial assistance to Australian scientists, innovators, and businesses, the efficiency of that spending could have been improved. Assessment of the project funding leverage identifies that there is scope for ARENA's funding to be better matched by private sector investment to meet the current performance framework targets.

As shown in Table 3, 3 of the 11 projects achieved the target leverage of 1:2 to 1:3 and two projects exceeded the leverage target of 1:2 and 1:3. The remaining 6 projects did not achieve the target leverage of 1:2 to 1:3 however all projects garnered funding from non-ARENA sources which is positive. ARENA's leverage target is lower than the Government's target under the First Low Emissions Technology Statement[8] as ARENA is an early-stage technology investor.

The leverage performance target only focuses on ARENA's contribution of funding. This report recommends that there may be value in considering the leverage of public to private sector investment. Such a measure would help flag whether projects are being subsidised by both ARENA and other government departments. The SA Government's battery subsidies, for example, led to an accumulation of funding grants within South Australia that impacted customers' decision making, allowing customers to 'shop around' for discounted batteries. Balancing investment between the private sector and public sector (as a whole) may help improve value for money for the Australian public.

Table 3 – VPP project leverage

Project	Project Investment Leverage
Tesla's Virtual Power Plant	1:6.83
Ergon's New Residential Solar PV and Battery Model	1:5.55
AGL's Virtual Power Plant	1:2.84
Horizon Power's Business Model Pilot Phase 1	1:2.69
Simply Energy's Virtual Power Plant	1:2.08
Curtin University's Solar PV in Strata Residential Developments	1:1.88
SAPN's Advanced VPP Grid Integration	1:1.41
Indra Monash's Smart City	1:1.41
LO3 Energy's Latrobe Valley Microgrid Feasibility Study	1:1.41
Synergy's Solar and Storage Trial at Alkimos Beach Residential Development	1:1.03
AEMO's Virtual Power Plant Demonstrations	1:0.98

In terms achieving the expected results for ARENA's second key activity, the projects made a strong contribution to helping increase the spread of ideas among interested stakeholders, mostly within or related to the industry. This was chiefly by design, with contractual agreements specifying comprehensive knowledge sharing plans that ensured increased collaboration and knowledge sharing within industry and beyond such as regulators, government and universities.

[8] Australian Government, Department of Industry, Science, Energy and Resources. 2020; https://www.industry.gov.au/sites/default/files/September%202020/document/first-low-emissions-technology-statement-2020.pdf

3.1.2 Summary (Appropriateness)

A summary of the appropriateness evaluation against the criteria is set out in Table 4 below.

Table 4 – Appropriateness Evaluation

Criteria	Evaluation
Appropriateness	
Overall, the VPP projects assessed are appropriate in terms of meeting ARENA's legislated objectives	**Fully meets the criteria** Overall, project objectives clearly align to ARENA's legislative objectives to improve the competitiveness and increase the supply of renewable energy technologies. In Australia, grid connected VPPs focus on coordinating rooftop photovoltaic (PV), battery storage and controllable load devices to deliver services traditionally performed by a conventional power plant. The ARENA-funded projects have driven innovation in VPP management and helped demonstrate value streams that can be obtained from VPPs. These projects have enabled increased integration of renewable energy sources, helping improve the technologies' competitiveness.
Overall, the VPP projects assessed are appropriate in terms of meeting ARENA's Performance Framework	**Partially meets the criteria** Overall, the VPP projects largely met ARENA's Performance Framework, with some clear exceptions. ARENA funds have the potential to promote more competitive renewable energy choices for Australian consumers and businesses. However, the amount of financial assistance for 7 out of 11 of the projects fell outside ARENA's target leverage ratio with private contributions falling short in 7 out of 11 projects. With regards to the impact of knowledge sharing, the projects made a strong contribution to helping increase the spread of ideas among interested stakeholders, mostly within or related to the industry. The extent to which knowledge reached the wider public is unclear.
Overall, the frequency of reporting required (milestones, finances and knowledge sharing) under the funding agreement was appropriate	**Fully meets the criteria** The frequency of reporting was overall sufficient and appropriate, with reports tied to project milestones. Interviews revealed that the frequency of reporting was appropriate for all but one project. Overall, however, all other projects had the right frequency of reporting so from a portfolio perspective this criterion was met.

3.2 Effectiveness

The evaluation of the effectiveness of the portfolio of VPP projects is described below in terms of the extent to which the portfolio accelerated the development of a market for VPP services and delivered benefits to stakeholders including customers and the wider public.

3.2.1 Accelerated Development of the VPP Market

A clear theme from the stakeholder interviews was that ARENA's funding triggered VPP trials to go ahead and, in several cases, enabled projects of greater scale and depth. As such, these projects allowed funding recipients to accelerate the development of VPP technologies and test their commercial feasibility.

The ARENA funding resulted in three broad outcomes that helped accelerate the VPP market:

- Early-stage development of a VPP market – ARENA's funding came at a time when a VPP market was not yet defined and poorly developed. While this continues to be true in many respects, ARENA's funds have helped the industry develop and test both VPP technologies as well as commercial models. Importantly, the project funding allowed technology developers to test the markets in which VPPs could participate, and the technologies required to enable it. ARENA's funds have helped industry take its first steps towards establishing a VPP market in Australia.

- Internal commitment – ARENA's project timeframes and milestone payments encouraged organisations to commit resources for an extended timeline to achieve the scope. This gave funding recipients the necessary continuity and momentum to push projects, as innovative and experimental in nature as these, through the commercialisation phases.

- ARENA credibility – The funding provided credibility to the funding recipients both internally and externally. Internally, the milestones developed by ARENA helped drive internal approvals and subsequently the development of the projects. Externally, the credibility of ARENA's name and participation in the projects facilitated engagement with project partners and was a tool which organisations could use to promote their brand.

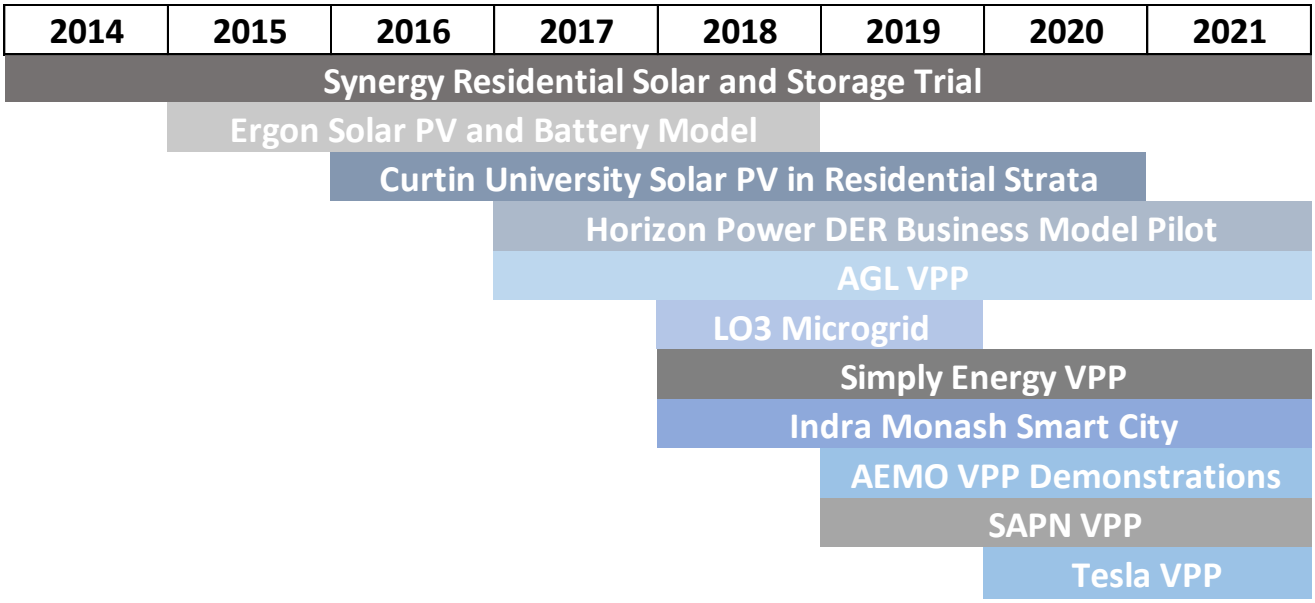
Industry Stakeholder's Feedback

A lot has been learned in the VPP space in the last few years. It would be hard to criticise ARENA for the approach taken to fund projects individually rather than applying a funding round approach (as was performed for the ARENA Demand Response Trial). VPPs are complex, developing technology and involves several parties working together to generate value. It therefore makes them less suited to a funding round with rigid structures and expectations. ARENA has been able to continue to learn and assist VPP technologies over recent years through running VPP funding in an iterative manner.

3.2.2 Benefits through progressive project learnings

There is clear evidence that the VPP projects built off the learnings of previous projects to enable progressive development testing of the different value streams accessed by VPPs. Figure 3 shows the timeline of each of the 11 projects within ARENA's VPP portfolio.

Figure 3 – Timeline of VPP projects



Firstly, it was noted throughout the interviews that the VPP projects did in fact build off one another. For example, the AGL VPP projects helped inform the Simply Energy VPP project, and there was a clear link that the Simply Energy project informed the SAPN VPP project. Both the AGL and Simply Energy projects deployed batteries in homes and tested VPPs. These projects encouraged AEMO to establish the VPP Demonstration project that aimed to provide visibility of VPPs to AEMO. Finally, anecdotally, several the ARENA VPP projects informed AEMO's Project EDGE[9] and WA's Project Symphony[10] which is the latest series of DER and VPP projects.

Secondly, the series of projects funded by ARENA continued to develop and test increasingly complex market benefits:

- The Synergy project (2014) and the Curtin University project (2016) worked to enable batteries to access wholesale market benefits for batteries.
- The AGL VPP project (2017), Simply Energy VPP (2018) and AEMO VPP Demonstration (2019) tested VPP's ability to access the FCAS market.
- The SAPN VPP project (2019) tested dynamic export limits helps to leverage the benefits of both wholesale market arbitrage and FCAS markets.

Network services benefits were also tested within the projects, however the funding recipients were unable to capture the market benefits due to lack of density of behind the meter batteries around network assets.

Although there are progressive learnings within ARENA's portfolio of VPP projects, this report suggests that there are means to further enhance the effectiveness of the VPP portfolio. These include the following:

- Despite the complexity of VPPs, a strategic roadmap that sets out the path for development of VPP technologies would help guide project implementation. Additionally, it may assist in ensuring the most appropriate projects are selected to meet the objectives of the VPP roadmap.
- There was a perception from some of the funding recipients that there was no clear plan for how the lessons attained throughout the project would be carried forward to further develop the VPP market. There may be value in ARENA establishing an interim project assessment, mid-way through the project funding to assess whether there is value in extending funding with the current project or pivoting from the lessons acquired to develop another project that better aligns to the VPP roadmap. Doing so may help leverage the learnings of particularly successful projects to ensure the learnings are carried forward and not lost on project completion.

3.2.3 Benefits for technological and commercial development

Technological Readiness

As the VPP portfolio of projects has grown organically over the last 7 years, the technologies tested have varied greatly. All projects advanced the technologies tested within the scope of the project; however, it is the view of this evaluation that the technical developments of certain projects will prove more impactful than others.

SAPN's Advanced VPP Grid Integration serves as an example of an impactful project. There are two core functions that resulted in the project being effective in developing VPP technologies. Firstly, the outcomes of the project were to develop a technical solution (standard API) that could be adopted by other jurisdictions and also be technology agnostic (any VPP operator can integrate with the API). Secondly, the project utilised existing hardware in the market, thus the funding could be effectively applied to developing technology, rather than deployment of established battery hardware.

Similarly, the AEMO VPP Demonstrations are likely prove to be effective in developing the technologies to enable adoption of VPPs. The technical learnings include the accuracy of a VPP operator's ability to forecast their capability

[9] AEMO Project EDGE, https://aemo.com.au/en/initiatives/major-programs/nem-distributed-energy-resources-der-program/der-demonstrations/project-edge
[10] AEMO Project Symphony, https://aemo.com.au/en/initiatives/major-programs/wa-der-program

which allowed AEMO to improve accuracy of their forecasts and better manage integration of VPPs into the NEM. This results in technical developments that benefit a broader range of VPP operators. Additionally, the outcomes of the AEMO VPP Demonstrations have informed the Market Ancillary Service Specification (MASS)[11], providing wider technical policy outcomes.

Conversely, there are perceptions within the market that ARENA's funding of certain projects provided technology providers a disproportionate advantage in the market.

Commercial Readiness

ARENA's portfolio of VPP projects helped improve the commercial readiness of the VPP technologies. However, there are still clear commercial barriers remaining to mass market adoption of operating VPPs.

As discussed in Section 3.2.2, ARENA's portfolio of VPP projects tested and validated that VPPs can access the benefits of arbitraging in the wholesale market and participating in the FCAS market. The projects confirmed that at present, VPPs were unable to access network benefits due to the lack of density of VPPs around network assets. Anecdotally, FCAS is now established as the dominate source of value for VPPs.

Retailers are now starting to deploy VPPs within their business as usual. For example, AGL has now incorporated VPPs into their service offering to customers, offering a $1,000 participation discount, albeit customers need to have their own batteries.

However, limitations remain with accessing the FCAS market as the AEMO Demonstrations required a minimum capacity of 1MW to participate in the FCAS market. As such, VPP operators must have a minimum capacity of deployed batteries before these market benefits can be access which may slow early-stage market development. This is especially true given the high upfront cost of purchasing and installing behind the meter batteries. The portfolio of VPP projects validated that the benefits that a VPP is presently able to access is insufficient to justify the capital expense of deploying behind the meter battery to capitalise on VPP benefits. Therefore, present battery costs remain prohibitive for a rapidly developing VPP market.

However, the commercial models are still of value as consumers are expected to continue to install batteries to access non-VPP benefits such as to reduce solar spillage resulting in reduced self-consumption. Additionally, VPP technology has the potential to be applied to additional asset types including residential hot water load control, vehicle to grid and future behind the meter storage technologies. The development of such technologies will assist in improving the commercial readiness of the broader VPP market.

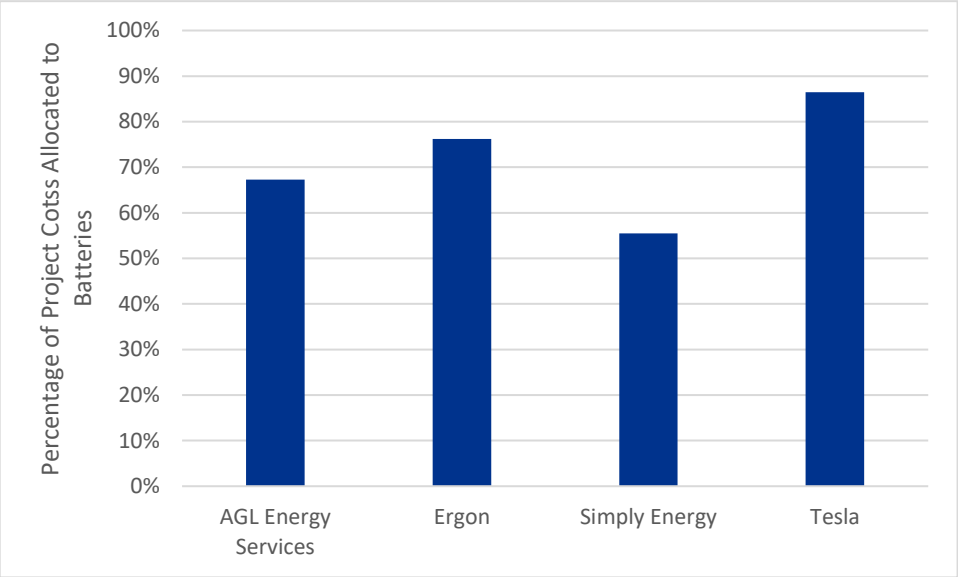
3.2.4 Accumulation of Benefits in South Australia

The ARENA VPP portfolio resulted in a concentration of benefits in the South Australian market. Projects that deployed batteries at scale to test aggregation of behind the meter batteries as a VPP needed to initially deploy the batteries to consumers' homes. As a result, a high percentage of the project costs were allocated to the hardware and installation of batteries and associated technologies[12]. In the case of the Tesla VPP project, the battery costs comprised approximately 86% of the total project cost. The proportion of project costs allocated to the deployment of batteries in the AGL, Ergon, Simply Energy and Tesla projects is shown in Figure 4.

[11] AEMO, Market Ancillary Service Specification consultation. https://aemo.com.au/en/consultations/current-and-closed-consultations/mass-consultation

[12] This includes solar PV systems and home energy management systems in some projects.

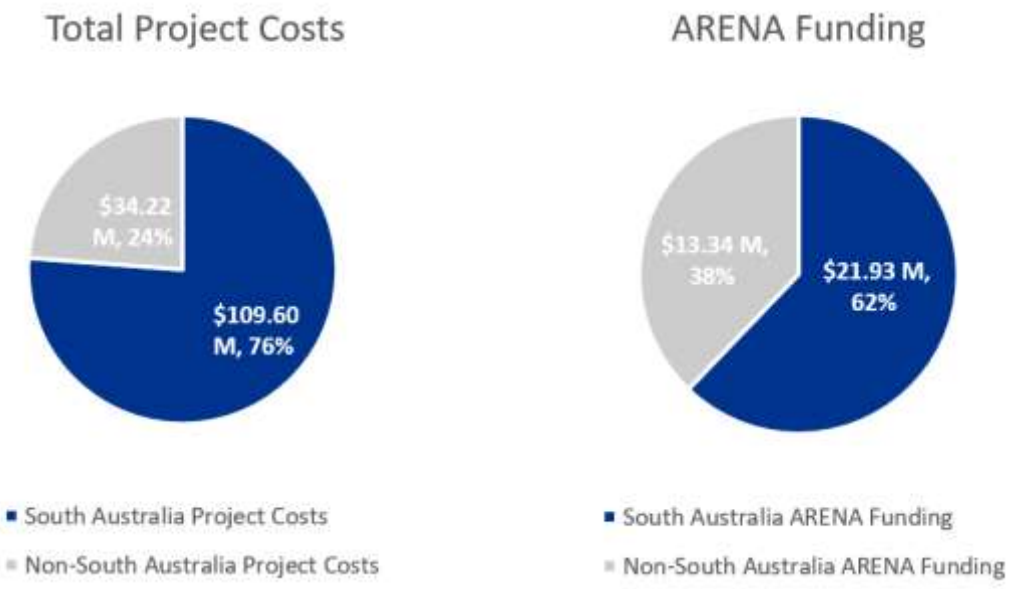
Figure 4 – Percentage of Project Costs Allocated to Batteries



There are two key implications of high levels of investment in South Australia. Firstly, it resulted in an aggregation of battery subsidies in South Australia where the AGL, Simply Energy and Tesla VPP projects were implemented. Though South Australia is the region where demand for storage technologies is the greatest, the ARENA funding instead largely supported deployment of existing battery technologies allowing customers to 'shop around' for battery subsidies. Though beneficial for customers, it could be argued that there are more effective means to deploy funding given the present price point of batteries.

Secondly, as 76% of the total project costs and 62% of ARENA's funding was allocated to South Australia, there is risk of knowledge being limited to South Australia.

Figure 5 – Percentage of Total Project Costs (left) and ARENA Funding (right) Allocated to South Australia



3.2.5 Summary (Effectiveness)

Evaluation of the portfolio of DR projects' effectiveness is given in Table 5 below.

Table 5 – VPP portfolio evaluation – Effectiveness

Criteria	Evaluation
Effectiveness	
The VPP projects captured the broad range of value streams available to VPPs	**Partially meets the criteria** The trials provided a strong learning opportunity of the value streams available but given the innovative and experimental nature of the projects, funding recipients encountered challenges in realising some of the benefits. However, the acquisition of knowledge to better understand the barriers to obtaining benefits was in and of itself beneficial and helped fast-track the industry towards overcoming such barriers.
A qualitative assessment suggests the TRL of the VPP technology has progressed as a result of the ARENA funding	**Fully meets the criteria** Overall, the TRL of the VPP technologies has progressed as a result of the ARENA funding. This was driven by specific projects rather than across the portfolio. Several projects contributed to materially advancing the TRL of VPP technologies and supporting systems. Given the less commercially mature nature of VPP technologies and, it would not be unusual for some projects 'fail' and not advance the technologies. However, the increase in technical complexity of projects over the course of the ARENAs funding period suggests a step change in technical development.
A qualitative assessment suggests the CRI of the project technology has progressed as a result of the ARENA funding	**Fully meets the criteria** Overall, the CRI of the VPP technology has progressed as a result of the ARENA funding. This is driven by specific projects rather than across the portfolio. Several projects were able to demonstrate the commercial value of the VPP technology and have incorporated the service offering into business-as-usual activities or are pursuing further commercial ventures following the trials. Importantly, the projects also tested and identified commercial models that weren't effective. Additionally, key projects tested and validated new revenue streams such as FCAS.
The funding provides 'good' coverage of the DER Technology Integration Functional Framework functional areas which are applicable to VPPs	**Fully meets the criteria** Overall, there is good coverage of the relevant functional areas within the DER Technology Integration Functional Framework. 6 of the 11 projects have been mapped to the DER Technology Integration Functional Framework within the State of Distributed Energy Resources Technology Integration Report (2021)[13]. All 13 Functional Areas within the framework are covered within AEMO's portfolio of projects.
Overall, the knowledge sharing activities enhanced the competitiveness of renewable energy technologies	**Fully meets the criteria** There is clear evidence of the knowledge sharing activities of most projects enhancing the competitiveness of renewable energy technologies. The trials provided a strong learning opportunity on designing and operating VPPs that are feasible from a technical, financial and regulatory standpoint. The costs, benefits and barriers to VPPs were explored with an aim to improving the business case for VPPs, which in several cases was achieved. Overall, the trials were informative in growing the VPP market and provided valuable insights to industry.
Overall, the knowledge sharing activities better informed the public about renewable energy technologies and the role they can play in Australia's energy transition	**Fully meets the criteria** The knowledge sharing activities informed interested parts of the public about renewable energy technologies. Stakeholders such as network service providers, market bodies, energy retailers and universities were exposed to project findings through ARENA's knowledge sharing events and requirements, such as industry webinars and conferences as well as publication of milestone reports.

[13] ARENA, 2021: https://arena.gov.au/knowledge-innovation/state-of-der-technology-integration/

Criteria	Evaluation
Overall, ARENA's responsiveness to communications with funding recipients was effective	**Fully meets the criteria** Stakeholder interviews overwhelmingly indicated that interactions with ARENA were constructive, with ARENA responding very well to any queries from funding recipients. Funding recipients consider ARENA easy to engage with and a source of valuable support.
Overall, the timeliness of the milestones / progress report assessment process was effective	**Fully meets the criteria** Milestone / progress reports were for the most part tied to project milestones, which was considered timely.

3.3 Efficiency

The evaluation of the efficiency of the portfolio of VPP projects is described below in terms of ARENA's efficiency in delivering the portfolio and the overall efficiency of the projects and portfolio in delivering VPP services.

3.3.1 ARENA's Portfolio Delivery

ARENA capably delivered the VPP portfolio, managing interactions with funding recipients efficiently. Feedback received from funding recipients indicated a high level of satisfaction in the way ARENA managed communications, responding to queries and providing support where needed in a timely manner. ARENA's flexibility to accommodate for change was valued as a critical aspect of the successful delivery of projects.

Horizon Power's Feedback

The partnership with ARENA was absolutely brilliant. ARENA provided good opportunities for Horizon Power to present to industry and create relationships with others. Throughout the project ARENA maintained fluid communications, ensured milestone payments were made in a timely manner, turned reports around quickly and provided relevant feedback. Overall, ARENA was great to work with.

Contract drafting and signing was an area where some funding recipients suggested improvements could be made. The time taken between awarding a project and having a signed funding agreement was considered to be unnecessarily lengthy in some cases, with ARENA's processes for sign-off proving cumbersome for funding recipients. However, inefficiencies that were apparent in the contracts were alleviated by ARENA's flexible approach to resolving problems.

The level of engagement required to meet ARENA's requirements and manage projects represented a significant cost to some funding recipients, in particular start-ups. ARENA should consider ways in which it can alleviate the time and effort needed to meet requirements to avoid deterring eligible businesses from accessing funding.

3.3.2 Efficiency in the Allocation of Funding

As the portfolio of projects within the VPP trial varied greatly in scope and objectives, only a selected number of projects have been quantitatively benchmarked to assess the efficiency of their respective project funding[14]. These are primarily projects that focused on deploying batteries to establish, develop and test VPP aggregation and control functionality. As such, the annual project funding on a per MW of VPP deployed basis is shown in Figure 6. These projects were benchmarked against the per MW cost of a large-scale battery system to reflect the cost of a

[14] We have excluded quantitatively benchmarking projects which did not have a material quantitative outcome, including those that were primarily research-based or aimed to develop governance frameworks or standards.

comparable technology which can provide similar services. On average between the projects, deploying and operating a VPP costs approximately $844,200 per MW of capacity.

Figure 6 shows the total annual project cost, including any subsidy provided by the funding recipient to the customers participating in the program, not the total battery cost.

Figure 6 - Annual project costs including subsidies for hardware costs ($/MW)

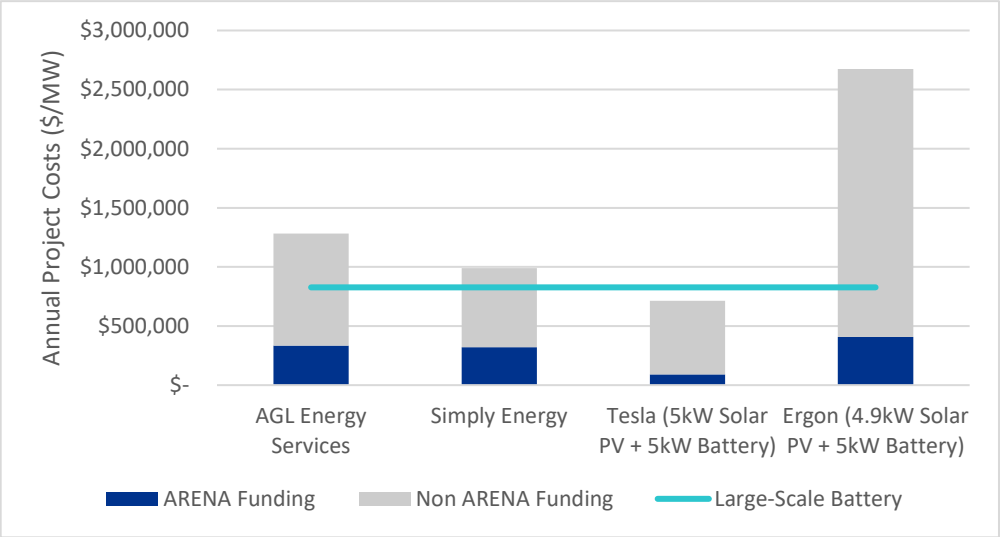
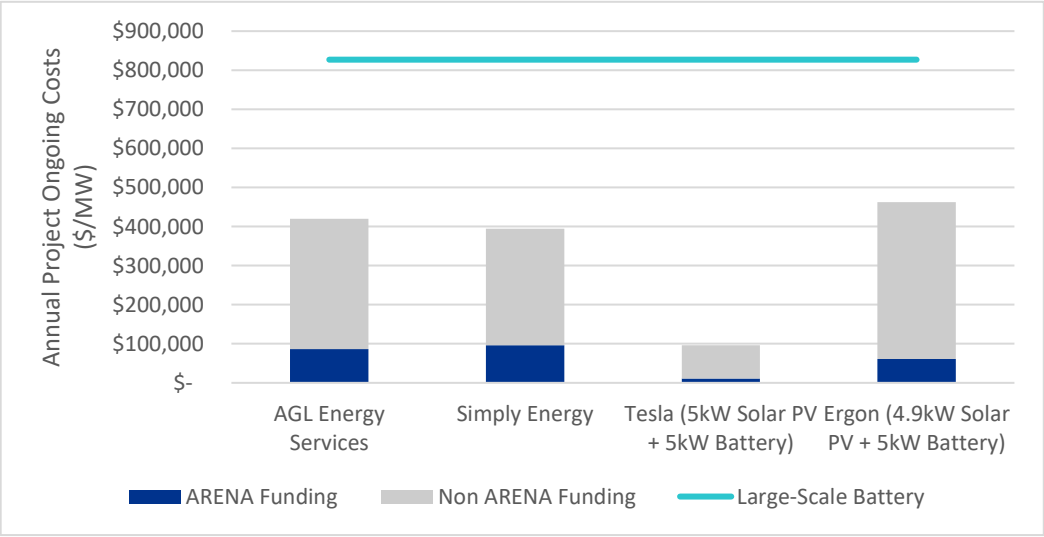


Figure 7 displays the annual project costs excluding any subsidies towards battery and solar hardware costs (where it was possible to extract these costs from overall project costs) to provide a like for like comparison of the cost to establish and operate a VPP under each project. It shows that if consumers have already purchased a battery (such that this is considered a sunk cost), then VPPs may be a cost effective alternative to large scale batteries.

Figure 7 - Annual project costs excluding hardware costs (i.e., battery, install etc.) ($/MW)



3.3.3 Summary (Efficiency)

Evaluation of the portfolio of VPP projects' efficiency is given in Table 6 below.

Table 6 – VPP portfolio evaluation – Efficiency

Criteria	Evaluation
Efficiency	
The total net benefits /MW VPP capacity delivered appears to be efficient relative to benchmarks*	**Partially meets the criteria** Within the trial, the cost of deploying a VPP was in most cases more expensive than installing a large-scale battery. Given the early-stage nature of the VPP projects, this is to be expected. As more consumers purchase batteries, due to a decline in the cost of batteries, then VPPs may be a cost effective alternative to large scale batteries.
Portfolio participants (including funding recipients, DNSPs and AEMO) believe that the projects were efficiently delivered by ARENA	**Fully meets the criteria** Funding recipients had positive engagement experiences with ARENA throughout the trials. ARENA worked around any issues with flexibility and clear communications to impact projects as little as possible. That said, the contracting period was seen by several funding recipients as protracted and unnecessarily complex. Additionally, the level of engagement required to meet ARENA's requirements and manage projects represented a significant cost to some funding recipients, in particular start-ups.

*Only the VPP projects that operated to establish a VPP business model and access market benefits have been used in the benchmarking exercise which include AGL, Ergon, Simply Energy and Tesla. These project costs have been compared to the cost of deploying a large-scale battery.

4. Trial Impact Evaluation (Quantitative)

4.1 Overview

The quantitative evaluation of the impact of ARENA's funding of VPP projects was undertaken using CSIRO's Impact Evaluation Guide[15]. The evaluation guide strongly suggests that an evaluation approach be developed during the program planning phase including the development of:

- An impact pathway setting out how the funding gave rise to various impacts as a result of activities, outputs and outcomes.
- A counterfactual scenario, setting out the impacts that would have occurred in the absence of the funding.
- A cost benefit assessment, quantifying the net benefits of the impacts relative to the counterfactual scenario.

Although a DER monitoring and evaluation plan was developed and approved as part of the documentation for evaluating the projects, no impact pathway or formal quantitative evaluation of the costs, benefits and impacts were developed. Accordingly, CutlerMerz has retrospectively developed an impact pathway and carried out a high-level cost benefit assessment (CBA) to quantify the benefits of ARENA's funding to the energy system. The application of a retrospective pathway has two main limitations:

- There is limited data available directly from the projects to inform the cost benefit assessment and assumptions and benchmarks (which may not be directly applicable) are required to be used instead.
- There are likely to have been missed opportunities for the projects/portfolio of projects to be designed or adapted overtime to maximise the potential impacts.

The assessment below should therefore be considered indicative only.

4.2 Impact pathway

The impact pathway in Table 7 below sets out a framework to identify how the ARENA-funded trial delivered the outputs and associated economic and environmental impacts to be attributed to the funding in the CBA.

[15] CSIRO (2020) 'Impact Evaluation Guide', https://www.csiro.au/-/media/About/Files/Our-impact-framework/CSIROImpactEvaluationGuide_WEB.pdf

Table 7 – Trial Impact Pathway Framework

Inputs	Activities	Outputs	Outcomes	Impact
ARENA funding to various projects in the VPP trial	Funding recipients undertake their projects to achieve each project's objectives	Funding recipients acquired additional understanding of VPP capability, functionality and barriers, and roll out of batteries to deliver and participate in VPP activities Key findings from the VPP trials outlined in various reports to ARENA	Development of the MASS Development of an API to enable VPPs to consistently access dynamic export limits from distribution system operators (DSOs) (networks) Demonstration of VPP capabilities and revenue streams	Societal benefit of avoided cost of large-scale battery systems installed to participate in the FCAS markets. Increased benefits to customers from VPP participants exporting due to earlier adoption of dynamic export limits in selective states

4.3 Scenarios (Counterfactual and with ARENA Funding)

Having consulted to the various funding recipients and with our understanding of Australia's current VPP market, we estimate that ARENA's funding of the trial did not impact the rate of adoption of the VPP fleet in Australia, with the exception of the systems directly funded as a major barrier to rate of adoption is deployment of behind the meter batteries. However, key outputs of the trial led to the following which would have otherwise had been developed at a later date:

- Development of the MASS which outlines the performance parameters and requirements needed for participants, such as VPP aggregators, to provide services in the FCAS markets. With this, we estimate that the trial had brought forward the ability for VPPs to access the FCAS market by 3 years.

- Development of an API and associated operating systems and procedures to enable VPPs aggregators to consistently access dynamic export limits from DSOs and therefore have an increased export limit. Although the API would not impact the timing of distribution networks adopting dynamic export limits. Instead, it would allow for VPPs to have earlier access, assumed to be 3 years, to the benefits of increased export limits assuming networks and aggregators also adopt this API.

4.4 Cost Benefit Assessment

The key costs and benefits associated with overall benefit from ARENA's funding and included in this quantitative assessment include:

- Avoided large-scale battery investment as VPPs with earlier access to the FCAS markets would limit the level of large-scale battery investment that would have otherwise been deployed to participated in the FCAS market. As the MASS is effective from July 2020 onwards, we assume that the avoided large-scale battery investment is available from 2020 onwards in the With ARENA Funding scenario, or three years after in the Counterfactual scenario. This benefit is calculated based on the total available power output of the VPP fleet on an incremental basis each year, and the per MW cost of installing large-scale batteries.

- Costs of Accessing Dynamic Operating Envelopes as VPPs aggregators would need to adopt and integrate the operating systems and procedures needed to access the API and therefore to access the associated benefits of increasing the export limits with their systems. This cost is calculated using SAPN's cost values in

their public trial report[16] for each VPP aggregator as an upfront cost, the number of aggregators present in the market[17], and the assumed timing that distribution networks would implement dynamic operating envelopes. However, these costs act as the upper boundary towards the actual cost of future VPP aggregators as the costs include the initial cost to co-design, develop, test and integrate the systems needed to access the API. Further information is required to more accurately quantify this cost, particularly the cost to adopt the API with the standard (i.e. without the cost of designing and developing the operating systems).

SAPN has been approved to provide dynamic operating envelopes in their 2020-2025 regulatory period. Networks are likely to pursue dynamic operating envelopes if the network is heavily constrained by exports and are pressured to avoid static or absolute export limits by industry stakeholders and customers. Energy Queensland is currently aiming to have the capability to deliver dynamic operating envelopes by mid-2022. It is expected the Victoria is unlikely to have the capability for dynamic connection agreement earlier than mid-2023. We have assumed that networks in Victoria and Queensland would begin adopting dynamic operating envelopes on these dates and therefore VPP aggregators can access these dynamic operating envelopes. Without ARENA funding, VPP aggregators would instead access dynamic operating envelopes three years later in the Counterfactual scenario.

- Benefit of Increased Export Limits as networks implementing dynamic operating envelopes and networks and VPP aggregators both adopting the API would allow for VPPs to have increased export limits and therefore have greater capacity to export and participate in various markets. We have assumed that distribution networks, primarily in South Australia, Victoria and Queensland[18], would increase their existing export limit of 5kW to 10kW[19]. The associated benefits are calculated using SAPN's benefit values in their public trial report. These benefits are primarily estimated in terms of the additional wholesale electricity market benefits (i.e. revenue streams in the spot market) in South Australia gained from increased export limits.

  The value of these benefits would vary between the wholesale market in each state, between customers who have bespoke export limit agreements with their network, and between different business VPP models adopted with each VPP aggregator.

- Upfront program costs associated with VPP aggregators developing the functionality and capability for VPPs, such as developing software for customer access and acquiring an initial customer base through marketing. Not included in these costs are the cost of purchasing and installing the hardware needed for VPPs, including batteries, solar PV systems, home energy management systems, or required metering as customers are assumed to have access to these technologies prior to joining a VPP program. These costs do not change between scenarios, are calculated using an average upfront cost of establishing a VPP based on a breakdown of the total funding for selective projects in the trial[20] and the number of VPP aggregators present in the market. As data on the breakdown of costs is limited, more detail of upfront costs of a commercial VPP program rather than a trial would increase the validity of this assessment.

- Ongoing program costs associated with VPP aggregators which include project management costs. These costs do not change between scenarios, and are calculated using an average ongoing cost of operating a VPP based on a breakdown of the total funding for selective projects in the trial. More detail of operating costs which would better reflect the costs associated with a commercial VPP program rather than a trial would increase the validity of this assessment.

[16] CSIRO, SAPN, Tesla (2020) 'Analysis of the VPP dynamic network constraint management', https://arena.gov.au/assets/2021/01/analysis-of-the-vpp-dynamic-network-constraint-management.pdf

[17] Aggregators present in the market offering VPP services predominantly consist of Tesla, AGL, Origin, EnergyAustralia and Simply Energy. These aggregators operate across all states in the NEM. Additional aggregators may be present in the market during the modelling period, but are unlikely to access the benefits of dynamic operating envelopes due to the high upfront cost.

[18] We see that distribution networks in New South Wales and Tasmania are not likely to adopt dynamic operating envelopes in the near term, and as such VPPs in these states would not access the benefits of having increased export limits.

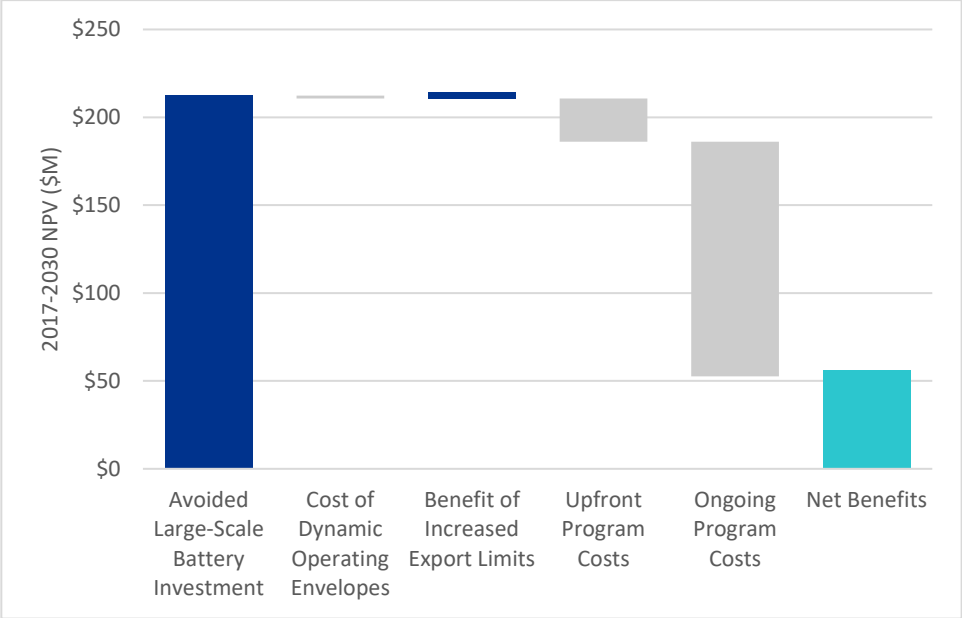
[19] Note that United Energy currently provides a 10kW export limit. As such, the benefits of increasing the export limit to 10kW would not be available for VPPs operating in the United Energy network.

[20] Upfront program costs included stem from the breakdown of funding from AGL, Simply Energy and Tesla's project. We note that the ARENA projects include additional costs, such as those for knowledge sharing and travel, which we have excluded as they are assumed to be specific costs related to meeting the overall trial requirements.

Further details on the key costs and benefits, including those not included in this assessment, and their associated key assumptions and inputs are discussed in Appendix Sections 5.5and 5.6 respectively.

The total net benefits from 2017 to 2030 for the "With ARENA Funding" scenario is shown in Figure 8 below. The avoided cost of large-scale battery investment accounts for the majority of the total benefits, with the benefits of increased export limits only marginally providing additional benefits in comparison[21]. Overall, the resulting Benefit Cost Ratio (BCR) comparing the total benefits to the total costs over the modelled period is 1.35[22].

Figure 8 – NPV of VPP Costs and Benefits from 2017 to 2030 (With ARENA Funding Scenario)

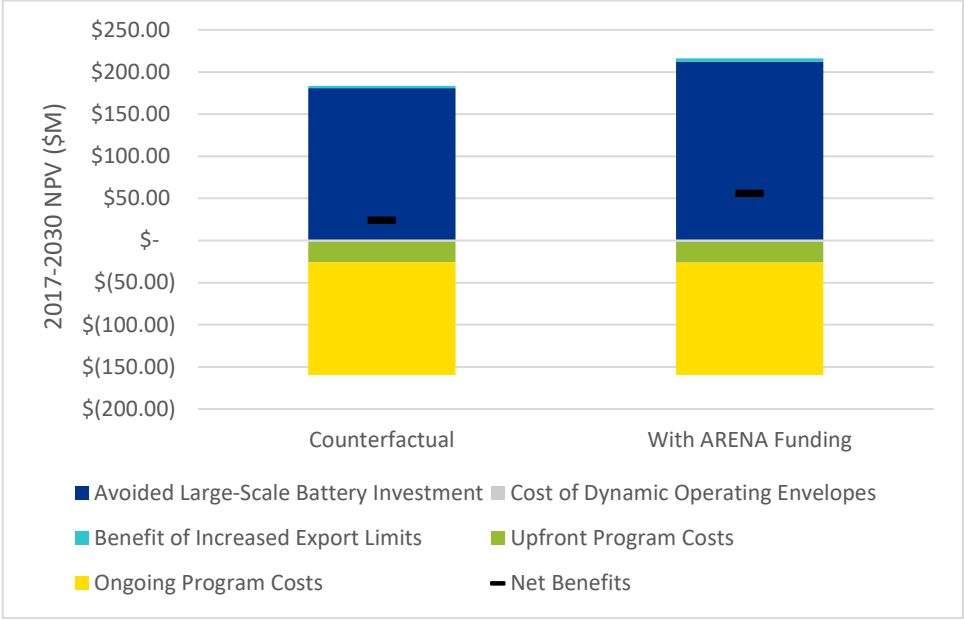


Through fast-tracking the access to FCAS markets and dynamic operating envelopes, the total and net benefits from 2017 to 2030 increases by 18% and 143% respectively, as shown in Figure 9 below.

[21] We note that applying dynamic operating envelopes would have additional benefits that are not included in this CBA, including reduced curtailment of solar PV customers that are not participating in a VPP and increasing hosting capacity within the network to allow additional take up of distributed energy resources.

[22] We note that there are additional costs that are not quantified and thus not included in this CBA, please see Section 5.5 for more information.

Figure 9 – Comparison of 2017 to 2030 NPV of DR Costs and Benefits by Scenario



5. Summary and recommendations

5.1 Summary

Overall, CutlerMerz considers that the ARENA funding of its portfolio of VPP projects was appropriate, effective, and efficient.

There is clear evidence that the portfolio of projects is appropriate in meeting ARENA's legislative objectives and contributing to the expected results set out in the performance framework. The funding helped support the development of a portfolio of projects that increased the competitiveness of VPPs and the renewable energy technologies supporting them. Similarly, ARENA deployed funding to support the supply of hardware and actively increased the supply of renewable energy in Australia. Additionally, the portfolio supported projects within both industry and universities, and in doing so, helped drive collaboration and knowledge sharing.

Although the evaluation highlights that the projects were appropriate in the most part, there remain areas for improvement. Firstly, there was no clear overarching strategy for how and why ARENA selected the VPP projects as appropriate. The amount of private sector capital mobilised could have been larger. This is reflected in the leverage ratio of ARENA to private sector funding falling below the target in 6 of the 11 projects.

The portfolio of projects was effective in validating VPP technologies and testing the VPPs' ability to access market benefits. In part, this was achieved through ARENA's funding strategy of progressively investing in VPP projects rather than a single funding round. This meant that support was available for technology innovators when required in a rapidly changing market. This allowed projects to learn from one another over time. It is suggested that such a strategy was effective for VPPs due to their inherent technical complexity, complex stakeholders' interactions and the early stage in which ARENA commenced supporting VPP projects. IF ARENA elected to support VPP technologies later in their development curve in Australia, then a single funding round may have been appropriate.

Importantly, the projects validated the ability of VPPs to access and effectively participate in Frequency Control Ancillary Services (FCAS) markets and provide network benefits. The outcomes of the test FCAS market, has informed the development of AEMO's Market Ancillary Services Specification (MASS)[23] which we estimate has brought forward access to the FCAS market for VPPs by approximately 3 years.

As would be expected, ARENA's funding was focused on South Australia where the uptake of DER is high, network and system issues from high penetration renewable energy are emerging, and the need for VPP technologies is the greatest. The outcome was an organic accumulation of funding subsidies for batteries, allowing customers to "shop around for home battery installations. It also meant a build-up of expertise in the state in particular, which need not be problematic, so long as the learnings from the state are actively shared across Australia.

The use of funding to deploy behind the meter batteries and integrate with network VPP software was viewed by some stakeholders as having provided an unequal advantage to certain VPP operators. In this context, and moving forward, a concerted effort should be made to ensure the benefits and lessons are shared broadly.

The evaluation of the VPP portfolio validated that ARENA's coordination of the portfolio was efficient resulting in high levels of satisfaction from the funding recipients relative to level of investment. In particular, ARENA's flexibility to adjust to the dynamic changes in the projects proved valuable to the funding recipients.

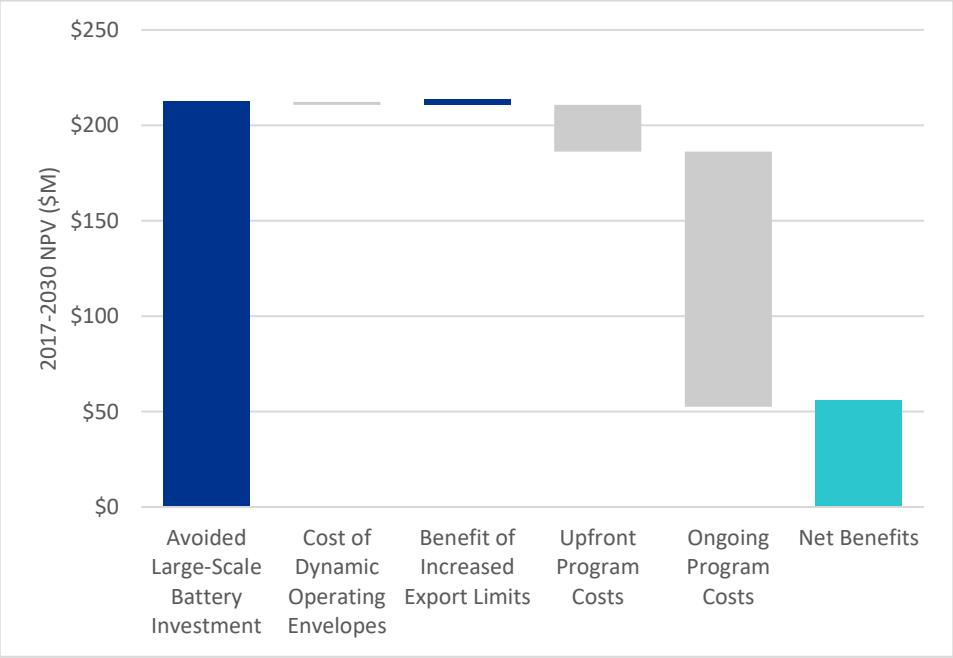
Overall, while the program was efficient and effective, few direct quantifiable benefits were able to be identified. Markets for VPPs remain in the very early stages and are not yet operational without government support. This is partly due to the costs of battery storage which remains prohibitively high for wide-scale investment by individual customers. Notwithstanding, the evaluation identified that the trials have likely brought forward the potential for VPPs

[23] AEMO (2020) 'Market Ancillary Service Specification', https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2020/primary-freq-resp-norm-op-conditions/market-ancillary-services-specification---v60.pdf?la=en&hash=4E46BE456C8D1DEAF12D0FF922DE4DBA

to participate in FCAS markets by approximately 3 years, owing to the specific investment in developing and testing of this particular service. Other benefit streams, and network benefits in particular, remain largely inaccessible to VPPs.

A quantitative cost benefit assessment (CBA) was undertaken specific to the key portfolio outcome of bringing forward an FCAS market for VPPs by 3 years as well as co-benefits of increasing export limits for behind the meter DER. Importantly, where VPPs can effectively participate in FCAS markets, it may avoid the capital cost of deploying large scale batteries to provide FCAS services. The avoided cost of large-scale battery investment accounts for the majority of the total benefits, with the benefits of increased export limits only marginally providing additional benefits in comparison[24]. Overall, the resulting Benefit Cost Ratio (BCR) comparing the total benefits of bringing forward VPPs by three years to the total costs over the modelled period is 1.35[25].

Figure 10 – NPV of VPP Costs and Benefits from 2017 to 2030 (With ARENA Funding Scenario)



5.2 Recommendations

Appropriateness

- There was no documentation to suggest that ARENA had an overarching strategy to guide development of ARENA's VPP portfolio and justify how and why VPP projects were selected as appropriate. This resulted in funding recipients being uncertain on how their project 'fit' within the broader VPP strategy. Although this report notes that developing a clear 'roadmap' is challenging in developing technologies such as VPPs it could provide certain advantages.
    - A VPP strategy may better guide ARENA in electing projects that resolve VPP technical or commercial gaps. In doing so, more appropriate projects may be selected resulting in more effective delivery to meet ARENA's legislative and performance objectives.
    - A VPP strategy will inform funding recipients and the wider market. The benefit of doing so will help flag the projects with which they can gain learnings. Importantly, it will also allow the broader market to develop products and solutions to meet the technical and commercial knowledge gaps. Similarly,

[24] We note that applying dynamic operating envelopes would have additional benefits that are not included in this CBA, including reduced curtailment of solar PV customers that are not participating in a VPP and increasing hosting capacity within the network to allow additional take up of distributed energy resources.
[25] We note that there are additional costs that are not quantified and thus not included in this CBA, please see Section 5.5 for more information.

as technology solutions to enable microgrids continue to evolve, a guiding strategy for investment in impactful microgrid technologies will be beneficial for both ARENA and future funding recipients.

- The evaluation identified the benefits workshops and industry steering groups provided knowledge sharing and guiding industry. ARENA has continued to improve in helping steer these knowledge sharing requirements in its contracts with funding recipients. It is recommended that ARENA continue to identify and leverage the knowledge sharing activities and maximise value such as the workshops and industry steering groups.

- As VPPs' are a developing technology, ARENA must balance investment in less commercially mature projects that require a higher percentage of ARENA funding with more commercially mature projects that attract a higher percentage of private sector investment. When electing which projects to invest, it is recommended that ARENA balance investment with commercial maturity to help attract an appropriate level of investment from private sector. Developing a risk / cost KPI may be a more appropriate metric than the 'project leverage' KPI presently used by ARENA.

Effectiveness

- This report notes that although the ARENA funding has made great strides in the development of technologies and commercial models to enable VPP, some clear barriers remain. Notably the findings of this evaluation suggest that there is inherent conflict of thought between how network businesses and AEMO believe VPP's should be managed. AEMO will continue to work towards a centralised bidding platform yet networks may be resistive to such a model. To effectively transition the market to a single and uniform model, ARENA may play a role in helping identify technologies and projects that help support a common bidding and governance framework.

- Another challenge for the industry will be standards for operability to ensure platforms for VPP aggregation are technology agnostic. That is, to help ensure all technologies and platforms can be integrated with one another. Doing so shall help maintain an open market in which companies can participate, generate competition and drive down prices for consumers. Although no solution is provided here, ARENA should be cognisant of continuing to provide funding to projects that support technology interoperability.

- The VPP projects resulted in a disproportionate percentage of funding in South Australia. Though appropriate for the time, ARENA should consider how to share the learnings from South Australia to efficiently support the update of VPP's in other jurisdictions.

Appendix

5.3 VPP Evaluation Framework

Table 8 – VPP Portfolio Evaluation Framework

Criteria	Does not meet the criteria	Partially meets the criteria	Fully meets the criteria
Appropriateness			
Overall, the VPP projects assessed are appropriate in terms of meeting ARENA's legislated objectives	Overall, it is difficult to say that the VPP projects assessed meet ARENA's legislated objectives, with large inconsistencies between projects	Overall, the VPP projects largely meet ARENA's legislated objectives with some clear exceptions	Overall, the VPP projects assessed meet ARENA's legislated objectives
Overall, the VPP projects assessed are appropriate in terms of meeting ARENA's Performance Framework	Overall, it is difficult to say that the VPP projects assessed meet ARENA's Performance Framework, with large inconsistencies between projects	Overall, the VPP projects largely meet ARENA's Performance Framework with some clear exceptions	Overall, the VPP projects assessed meet ARENA's Performance Framework
Overall, the frequency of reporting required (milestones, finances and knowledge sharing) under the funding agreement was appropriate	Reporting frequency was insufficient to disseminate information OR was overly cumbersome and an inefficient use of time	Reporting frequency sufficient, however there are clear areas for improvement	Reporting frequency was good / sufficient
Effectiveness			
The VPP projects captured the broad range of value streams available to VPPs	Overall, the program was very limited in identifying and delivering a broad range of value streams	Overall, there were multiple value streams that were explored, but these tended to be limited to a small number of projects or a limited number of value streams	Overall, there were significant value streams identified and delivered, by the majority of projects
A qualitative assessment suggests the TRL of the VPP technology has progressed as a result of the ARENA funding	Overall, it is difficult to say that the TRL of the VPP technology has progressed as a result of the ARENA funding	Overall, the TRL of the VPP technology has progressed as a result of the ARENA funding, but this is driven by a small number of projects rather than across the board	Overall, the TRL of the VPP technology has progressed as a result of the ARENA funding, with significant contributions from all/most projects
A qualitative assessment suggests the CRI of the project technology has progressed as a result of the ARENA funding	Overall, it is difficult to say that the CRI of the VPP technology has progressed as a result of the ARENA funding	Overall, the CRI of the VPP technology has progressed as a result of the ARENA funding, but this is driven by a small number of projects rather than across the board	Overall, the CRI of the VPP technology has progressed as a result of the ARENA funding, with significant contributions from all/most projects

Criteria	Does not meet the criteria	Partially meets the criteria	Fully meets the criteria
The funding provides 'good' coverage of the DER Technology Integration Functional Framework functional areas which are applicable to VPPs	Overall, there is poor coverage of the relevant functional areas within the DER Technology Integration Functional Framework	Overall, there is some coverage of some of the relevant functional areas within the DER Technology Integration Functional Framework, but this tends to be concentrated in certain areas with opportunities missed in others	Overall, there is good coverage of all the relevant functional areas within the DER Technology Integration Functional Framework
Overall, the knowledge sharing activities enhanced the competitiveness of renewable energy technologies	Overall, it is difficult to say that the VPP projects enhanced the competitiveness of renewable energy technologies	Overall, the VPP projects enhanced the competitiveness of renewable energy technologies, but this was driven by a small number of projects rather than across the board	Overall, the VPP projects enhanced the competitiveness of renewable energy technologies, with significant contributions from all/most projects
Overall, knowledge sharing activities better informed the public about renewable energy technologies and the role they can play in Australia's energy transition	Overall, it is difficult to say that the VPP projects better informed the public about renewable energy technologies	Overall, the VPP projects better informed the public about renewable energy technologies, but this was driven by a small number of projects rather than across the board	Overall, the VPP projects better informed the public about renewable energy technologies, with significant contributions from all/most projects
Overall, ARENA's responsiveness to communications with funding recipients was effective	Poor / slow	Reasonable with room for improvement	Excellent
Overall, the timeliness of the milestones / progress report assessment process was effective	Poor / slow	Reasonable with room for improvement	Excellent
Efficiency			
The total net benefits /MW VPP capacity delivered appears to be efficient relative to benchmarks*	The total net benefits /MW VPP capacity delivered is much higher (more than 100%) than the benchmark	The total net benefits /MW VPP capacity delivered response for is somewhat close (between 50% and 100%) to the benchmark	The total net benefits /MW VPP capacity delivered is close (within 50%) of the benchmark

Criteria	Does not meet the criteria	Partially meets the criteria	Fully meets the criteria
Portfolio participants (including funding recipients, ARENA, DNSPs and AEMO) believe that the projects were efficiently delivered by ARENA	The majority of the portfolio participants believe that the projects were not efficiently delivered by ARENA with significant opportunities for improvement	The majority of the portfolio participants believe that the projects were somewhat efficiently delivered by ARENA with some opportunities for improvement OR Some portfolio participants believe that the projects were not efficiently delivered by ARENA with significant opportunities for improvement	The majority of the portfolio participants believe that the projects were efficiently delivered by ARENA with limited opportunities for improvement

*Only the VPP projects that operated to establish a VPP business model and access market benefits have been used in the benchmarking exercise which include AGL, Ergon, Simply Energy and Tesla. These project costs have been compared to the cost of deploying a large-scale battery.

5.4 VPP Portfolio of Projects

Proponent name	Project title	State	ARENA ref.
AEMO	AEMO Virtual Power Plant Demonstrations	VIC	2019/ARP003
AGL	Virtual Power Plant Project	SA	2016/ARP022
Ergon	Trialling a New Residential Solar PV and Battery Model	QLD	2014/ERP119
SAPN	Advanced VPP Grid Integration	SA	2018/ARP157
Simply Energy	Simply Energy Virtual Power Plant (VPP) Project	SA	2018/ARP002
Tesla	Tesla VPP	SA	2019/ARP029
Curtin	White Gum Valley	WA	2015/RND022
Horizon Power	Business Model Pilot Project - Phase 1 (Highgarden)	WA	2016/ARP037
Indra Australia	Indra Monash Smart City	VIC	2018/ARP017
LO3	Latrobe Valley Microgrid Feasibility Study	VIC	2018/ARP005
Synergy	Alkimos Beach Energy Storage Project	WA	2014/ARP056

5.5 Rationale for Costs and Benefits

Table 9 – Detailed Costs and Benefits

	Description	Party Involved	Approach to Modelling
Avoided large-scale battery investment	VPPs with earlier access to the FCAS markets would limit the level of large-scale battery investment that would have otherwise been deployed to participated in the FCAS market.	Societal benefit of reducing the cost to build energy infrastructure.	This benefit is included in our quantitative modelling and is calculated based on the total available power output of the VPP fleet, and the per MW cost of installing large-scale batteries.
Costs of Accessing Dynamic Operating Envelopes	VPPs aggregators would need to adopt and integrate the operating systems and procedures needed to access the API and therefore to access the associated benefits of increasing the export limits with their systems.	VPP aggregators would encounter this cost to ensure their systems are able to integrate with the API.	This cost is included in our quantitative modelling and is calculated using SAPN's cost values in their public trial report as well as the assumed timing that distribution networks would implement dynamic operating envelopes.
	Distribution networks would need to develop functionality to allow for VPPs to access the dynamic operating envelopes	Networks would encounter this cost to allow for VPPs to access their systems.	This cost is not included or quantified in our quantitative modelling due to insufficient data available.
Benefit of Increased Export Limits	Networks implementing dynamic operating envelopes and networks and VPP aggregators both adopting the API would allow for VPPs to have increased export limits and therefore have greater capacity to export and participate in various markets.	VPP aggregators would receive this benefit as they have greater capacity to participate in markets, and therefore gain additional revenue.	This benefit is included in our quantitative modelling and is calculated using SAPN's benefit values in their public trial report, which estimates the additional wholesale electricity market benefits gained from increased exports, and assuming distribution networks, primarily in South Australia, Victoria and Queensland, would increase their existing export limit of 5kW to 10kW.
		VPP participants would receive this benefit as they would be paid by VPP aggregators for their additional capacity to participate in VPP services.	This benefit is not included or quantified in our quantitative modelling as we assume VPP aggregators would pass-down some of their revenue to participants as part of their business model and as such would double-count this benefit.
Upfront Cost of Establishing a VPP Business	VPP aggregators would encounter upfront costs to establish their VPP business model.	VPP aggregators would encounter this cost.	This cost is included in our quantitative modelling and is calculated using an average upfront cost of establishing a VPP based on a breakdown of the total funding for selective project in the trial and the number of VPP aggregators present in the market.
Ongoing Cost of Operating a VPP Business	VPP aggregators would encounter various costs to operate their VPP business model.	VPP aggregators would encounter this cost.	This cost is included in our quantitative modelling and is calculated using an average ongoing cost of operating a VPP based on a breakdown of the total funding for selective project in the trial.
Benefit of Participating in a VPP Business	Customers participating in a VPP would be paid to provide energy to the VPP aggregator.	VPP participants would receive this benefit.	This cost is not included or quantified in our quantitative modelling as the benefits associated with VPP participants would not vary between the scenarios (with the exception of the incremental capacity available to be exported with increased

	Description	Party Involved	Approach to Modelling
			export limits which is included as a separate benefit). Additionally, there is insufficient data available on the total VPP rebates provided to VPP participants.
Increased FCAS Revenue	Due to ARENA's funding, VPPs have access to the FCAS markets than otherwise resulting in an increase in revenue from access an additional revenue stream that may be potentially of greater value.	VPP aggregators would receive this benefit.	This benefit is not included or quantified in our quantitative modelling as this reflects a wealth transfer from FCAS participants to VPP aggregators.
Lower FCAS Costs	With VPPs accessing the FCAS market, the total cost to provide ancillary services that AEMO recovers would decrease as VPP offers competition to the market.	Societal benefits of reduced FCAS costs.	This cost is not included or quantified in our quantitative modelling due to insufficient data, time and resources as this would require modelling of the FCAS market and participants.

5.6 Quantitative Evaluation Inputs and Assumptions

Table 10 – Detailed Inputs and Assumptions

	Assumption Description	Source
Benefit of Increased Export Limits	Export limits increasing from 5kW to 10kW would lead to an annual benefit of $35 per VPP participant.	SAPN's trial report
Cost of Accessing Dynamic Operating Envelopes	An upfront cost of $460,065 per aggregator involving VPP aggregators adopt and integrate the operating systems and procedures needed to access the API and therefore dynamic operating envelopes.	SAPN's trial report[26]
Cost of Large-Scale Batteries	CSIRO's forecast of one hour battery storage cost data in the Central scenario.	CSIRO's 2020 Gencost Data[27]
Discount Rate	7%	CSIRO's Impact Evaluation Guide[28]
Increased Export Limit	Networks that implement dynamic operating envelopes would be able to increase the export limit of customers to 10kW.	CutlerMerz's expert judgement
Number of Aggregators in the Market	Aggregators present in the market offering VPP services predominantly consist of Tesla, AGL, Origin, EnergyAustralia and Simply Energy. These aggregators operate across all states in the NEM. Additional aggregators may be present in the market during the modelling period, but are unlikely to access the benefit of dynamic operating envelopes due to the high upfront cost.	CutlerMerz's expert judgement
Ongoing Cost of Operating a VPP	$87,657/MW/year based on the on a breakdown of the total funding for selective projects in the trial. Note that AGL's project management costs were not included as these costs were significantly larger than Tesla's and Simply Energy's and limited information was available to further break out the project management costs.	ARENA Trial Documents and CutlerMerz's expert judgement
Timing of Avoided Large-Scale Battery Investment	2020 onwards in the With ARENA Funding scenario or three years after in the Counterfactual scenario. This is based on the fact that the MASS is effective from July 2020 onwards.	CutlerMerz's expert judgement
Timing of Networks Implementing Dynamic Operating Envelopes	SAPN has already been approved to provide dynamic operating envelopes in this regulatory period (i.e. 2020). Networks in Victoria and Queensland would begin adopting dynamic operating envelopes in mid-2023 and mid-2022 respectively.	CutlerMerz's expert judgement
Timing of VPP Aggregators Accessing Dynamic Operating Envelopes	VPPs can access dynamic operating envelopes a year after it is offered by networks in the With ARENA Funding scenario, or three years after in the Counterfactual scenario to account for the planning and integration of the systems between the network and the VPP aggregator.	CutlerMerz's expert judgement
Upfront Cost of Establishing a VPP	$5,244,185/aggregator based on the on a breakdown of the total funding for selective projects in the trial. Not included in these costs are the cost of purchasing and installing the hardware needed for VPPs.	ARENA Trial Documents and CutlerMerz's expert judgement
VPP Power Output and Capacity Forecast	AEMO's forecast of aggregated embedded energy storages (small-scale batteries) in the Central scenario.	AEMO's 2020 ISP[29]

[26] CSIRO, SAPN, Tesla (2020) 'Analysis of the VPP dynamic network constraint management', https://arena.gov.au/assets/2021/01/analysis-of-the-vpp-dynamic-network-constraint-management.pdf
[27] CSIRO (2020) 'GenCost 2020-21', https://www.csiro.au/-/media/News-releases/2020/renewables-cheapest/GenCost2020-21.pdf
[28] CSIRO (2020) 'Impact Evaluation Guide', https://www.csiro.au/-/media/About/Files/Our-impact-framework/CSIROImpactEvaluationGuide_WEB.pdf
[29] AEMO (2020) '2020 inputs and assumptions workbook', https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/inputs-assumptions-methodologies/2020/2020-inputs-and-assumptions-workbook-dec20.xlsx?la=en

5.7 Project Specific Evaluation

Table 11 – Project Specific Evaluation Framework

Criteria	Does not meet the criteria	Partially meets the criteria	Fully meets the criteria
Appropriateness – ARENA's legislated objectives			
The project objectives tangibly link to ARENA's legislative objective to improve the competitiveness of renewable energy technologies	Project objectives in no way link to ARENA's legislative objectives to improve the competitiveness of renewable energy technologies.	Project objectives somewhat align to ARENA's legislative objectives to improve the competitiveness of renewable energy technologies.	Project objectives clearly align to ARENA's legislative objectives to improve the competitiveness of renewable energy technologies.
The project objectives tangibly link to ARENA's legislative objective to increase the supply of renewable energy in Australia	The project objectives in no way link to increasing the supply of renewable energy in Australia.	The project objectives somewhat link to increasing the supply of renewable energy in Australia.	The project objectives are clearly tied and link to increasing the supply of renewable energy in Australia.
Appropriateness – ARENA's Performance Framework			
The funding provided to the project by ARENA supports technologies that align to ARENA's 'Priority Areas'	The project is not aligned to any of ARENA's priority areas	The project is only weakly aligned to ARENA's priority areas	The project aligns well to at least one of ARENA's priority areas
Private sector invested in the project	No private sector investment	Leverage is outside of the target range, 1:2 to 1:3.	Leverage is between the target range 1:2 to 1:3.
The project intends to advance the TRL and CRI of the proposed technology	Project objectives do not align with advancement of TRL and CRI of the proposed technology	Project objectives somewhat align with advancement of TRL and CRI of the proposed technology	Project objectives clearly align with advancement of TRL and CRI of the proposed technology
Contractual obligations of the individual projects included knowledge sharing products	No knowledge sharing product contractually required	Knowledge sharing products required	Knowledge sharing products required and collected
The frequency of reporting required (milestones, finances and knowledge sharing) under the funding agreement relative to the nature of the project was sufficient	Reporting frequency was insufficient to disseminate information OR was cumbersome and an inefficient use of time	Reporting frequency sufficient, however there are clear areas for improvement.	Reporting frequency was good / sufficient.
Effectiveness			
The extent to which the project achieved its stated objective/s	The project struggled to achieve its stated objectives	Project mostly achieved its stated objectives	The project achieved its stated objective

Criteria	Does not meet the criteria	Partially meets the criteria	Fully meets the criteria
The project delivered benefits across the full range of potential value streams available within its project context	The project focussed on one value stream only	The project focussed on a limited subset of value streams	The project attempted to capture the full range of value streams available within its project context
A qualitative assessment suggests the TRL of the project technology has progressed as a result of the ARENA funding. Note that formal TRL / CRI assessment of the projects shall be completed by Aurecon	TRL has not progressed as a result of ARENA funding	It appears that the project has somewhat progressed the TRL of the technology	The project has clearly progressed the TRL of the technology
A qualitative assessment suggests the CRI of the project technology has progressed as a result of the ARENA funding. Note that formal TRL / CRI assessment of the projects shall be completed by Aurecon	CRI has not progressed as a result of ARENA funding	It appears that the project has somewhat progressed the CRI of the technology	The project has clearly progressed the CRI of the technology
The project maps to the DER Technology Integration Functional Framework functional areas which are applicable to VPPs	The project does not map to any of the functional areas which are applicable to VPPs	The project does maps to some of functional areas which are applicable to VPPs	The project maps to all of functional areas which are applicable to VPPs
The project data was provided and collected as contractually required to ARENA	Project data (excel/CSV) has not been provided by the funding recipient or collected by ARENA such that there is likely a breach of contract	Some project data (excel/CSV) has been provided by the funding recipient or collected by ARENA, but it is unclear whether the contract requirements have been fully met.	All core project data (excel/CSV) required by the contract has been provided by the funding recipient or collected by ARENA
The funding recipient will continue its activities beyond the funded project	The funding recipient will not continue its VPP activities on completion of the project funding	The funding recipient will continue portions of its VPP activities beyond completion of the project funding	The funding recipient will continue its VPP activities in full beyond completion of the project funding
There is evidence of direct beneficiaries of the VPP funding	No evidence of direct beneficiaries from the VPP funding	Evidence of a narrow spectrum of direct beneficiaries from the VPP funding	Strong evidence of wide spectrum of direct beneficiaries from the VPP funding

Criteria	Does not meet the criteria	Partially meets the criteria	Fully meets the criteria
The knowledge sharing activities enhanced the competitiveness of renewable energy technologies (such activities include, but are not limited to, reports, presentations, workshops, interviews and working groups)	No evidence of knowledge sharing activities enhancing the competitiveness of renewable energy technologies	Some evidence of knowledge sharing activities enhancing the competitiveness of renewable energy technologies	Clear evidence of knowledge sharing activities enhancing the competitiveness of renewable energy technologies
The knowledge sharing activities better informed the public about renewable energy technologies and the role they can play in Australia's energy transition	No evidence of knowledge sharing activities informing the public about renewable energy technologies	Some evidence of knowledge sharing activities informing the public about renewable energy technologies	Clear evidence of knowledge sharing activities informing the public about renewable energy technologies
ARENA's responsiveness to communications requested by the funding recipient was appropriate	Poor / slow	Reasonable with room for improvement	Excellent
The timeliness of the milestones / progress report assessment process was appropriate	Poor / slow	Reasonable with room for improvement	Excellent
Efficiency			
Overall, the program was delivered efficiently, in terms of net benefits per MW of VPP capacity deployed*	The net benefits per MW of VPP capacity deployed was more than 100% below the benchmark	The net benefits per MW of VPP capacity deployed was 50% to 100% less than the benchmark	The net benefits per MW of VPP capacity deployed was within 50% of the benchmark
The project was efficiently delivered across stakeholders including ARENA	The project was not efficiently delivered with significant opportunities for improvement	The project was somewhat efficiently delivered with some opportunities for improvement	The project was delivered efficiently with limited opportunities for improvement

*Only the VPP projects that operated to establish a VPP business model and access market benefits have been used in the benchmarking exercise which include AGL, Ergon, Simply Energy and Tesla. These project costs have been compared to the cost of deploying a large-scale battery.

5.7.1 AEMO VPP Evaluation

Table 12 – AEMO VPP Project Specific Evaluation

Criteria	Does not meet the criteria	Partially meets the criteria	Fully meets the criteria
Appropriateness – ARENA's legislated objectives			
The project objectives tangibly link to ARENA's legislative objective to improve the competitiveness of renewable energy technologies	**Fully meets the criteria** Project objectives clearly align to ARENA's legislative objectives to improve the competitiveness of renewable energy technologies. In Australia, VPPs coordinate residential and commercial DER including solar PV, batteries and smart loads so that, in aggregate, they can deliver services traditionally provided by centralised power plants. The project has driven innovation in VPP management which enables increased integration of renewable energy sources, helping improve the technologies' competitiveness. Although the 7 VPP participants gained substantial learnings from the project which better placed them for future developments, it was unclear how parties that missed out on the project could avoid unduly falling behind. It is the view of this evaluation that the project's knowledge sharing activities will help bridge this gap.		
The project objectives tangibly link to ARENA's legislative objective to increase the supply of renewable energy in Australia	**Fully meets the criteria** The project objectives are clearly tied and link to increasing the supply of renewable energy in Australia. The project has helped demonstrate value streams that can be obtained from VPPs, and by doing so, has promoted the uptake of renewable energy in Australia.		
Appropriateness – ARENA's Performance Framework			
The funding provided to the project by ARENA supports technologies that align to ARENA's 'Priority Areas'	**Fully meets the criteria** The project aligns well to ARENA's Priority Area 1 and Priority Area 3 as presented in the 2020/21 Corporate Plan, helping integrate renewables and supporting industry reduce emissions.		
Private sector invested in the project		**Partially meets criteria** Leverage is outside of the target range of 1:2 to 1:3. Project leverage was 1:0.98.	
The project intends to advance the TRL and CRI of the proposed technology	**Fully meets the criteria** The project objectives clearly align with advancement of the TRL and CRI of the proposed technology. AEMO was able to innovate in the areas of testing a new technical specification for DER to deliver FCAS and in developing systems to receive data from VPPs to enable coordination and operation. This potentially facilitates more competition to deliver FCAS services at a lower cost to consumers and allows AEMO to observe VPP behaviour and learn the changes required (either to a regulatory setting or operational processes) to integrate VPPs at large-scale.		
Contractual obligations of the individual projects included knowledge sharing products	**Fully meets the criteria** Knowledge sharing products were contractually required including knowledge sharing reports, participation in knowledge sharing workshops and project data.		

Criteria	Does not meet the criteria	Partially meets the criteria	Fully meets the criteria
The frequency of reporting required (milestones, finances and knowledge sharing) under the funding agreement relative to the nature of the project was sufficient	**Fully meets the criteria** The frequency of reporting was overall sufficient and adequate.		
Effectiveness			
The extent to which the project achieved its stated objective/s	**Fully meets the criteria** The project achieved its stated objectives, providing AEMO greater visibility of how quickly VPPs can respond to market events in terms of dispatchability and reliability. AEMO also obtained a better understanding of VPP cybersecurity risks, consumer perspectives on participating in early stage VPPs as well as the role VPPs can play in maintaining local power quality.		
The project delivered benefits across the full range of potential value streams available within its project context	**Fully meets the criteria** The project attempted to capture the full range of value streams available. AEMO was able to: • Test a new technical specification for portfolios of DER to deliver FCAS • Better understand VPP value streams in practice (by delivering FCAS, network support services and responding to energy price signals) • Provide an evidence base to inform changes to regulatory settings and AEMO's operational processes		
A qualitative assessment suggests the TRL of the project technology has progressed as a result of the ARENA funding. Note that formal TRL / CRI assessment of the projects shall be completed by Aurecon		**Partially meets the criteria** It appears that the project has somewhat progressed the TRL of the technology. AEMO scored the technical readiness of the technology at project commencement as TRL 7, meaning the technology is at or near scale of the operational system with most functions available for demonstration and test. Although AEMO has managed to improve its systems and processes to obtain better visibility of VPPs, such as through improvements in forecasting bidding behaviour, the technology is still developing and is yet to be fully integrated with operational hardware and software systems.	
A qualitative assessment suggests the CRI of the project technology has progressed as a result of the ARENA funding. Note that formal TRL / CRI assessment of the projects shall be completed by Aurecon		**Partially meets the criteria** It appears that the project has somewhat progressed the CRI of the technology. AEMO scored the commercial readiness of the technology at project commencement as CRI 2, meaning the technology was at a small-scale commercial trial level. Although there are elements resulting from the project to suggest the CRI is developing, such as the Market Ancillary Services Specification (MASS) consultation process, no clear frontrunner in terms of a workable business model has been identified that would take the CRI to the level of commercial scale up.	
The project maps to the DER Technology Integration Functional Framework functional areas which are applicable to VPPs	**Fully meets the criteria** The project does map to most of functional areas which are applicable to VPPs. Project was captured as a project within the State of Distributed Energy Resources Technology Integration Report, thus has be mapped to the DER Functional Framework		

Criteria	Does not meet the criteria	Partially meets the criteria	Fully meets the criteria
The project data was provided and collected as contractually required to ARENA	**Fully meets the criteria** Data collection requirements in the contract were mostly directed at ensuring any material learnings arising from project data were included in knowledge sharing reports. AEMO has achieved these requirements. More stringent data collection requirements could have been made by ARENA to ensure the appropriate data was collected.		
The funding recipient will continue its activities beyond the funded project	**Fully meets the criteria** AEMO shall continue exploring improvements to VPP operations beyond the funding agreement. Having recognised that many of the VPP operators require assistance complying with requirements, AEMO is setting up an onboarding team for VPPs and will create training material and resources that will be published on its website. AEMO has also started the Market Ancillary Services Specification consultation process to inform the requirements for DER to participate in the Contingency FCAS markets.		
There is evidence of direct beneficiaries of the VPP funding	**Partially meets the criteria** The project directly benefitted AEMO as the market operator. For example, VPPs assisted in elevating the South Australian operational demand by approximately 5MW during the record minimum demand period on 11 October 2020, which reduced the severity of the event. The project also benefitted VPP participants who earned revenue from power system events, including consumers. Notwithstanding, benefits to DNSPs in terms of the ability of VPP operational data to provide useful insights about the real time status of low voltage networks did not materialise.		
The knowledge sharing activities enhanced the competitiveness of renewable energy technologies (such activities include, but are not limited to, reports, presentations, workshops, interviews and working groups)	**Fully meets the criteria** Clear evidence of knowledge sharing activities enhancing the competitiveness of renewable energy technologies. The project provided a strong learning opportunity for VPPs on how to participate in energy markets, bearing in mind that several of the VPPs were start-up companies that required a considerable level of assistance. The trials were informative in growing the VPP market and provided valuable insights to AEMO to be well prepared for when VPPs scale up. Participants found that the project provided a good forum to develop their VPP capability in a fast-tracked way than would have been otherwise.		
The knowledge sharing activities better informed the public about renewable energy technologies and the role they can play in Australia's energy transition	**Partially meets the criteria** Some evidence of knowledge sharing activities informing the public about renewable energy technologies. AEMO attempted to bridge the informational gap between participants and parties that missed out on the project by having an open forum with frequently asked questions on the VPP demonstrations, publishing VPP Consumer Insights reports, conducting an open webinar on the VPP demonstrations and fulfilling its other knowledge sharing requirements.		
ARENA's responsiveness to communications requested by the funding recipient was appropriate	**Partially meets the criteria** ARENA met most of the expectations of the funding recipient regarding responsiveness to communications. That said, the funding recipient found ARENA's responsiveness to an extension request quite slow, holding up the progress.		

Criteria	Does not meet the criteria	Partially meets the criteria	Fully meets the criteria
The timeliness of the milestones / progress report assessment process was appropriate	Fully meets the criteria ARENA's assessment process of milestone reports was timely.		
Efficiency			
Overall, the program was delivered efficiently, in terms of net benefits per MW of VPP capacity deployed	Not Assessed No benchmarking performed as the project wasn't deemed suitable for comparison against the VPP aggregation projects.		
The project was efficiently delivered across stakeholders including ARENA	Fully meets the criteria The project was delivered efficiently with limited opportunities for improvement. ARENA provided a strong level of due diligence to ensure funds were well spent. ARENA regularly attended meetings, providing a valuable steer on issues as they arose during the project.		

5.7.2 AGL VPP Evaluation

Table 13 – AGL VPP Project Specific Evaluation

Criteria	Does not meet the criteria	Partially meets the criteria	Fully meets the criteria
Appropriateness – ARENA's legislated objectives			
The project objectives tangibly link to ARENA's legislative objective to improve the competitiveness of renewable energy technologies	**Fully meets the criteria** Project objectives clearly align to ARENA's legislative objectives to improve the competitiveness of renewable energy technologies. In Australia, grid-connected VPPs focus on coordinating rooftop photovoltaic (PV), battery storage and controllable load devices to deliver services traditionally performed by a conventional power plant. The project has driven innovation in VPP management which enables increased integration of renewable energy sources, helping improve the technologies' competitiveness.		
The project objectives tangibly link to ARENA's legislative objective to increase the supply of renewable energy in Australia	**Fully meets the criteria** The project objectives are clearly tied and link to increasing the supply of renewable energy in Australia. The project has helped demonstrate value streams that can be obtained from VPPs, and by doing so, has promoted the uptake of renewable energy in Australia.		
Appropriateness – ARENA's Performance Framework			
The funding provided to the project by ARENA supports technologies that align to ARENA's 'Priority Areas'	**Fully meets the criteria** The project aligns well to ARENA's Priority 1 and Priority 3 as presented in the 2020/21 Corporate Plan, helping integrate renewables and supporting industry reduce emissions.		
Private sector invested in the project	**Fully meets the criteria** Leverage is within the target range of 1:2 to 1:3. Project leverage was 1:2.84.		
The project intends to advance the TRL and CRI of the proposed technology		**Partially meets the criteria** The project was aimed at advancing the CRI of the proposed technology, with AGL scoring the TRL as 9 at project commencement (the highest possible score). AGL wanted to use the trial as an exemplar for residential two-way VPP with a view to structuring policy and regulation to provide a pathway to commercialisation.	
Contractual obligations of the individual projects included knowledge sharing products	**Fully meets the criteria** Knowledge sharing products were contractually required including knowledge sharing reports, participation in knowledge sharing workshops and project data.		
The frequency of reporting required (milestones, finances and knowledge sharing) under the funding agreement relative to the nature of the project was sufficient	**Fully meets the criteria** The frequency of reporting was overall sufficient and adequate. Reports were linked to project milestones and financial reporting was tied to each financial year during the agreement and after achievement of the final milestone.		
Effectiveness			

Criteria	Does not meet the criteria	Partially meets the criteria	Fully meets the criteria
The extent to which the project achieved its stated objective/s	Fully meets the criteria The project achieved its stated objectives. AGL has commercial offers in the market for VPPs following the trials. AGL have continued to evolve in their interactions with customers, having improved substantially on information transparency to customers to obtain buy in. The project was enrolled with AEMO's VPP Demonstrations initiative.		
The project delivered benefits across the full range of potential value streams available within its project context	Partially meets the criteria The project attempted to realise benefits that would help stabilise the grid while delivering extra value to customers, the network, and the retailer. That said, and even though AGL was not enrolled with the FCAS market initially, they tried participating in the 6 second market but realised it was not technically feasible. In terms of unlocking network services value, AGL identified a range of regulatory reforms that could better enable the provision of non-network solutions as a cost-effective alternative to network augmentation.		
A qualitative assessment suggests the TRL of the project technology has progressed as a result of the ARENA funding. Note that formal TRL / CRI assessment of the projects shall be completed by Aurecon	Partially meets the criteria The TRL of the project hardware technology has not materially progressed as a result of the funding, nor was this an objective at the onset of the project. The hardware technology was ready to be rolled out at the beginning of the project, with most inverters and batteries classified as generation 1 at the time. The project itself did not improve the technology that was deployed, although the technology has progressed significantly outside of the project. The project did however provided a strong learning opportunity on how cloud-based (API) interfaces can be used to control a diverse fleet of assets.		
A qualitative assessment suggests the CRI of the project technology has progressed as a result of the ARENA funding. Note that formal TRL / CRI assessment of the projects shall be completed by Aurecon	Fully meets the criteria The project has progressed the CRI of the technology. AGL scored the commercial readiness of the technology at project commencement as CRI 2, meaning the technology was at a small-scale commercial trial level. AGL has now incorporated VPPs into their service offering to customers, offering a $1,000 participation discount (customers need to have their own batteries).		
The project maps to the DER Technology Integration Functional Framework functional areas which are applicable to VPPs	Fully meets the criteria The project does map to most of functional areas which are applicable to VPPs. Project was captured as a project within the State of Distributed Energy Resources Technology Integration Report, thus has been mapped to the DER Functional Framework		
The project data was provided and collected as contractually required to ARENA	Fully meets the criteria AGL were contractually required to provide certain project data to AEMO. Although this data was mostly commercially sensitive, there is evidence indicating that AGL fulfilled its requirement, including participating in AEMO's VPP Demonstration project. AGL also shared valuable data through the knowledge sharing reports.		

Criteria	Does not meet the criteria	Partially meets the criteria	Fully meets the criteria
The funding recipient will continue its activities beyond the funded project	Fully meets the criteria AGL shall continue exploring improvements to VPP operations beyond the funding agreement. A VPP programme is now part of AGL's business-as-usual offering to customers with batteries. AGL will also continue exploring key VPP use cases to achieve broader value streams from their VPP programs, including network services, contingency FCAS, and services to the Wholesale Energy Market.		
There is evidence of direct beneficiaries of the VPP funding	Fully meets the criteria The funds supported a prototype of a VPP that catalysed the VPP industry both in Australia and internationally and informed the discussion around DER integration in support of customer value. It did so as it was the first project of its size in Australia. AGL's was the first retailer to lead a project in AEMO's VPP Demonstrations, enabling participation of the majority of SA's VPP fleet in the six contingency FCAS markets, and exploring the use of behind the meter DER devices for ancillary services provision.		
The knowledge sharing activities enhanced the competitiveness of renewable energy technologies (such activities include, but are not limited to, reports, presentations, workshops, interviews and working groups)	Fully meets the criteria Clear evidence of knowledge sharing activities enhancing the competitiveness of renewable energy technologies. The project provided a strong learning opportunity on how cloud-based (API) interfaces can be used to control a diverse fleet of assets. Though common today, the approach was novel at the time, with most VPP programs relying on a gateway device being installed alongside each battery to communicate with a single cloud control platform. Overall, the trial was informative in growing the VPP market and provided valuable insights to AGL and AEMO.		
The knowledge sharing activities better informed the public about renewable energy technologies and the role they can play in Australia's energy transition	Fully meets the criteria The knowledge sharing activities informed the public about renewable energy technologies. AGL created a stakeholder reference group at the start of the project comprised of key industry stakeholders to share insights with and seek feedback from through the course of the project's development and deployment phase. The group included Energy Consumers Australia, the South Australian Council of Social Service, and Uniting Communities among several others. Throughout the project AGL shared a large amount of data with UNSW.		
ARENA's responsiveness to communications requested by the funding recipient was appropriate	Fully meets the criteria ARENA was a supportive partner to work with and was flexible to accommodate for changes arising during the project.		
The timeliness of the milestones / progress report assessment process was appropriate	Fully meets the criteria ARENA's assessment process of milestone reports was timely.		
Efficiency			
Overall, the program was delivered efficiently, in terms of net benefits per MW of VPP capacity deployed	Fully meets the criteria The benchmark used was the cost to deploy a large-scale battery at $827,000/MW. With project hardware included, the project costs were $1,281,333 compared to the benchmark.		

Criteria	Does not meet the criteria	Partially meets the criteria	Fully meets the criteria
The project was efficiently delivered across stakeholders including ARENA	**Fully meets the criteria** The project was delivered efficiently with limited opportunities for improvement. The funding recipient suggested ARENA had no clear structure or framework to guide change management over the course of the project. Notwithstanding, ARENA was very accommodating of changes and this did not present a particular obstacle.		

5.7.3 Simply Energy VPP Evaluation

Table 14 – Simply Energy VPP Project Specific Evaluation

Criteria	Does not meet the criteria	Partially meets the criteria	Fully meets the criteria
Appropriateness – ARENA's legislated objectives			
The project objectives tangibly link to ARENA's legislative objective to improve the competitiveness of renewable energy technologies	**Fully meets the criteria** Project objectives clearly align to ARENA's legislative objectives to improve the competitiveness of renewable energy technologies. In Australia, grid-connected VPPs focus on coordinating rooftop photovoltaic (PV), battery storage and controllable load devices to deliver services traditionally performed by a conventional power plant. The project has driven innovation in VPP management which enables increased integration of renewable energy sources, helping improve the technologies' competitiveness.		
The project objectives tangibly link to ARENA's legislative objective to increase the supply of renewable energy in Australia	**Fully meets the criteria** The project objectives are clearly tied and link to increasing the supply of renewable energy in Australia. The project has helped demonstrate value streams that can be obtained from VPPs, and by doing so, has promoted the uptake of renewable energy in Australia.		
Appropriateness – ARENA's Performance Framework			
The funding provided to the project by ARENA supports technologies that align to ARENA's 'Priority Areas'	**Fully meets the criteria** The project aligns well to ARENA's Priority Area 1 and Priority Area 3 as presented in the 2020/21 Corporate Plan, helping integrate renewables and supporting industry reduce emissions.		
Private sector invested in the project	**Fully meets the criteria** Leverage is within the target range of 1:2 to 1:3. Project leverage was 1:2.08.		
The project intends to advance the TRL and CRI of the proposed technology	**Fully meets the criteria** The project intended to advance the TRL and CRI of the proposed technology. The inclusion of GreenSync's decentralised energy exchange or deX platform was a major point of difference for the project. The deX platform came from an A-LAB workshop run by ARENA for new initiatives. This project was the first time that deX was built and integrated into a VPP at a commercial scale. One of the main objectives of the project was understanding consumer sentiment around batteries and VPPs. Of particular interest was the sensitivity of customers to the costs of VPP participation, principally driven by the cost of residential battery storage systems and how varying product offers, government subsidies and broader economic factors impact the uptake of VPP products.		
Contractual obligations of the individual projects included knowledge sharing products	**Fully meets the criteria** Knowledge sharing products were contractually required including knowledge sharing reports, participation in knowledge sharing workshops and project data.		

Criteria	Does not meet the criteria	Partially meets the criteria	Fully meets the criteria
The frequency of reporting required (milestones, finances and knowledge sharing) under the funding agreement relative to the nature of the project was sufficient			**Fully meets the criteria** The frequency of reporting was overall sufficient and adequate (one report a year).
Effectiveness			
The extent to which the project achieved its stated objective/s			**Partially meets the criteria** The project mostly achieved its stated objectives. It successfully showed market value arising from using the deX platform in both the FCAS and the wholesale market. Highly valuable insights on customer perspectives were garnered and the technology improved considerably as a result of the project. That said, a marketplace was not really tested because Simply Energy was the single VPP. The intention was that more VPPs would join and that networks would contract their services. The value to networks was therefore not proven. Additionally, the value to aggregators is still questionable (this will be further tested through AEMO and AusNet's Project EDGE).
The project delivered benefits across the full range of potential value streams available within its project context			**Partially meets the criteria** The project attempted to realise benefits that would help stabilise the grid while delivering extra value to customers, the network, and the retailer. Although the project enabled considerable innovation in the technology, it was unable to properly test an energy marketplace that changes the way electricity is produced, used, stored and traded to harness the full range of potential value streams.
A qualitative assessment suggests the TRL of the project technology has progressed as a result of the ARENA funding. Note that formal TRL / CRI assessment of the projects shall be completed by Aurecon			**Fully meets the criteria** The TRL of the project technology has clearly progressed as a result of the project. The concept of Dynamic Operating Envelopes was built into the technology for this project which was pioneering. The deX technology informed the design of the platform being used for Project EDGE. The project was awarded several prizes, including the SA Premier's Innovation Award and IOT Award, suggesting its contribution to advancing the integration of VPPs into the energy system was considerable.
A qualitative assessment suggests the CRI of the project technology has progressed as a result of the ARENA funding. Note that formal TRL / CRI assessment of the projects shall be completed by Aurecon			**Fully meets the criteria** The project has progressed the CRI of the technology. Simply Energy ran a number of surveys with customers ahead of and during the trial which improved the industry's understanding of what matters for customers when deciding to participate in a VPP. The VPP product is now subsidy free excluding the battery cost and the revenue from operating the VPP exceeds the costs. Simply Energy also consolidated its relationships with 10 installers which were used during the project as the sales channel to the market.
The project maps to the DER Technology Integration Functional Framework functional areas which are applicable to VPPs			**Fully meets the criteria** The project does map to most of functional areas which are applicable to VPPs. Project was captured as a project within the State of Distributed Energy Resources Technology Integration Report, thus has been mapped to the DER Functional Framework

Criteria	Does not meet the criteria	Partially meets the criteria	Fully meets the criteria
The project data was provided and collected as contractually required to ARENA	Fully meets the criteria Simply Energy were contractually required to provide certain project data to AEMO. Although this data was mostly commercially sensitive, we understand that Simply Energy fulfilled its requirement. Simply Energy also shared valuable data through the knowledge sharing reports.		
The funding recipient will continue its activities beyond the funded project	Fully meets the criteria Simply Energy shall continue exploring improvements to VPP operations beyond the funding agreement. Simply Energy used to have 2 or 3 projects 3 years ago and now have 15, which are not to the scale of the ARENA project but are using the learnings from it. Simply Energy are partners in the ARENA-funded Rheem trial in SA where they are applying the battery technology to hot water load control. They are looking at new applications and markets for the technology and can see considerable value for retailers.		
There is evidence of direct beneficiaries of the VPP funding	Fully meets the criteria The main direct beneficiaries of the funding were customers. Each customer received an $11,000 subsidy which was market leading, composed of $6,000 from SA Government and $5,000 from Simply Energy through the ARENA funding. Overall, customers were satisfied with the experience and as a result of participating are getting mainly zero-dollar bills or credits. GreenSync was also a direct beneficiary of the funding, receiving $3 million to develop and refine the platform. Overall, the trial was informative in growing the VPP market and provided valuable insights with respect to the concept of a decentralised energy exchange platform.		
The knowledge sharing activities enhanced the competitiveness of renewable energy technologies (such activities include, but are not limited to, reports, presentations, workshops, interviews and working groups)	Fully meets the criteria Clear evidence of knowledge sharing activities enhancing the competitiveness of renewable energy technologies. The project provided a strong learning opportunity on how an energy exchange platform can change the way electricity is produced, used, stored and traded. This technology was pioneering and is now being further explored and progressed by industry as a result of the knowledge emanating from this trial.		
The knowledge sharing activities better informed the public about renewable energy technologies and the role they can play in Australia's energy transition	Fully meets the criteria The knowledge sharing activities informed the public about renewable energy technologies. In particular, the project was highly informative of AEMO and AusNet's Project EDGE which will build from the learnings of this project to develop the next generation of platforms for the provision of a marketplace for VPPs.		
ARENA's responsiveness to communications requested by the funding recipient was appropriate	Fully meets the criteria ARENA was a supportive partner to work with and was flexible to accommodate for changes arising during the project such as the sales model changing, one of the approved suppliers closing down, and shifting funding to a more successful product.		
The timeliness of the milestones / progress report assessment process was appropriate	Fully meets the criteria ARENA's assessment process of milestone reports was timely.		

Criteria	Does not meet the criteria	Partially meets the criteria	Fully meets the criteria
Efficiency			
Overall, the program was delivered efficiently, in terms of net benefits per MW of VPP capacity deployed	**Fully meets the criteria** The benchmark used was the cost to deploy a large-scale battery at $827,000/MW. The cost effectiveness of the project was well in excess of the benchmark. With project hardware included, the project costs were $988,750 compared to the benchmark.		
The project was efficiently delivered across stakeholders including ARENA	**Partially meets the criteria** The project was mostly delivered efficiently with some opportunities for improvement. The time elapsed between when the project was given Board approval and the contract was signed was protracted due to long contractual processes on ARENA's end. The level of engagement required to meet ARENA's requirements and manage the project requires full-time resources to be allocated to the project. Simply Energy are reluctant to lead bids in the future due to the time and effort needed and so are partnering instead or self-funding smaller projects.		

5.7.4 Synergy VPP Evaluation

Table 15 – Synergy VPP Project Specific Evaluation

Criteria	Does not meet the criteria	Partially meets the criteria	Fully meets the criteria
Appropriateness – ARENA's legislated objectives			
The project objectives tangibly link to ARENA's legislative objective to improve the competitiveness of renewable energy technologies	**Fully meets the criteria** Project objectives clearly align to ARENA's legislative objectives to improve the competitiveness of renewable energy technologies. In Australia, grid connected VPPs focus on coordinating rooftop photovoltaic (PV), battery storage and controllable load devices to deliver services traditionally performed by a conventional power plant. The project has driven innovation in solar plus storage management which enables increased integration of renewable energy sources, helping improve the technologies' competitiveness.		
The project objectives tangibly link to ARENA's legislative objective to increase the supply of renewable energy in Australia	The project objectives are clearly tied and link to increasing the supply of renewable energy in Australia. The project has helped demonstrate value streams that can be obtained from solar plus storage, and by doing so, has promoted the uptake of renewable energy in Australia.		
Appropriateness – ARENA's Performance Framework			
The funding provided to the project by ARENA supports technologies that align to ARENA's 'Priority Areas'	**Fully meets the criteria** The project aligns well to ARENA's Priority 1 and Priority 3 as presented in the 2020/21 Corporate Plan, helping integrate renewables and supporting industry reduce emissions.		
Private sector invested in the project		**Partially meets the criteria** Leverage is outside the target range of 1:2 to 1:3. Project leverage was 1:1.03.	
The project intends to advance the TRL and CRI of the proposed technology	**Fully meets the criteria** The project intended to advance the TRL and CRI of the proposed technology. The project involved developing, deploying and testing the commercial feasibility of a new energy retail model. The model was aimed at showing how solar PV can be commercially supported by innovative products and services to unlock additional value for consumers, land developers, electricity retailers and network operators.		
Contractual obligations of the individual projects included knowledge sharing products	**Fully meets the criteria** Knowledge sharing products were contractually required including knowledge sharing reports, participation in knowledge sharing workshops and project data.		
The frequency of reporting required (milestones, finances and knowledge sharing) under the funding agreement relative to the nature of the project was sufficient	**Fully meets the criteria** The frequency of reporting was overall sufficient and adequate.		
Effectiveness			

Criteria	Does not meet the criteria	Partially meets the criteria	Fully meets the criteria
The extent to which the project achieved its stated objective/s	**Fully meets the criteria** The Synergy project was effective in. • Understanding the implications of commercial scale community batteries. • Understanding the performance of a community battery and whether meaningful load shifting can be obtained. • Understanding customer preferences towards community batteries • Understanding the commercial implications and challenges of community batteries		
The project delivered benefits across the full range of potential value streams available within its project context	**Fully meets the criteria** Project benefits were captured, however network costs limited commercial benefits. • Energy arbitrage was the only commercial value captured. • More work can be done to add benefits to the value stack such as FCAS and network benefits. • The project also assisted networks understanding of how such products would be integrated into their business. Networks were initially resistive to community batteries however they are now investing in community batteries themselves.		
A qualitative assessment suggests the TRL of the project technology has progressed as a result of the ARENA funding. Note that formal TRL / CRI assessment of the projects shall be completed by Aurecon	**Fully meets the criteria** The project was the first community battery in Australia and was therefore a test-piece for how to integrate a community battery into a grid. It resulted in clear technical developments, learning and progress such as; • Technical learnings for battery / network connections • As an early stage VPP, there were also leanings that capture how to integrate a battery into a VPP.		
A qualitative assessment suggests the CRI of the project technology has progressed as a result of the ARENA funding. Note that formal TRL / CRI assessment of the projects shall be completed by Aurecon		**Partially meets the criteria** The project observed commercial learnings however the project was unable to prove an economically robust business model as energy arbitrage was the only value stack to be captured and network charges were too high. ARENA's continued funding of the project shall allow it to continue to operate. It would have otherwise been decommissioned and discontinued as a retail model.	
The project maps to the DER Technology Integration Functional Framework functional areas which are applicable to VPPs		**Partially meets the criteria** The project maps to some of functional areas which are applicable to VPPs. Project was not captured as a project within the State of Distributed Energy Resources Technology Integration Report. As the project operated as a community battery, many of the Functional Areas were not captured.	
The project data was provided and collected as contractually required to ARENA	**Not Assessed** Unable to determine whether data was provided as the contracted Knowledge Sharing Plan was unavailable.		

Criteria	Does not meet the criteria	Partially meets the criteria	Fully meets the criteria
The funding recipient will continue its activities beyond the funded project	Partially meets the criteria Simply Energy will continue its activities beyond the funded project however only as a result of continued financial support from ARENA. However, project and customer learnings shall extend beyond the project with the project outcomes informing other projects.		
There is evidence of direct beneficiaries of the VPP funding	Partially meets the criteria As an early stage technology project, the major beneficiaries shall be future projects that leverage the learnings of the Alkimos project. Customer did have a sense of 'community' through participating in the program, however financial outcomes were essential which was limited.		
The knowledge sharing activities enhanced the competitiveness of renewable energy technologies (such activities include, but are not limited to, reports, presentations, workshops, interviews and working groups)	Fully meets the criteria There was anecdotally large interest in the project, particularly as the first community battery. The outcomes have informed future projects, suggesting that knowledge was shared and improved outcomes. However, the WA market is isolated from the rest of the country and therefore learnings may not be sheared as readily / easily as those on the east coast. ARENA should continue to encourage and facilitate cross border learnings.		
The knowledge sharing activities better informed the public about renewable energy technologies and the role they can play in Australia's energy transition	Fully meets the criteria There was anecdotally large interest in the project, particularly as the first community battery. The outcomes have informed future projects, suggesting that knowledge was shared and improved outcomes.		
ARENA's responsiveness to communications requested by the funding recipient was appropriate	Fully meets the criteria Although ARENA were tough to negotiate with and land the final contract, they proved to be a good partner that showed interest in the project.		
The timeliness of the milestones / progress report assessment process was appropriate	Fully meets the criteria ARENA's assessment process of milestone reports was timely.		
Efficiency			
Overall, the program was delivered efficiently, in terms of net benefits per MW of VPP capacity deployed	Not Assessed Project was not deemed suitable for benchmarking against a large-scale battery and the VPP aggregation projects.		
The project was efficiently delivered across stakeholders including ARENA	Partially meets the criteria Synergy made note that overheads to manage the ARENA contract did prove cumbersome and the processes slower than is preferred. The intensive and thorough ARENA contracting process proved challenging. ARENA could optimise the contracting process to ease the funding application process.		

5.7.5 Indra Monash VPP Evaluation

Table 16 – Indra Monash VPP Project Specific Evaluation

Criteria	Does not meet the criteria	Partially meets the criteria	Fully meets the criteria
Appropriateness – ARENA's legislated objectives			
The project objectives tangibly link to ARENA's legislative objective to improve the competitiveness of renewable energy technologies	**Fully meets the criteria** Project objectives clearly align to ARENA's legislative objectives to improve the competitiveness of renewable energy technologies. In Australia, grid connected VPPs focus on coordinating rooftop photovoltaic (PV), battery storage and controllable load devices to deliver services traditionally performed by a conventional power plant. The project has driven innovation in smart microgrid management which enables increased integration of renewable energy sources, helping improve the technologies' competitiveness. Importantly the Indra / Monash were developing solutions that were device agnostic. Additionally, Indra / Monash are now developing forecasting software to better maximise value that can obtained from VPP's.		
The project objectives tangibly link to ARENA's legislative objective to increase the supply of renewable energy in Australia	**Fully meets the criteria** The project objectives are clearly tied and link to increasing the supply of renewable energy in Australia. The project has helped demonstrate value streams that can be obtained from smart microgrids, and by doing so, has promoted the uptake of renewable energy in Australia.		
Appropriateness – ARENA's Performance Framework			
The funding provided to the project by ARENA supports technologies that align to ARENA's 'Priority Areas'	**Fully meets the criteria** The project aligns well to ARENA's Priority 1 and Priority 3 as presented in the 2020/21 Corporate Plan, helping integrate renewables and supporting industry reduce emissions.		
Private sector invested in the project		**Partially meets the criteria** Leverage is outside the target range of 1:2 to 1:3. Project leverage was 1:1.41.	
The project intends to advance the TRL and CRI of the proposed technology	**Fully meets the criteria** The technical development and learnings are intended through the development of software to access the VPP value stack.		
Contractual obligations of the individual projects included knowledge sharing products	**Fully meets the criteria** Knowledge sharing products were contractually required including knowledge sharing reports, participation in knowledge sharing workshops and project data.		
The frequency of reporting required (milestones, finances and knowledge sharing) under the funding agreement relative to the nature of the project was sufficient	**Fully meets the criteria** The frequency of reporting was overall sufficient and adequate (each milestone was accompanied by a milestone report).		
Effectiveness			

Criteria	Does not meet the criteria	Partially meets the criteria	Fully meets the criteria
The extent to which the project achieved its stated objective/s	Partially meets the criteria As the project is still in progress, the final outcomes cannot be validated, however the project did achieve initial objectives; • To validate aggregation and control of DER • It validated control within a microgrid. The project has not yet achieved its objective to build a forecasting and optimisation tool for control of assets to maximise the VPP value stack.		
The project delivered benefits across the full range of potential value streams available within its project context	Does not meet criteria The full suite of benefits available from the project have not yet been delivered. Further assessment of the functionality of the forecasting tool and its integration with the Indra platform will better inform this evaluation criteria.		
A qualitative assessment suggests the TRL of the project technology has progressed as a result of the ARENA funding. Note that formal TRL / CRI assessment of the projects shall be completed by Aurecon	Fully meets the criteria There are clear technical learnings from the project, some of which include; • Optimising DER control without physically installing hardware. • The integration and control of DER with the Indra platform. • Validated the ability to access FCAS benefits.		
A qualitative assessment suggests the CRI of the project technology has progressed as a result of the ARENA funding. Note that formal TRL / CRI assessment of the projects shall be completed by Aurecon	Does not meet criteria It is not clear that the commercial readiness of a product has improved. The commercial product may result from the forecasting tool Monash is developing, however it was not clear that there was line of sight to commercialisation of the product.		
The project maps to the DER Technology Integration Functional Framework functional areas which are applicable to VPPs	Fully meets the criteria The project does map to most of functional areas which are applicable to VPPs. Project was captured as a project within the State of Distributed Energy Resources Technology Integration Report, thus has been mapped to the DER Functional Framework		
The project data was provided and collected as contractually required to ARENA	Partially meets the criteria Data collection requirements in the contract were mostly directed at ensuring any material learnings arising from project data were included in knowledge sharing reports. Indra Monash has achieved these requirements. More stringent data collection requirements could have been made by ARENA to ensure the appropriate data was collected.		
The funding recipient will continue its activities beyond the funded project	Not Assessed As the project is ongoing, it is unclear whether activities will or will not continue beyond the funding of the project.		

Criteria	Does not meet the criteria	Partially meets the criteria	Fully meets the criteria
There is evidence of direct beneficiaries of the VPP funding	Partially meets the criteria It is expected that the greatest beneficiaries from the project will be future research institutions that are able to continue the research performed by Indra / Monash. Should a commercial product be available for a wider market, then the wider public shall benefit from the research.		
The knowledge sharing activities enhanced the competitiveness of renewable energy technologies (such activities include, but are not limited to, reports, presentations, workshops, interviews and working groups)	Not Assessed The extent to which the project enhanced the competitiveness of renewable energy technologies is not clear. It is recommended to re-evaluate the effectiveness of the knowledge sharing at the end of the project.		
The knowledge sharing activities better informed the public about renewable energy technologies and the role they can play in Australia's energy transition	Not Assessed The extent to which the project has resulted in a better-informed public is not clear. It is recommended to re-evaluate the effectiveness of the knowledge sharing at the end of the project..		
ARENA's responsiveness to communications requested by the funding recipient was appropriate	Fully meets the criteria ARENA was a supportive partner to work with and was flexible to accommodate for changes arising during the project such as changes to the contract.		
The timeliness of the milestones / progress report assessment process was appropriate	Fully meets the criteria Report from Indra / Monash was that ARENA's assessment process of milestone reports was timely and appropriate.		
Efficiency			
Overall, the program was delivered efficiently, in terms of net benefits per MW of VPP capacity deployed	Not Assessed Project was not deemed suitable for benchmarking against a large scale battery and the VPP aggregation projects.		
The project was efficiently delivered across stakeholders including ARENA	Fully meets the criteria Indra / Monash reported that the project was mostly delivered efficiently, despite the high ARENA turnover of project managers. ARENA provided flexibility in adjustments to the contract which was valuable to Indra / Monash.		

5.7.6 SAPN VPP Evaluation

Table 17 – SAPN VPP Project Specific Evaluation

Criteria	Does not meet the criteria	Partially meets the criteria	Fully meets the criteria
Appropriateness – ARENA's legislated objectives			
The project objectives tangibly link to ARENA's legislative objective to improve the competitiveness of renewable energy technologies	**Fully meets the criteria** Project objectives clearly align to ARENA's legislative objectives to improve the competitiveness of renewable energy technologies. In Australia, grid-connected VPPs focus on coordinating rooftop photovoltaic (PV), battery storage and controllable load devices to deliver services traditionally performed by a conventional power plant. The project has driven innovation in VPP management which enables increased integration of renewable energy sources, helping improve the technologies' competitiveness.		
The project objectives tangibly link to ARENA's legislative objective to increase the supply of renewable energy in Australia	**Fully meets the criteria** The project objectives are clearly tied and link to increasing the supply of renewable energy in Australia. The project has helped demonstrate value streams that can be obtained from VPPs, and by doing so, has promoted the uptake of renewable energy in Australia.		
Appropriateness – ARENA's Performance Framework			
The funding provided to the project by ARENA supports technologies that align to ARENA's 'Priority Areas'	**Fully meets the criteria** The project aligns well to ARENA's Priority 1 and Priority 3 as presented in the 2020/21 Corporate Plan, helping integrate renewables and supporting industry reduce emissions.		
Private sector invested in the project		**Partially meets the criteria** Leverage is outside the target range of 1:2 to 1:3. Project leverage was 1:1.41.	
The project intends to advance the TRL and CRI of the proposed technology	**Fully meets the criteria** The project intended to advance the TRL and CRI of the proposed technology. The main objective of the project was to demonstrate how higher levels of energy exports to the grid from customer solar and battery systems can be enabled through dynamic, rather than fixed, export limits, and to test the value this can create for customers and VPP operators.		
Contractual obligations of the individual projects included knowledge sharing products	**Fully meets the criteria** Knowledge sharing products were contractually required including a single public knowledge sharing report with the final project milestone, participation in knowledge sharing workshops and project data.		
The frequency of reporting required (milestones, finances and knowledge sharing) under the funding agreement relative to the nature of the project was sufficient	**Does not meet criteria** The frequency of reporting was insufficient. Additional public knowledge sharing reports should have been required to keep the public informed of how the project was progressing and to provide lessons learned as the project developed.		
Effectiveness			

Criteria	Does not meet the criteria	Partially meets the criteria	Fully meets the criteria
The extent to which the project achieved its stated objective/s	Fully meets the criteria The project achieved its stated objectives, introducing an API to exchange real-time and locational data on distribution network constraints that enabled the VPP to optimise its output to make use of available network capacity.		
The project delivered benefits across the full range of potential value streams available within its project context	Fully meets the criteria The project enabled the VPP to operate at higher levels of export power than would otherwise have been allowed under normal fixed per-site export limits, providing greater market and system-wide benefits. A shortfall of the trial was that Tesla was not trading in the market throughout the full trial period due to the batteries being part simultaneously of the AEMO trial. This, however, was known from the start of the project (part of the project context).		
A qualitative assessment suggests the TRL of the project technology has progressed as a result of the ARENA funding. Note that formal TRL / CRI assessment of the projects shall be completed by Aurecon	Fully meets the criteria The TRL of the project technology has clearly progressed as a result of the project. The project delivered in terms of developing and testing the API, the technical capability of which was demonstrated. The API aligns with IEEE 2030.5 and is open (i.e. not proprietary). The technical learnings are now being applied in SAPN's solar PV trials for DOEs.		
A qualitative assessment suggests the CRI of the project technology has progressed as a result of the ARENA funding. Note that formal TRL / CRI assessment of the projects shall be completed by Aurecon	Fully meets the criteria The project has progressed the CRI of the technology. The learnings have accelerated the thinking around DOEs and have informed the benefits that can result from them. The FCAS value of VPPs using the API was demonstrated through the trial. The trial was a first in operating a VPP with DOEs, measuring the real-world costs and benefits of doing so.		
The project maps to the DER Technology Integration Functional Framework functional areas which are applicable to VPPs	Fully meets the criteria The project does map to most of functional areas which are applicable to VPPs. Project was captured as a project within the State of Distributed Energy Resources Technology Integration Report, thus has been mapped to the DER Functional Framework		
The project data was provided and collected as contractually required to ARENA	Fully meets the criteria With regards to data collection, the contract was limited to a statement indicating that data collection requirements would be developed in consultation with ARENA during the project. We understand that SAPN met its data collection requirements. More stringent data collection requirements could have been included in the contract to ensure the appropriate data was collected in a timely manner.		
The funding recipient will continue its activities beyond the funded project	Fully meets the criteria SAPN will continue exploring the opportunities of VPPs with DOEs. SAPN is a leader in the development and trialling of DOEs in Australia, with the ARENA-funded trial greatly informing the potential for VPPs with DOEs and the next steps in this space.		

Criteria	Does not meet the criteria	Partially meets the criteria	Fully meets the criteria
There is evidence of direct beneficiaries of the VPP funding	Fully meets the criteria Overall, the trial was informative in growing the VPP market and provided valuable insights with respect to the concept of dynamic, rather than fixed, export limits. The API is open and some uptake has already happened with Rheem using the API for its Active Hot Water Control trial in South Australia. CSIRO was also a beneficiary through the trial, obtaining valuable data and insights which will shape its research activities in this area.		
The knowledge sharing activities enhanced the competitiveness of renewable energy technologies (such activities include, but are not limited to, reports, presentations, workshops, interviews and working groups)	Fully meets the criteria Clear evidence of knowledge sharing activities enhancing the competitiveness of renewable energy technologies. The project has informed several industry bodies including: • The Distributed Energy Integration Program (DEIP) Panel on DOEs • The industry API working group which is helping tailor IEEE 2030.5 to the Australian context • The DNSP reference group with which SAPN has been sharing knowledge regularly.		
The knowledge sharing activities better informed the public about renewable energy technologies and the role they can play in Australia's energy transition	Does not meet criteria A material shortcoming of the project is that no public knowledge sharing reports were produced during the trial, with the first report due following the project's completion. This was a result of the knowledge sharing reports not being tied to project milestones. Although the public will have access to a report when it is published, the timeliness and transparency of the knowledge sharing process were significantly impacted by this arrangement.		
ARENA's responsiveness to communications requested by the funding recipient was appropriate	Fully meets the criteria ARENA was a supportive partner to work with and was flexible to accommodate for changes arising during the project such as shifting the dates of milestones.		
The timeliness of the milestones / progress report assessment process was appropriate	Does not meet criteria ARENA should ensure knowledge sharing reports are required throughout the duration of the trial as opposed to having a single report after project completion.		
Efficiency			
Overall, the program was delivered efficiently, in terms of net benefits per MW of VPP capacity deployed	Not Assessed Project was not deemed suitable for benchmarking against a large-scale battery and the VPP aggregation projects.		
The project was efficiently delivered across stakeholders including ARENA	Partially meets the criteria The project was mostly delivered efficiently with some opportunities for improvement. The funding recipient suggested that ARENA's Master Agreement was somewhat cumbersome to work through, requiring considerable effort before the project could start.		

5.7.7 Tesla VPP Evaluation

Table 18 – Tesla VPP Project Specific Evaluation

Criteria	Does not meet the criteria	Partially meets the criteria	Fully meets the criteria
Appropriateness – ARENA's legislated objectives			
The project objectives tangibly link to ARENA's legislative objective to improve the competitiveness of renewable energy technologies	**Partially meets the criteria** Project objectives somewhat align to ARENA's legislative objectives to improve the competitiveness of renewable energy technologies. In Australia, grid-connected VPPs focus on coordinating rooftop photovoltaic (PV), battery storage and controllable load devices to deliver services traditionally performed by a conventional power plant. The project has driven innovation in VPP management which enables increased integration of renewable energy sources, helping improve the technologies' competitiveness. Additionally, the project tested a new business model for VPP's to support customer uptake.		
The project objectives tangibly link to ARENA's legislative objective to increase the supply of renewable energy in Australia	**Fully meets the criteria** The project objectives are clearly tied and link to increasing the supply of renewable energy in Australia. The project has helped demonstrate value streams that can be obtained from VPPs, and by doing so, has promoted the uptake of renewable energy in Australia.		
Appropriateness – ARENA's Performance Framework			
The funding provided to the project by ARENA supports technologies that align to ARENA's 'Priority Areas'			**Fully meets the criteria** The project aligns well to ARENA's Priority 1 and Priority 3 as presented in the 2020/21 Corporate Plan, helping integrate renewables and supporting industry reduce emissions.
Private sector invested in the project		**Partially meets the criteria** Leverage is outside the target range of 1:2 to 1:3. Project leverage was 1:6.83.	
The project intends to advance the TRL and CRI of the proposed technology		**Partially meets the criteria** The project intended to advance the CRI of the proposed technology by demonstrating the viability of the SA VPP commercial model and the attractiveness of this model to residential customers. The technology itself, however, mostly developed however the commercial model wasn't yet proven as financiers were not willing to fund the ongoing rollout of the model. The project intended to test a new commercial model and improve CRI.	
Contractual obligations of the individual projects included knowledge sharing products			**Fully meets the criteria** Knowledge sharing products were contractually required including knowledge sharing reports, participation in knowledge sharing workshops and project data.
The frequency of reporting required (milestones, finances and knowledge sharing) under the funding agreement relative to the nature of the project was sufficient			**Fully meets the criteria** The frequency of reporting was overall sufficient and adequate, with lessons learnt reports once every quarter and a public knowledge sharing report at the end of the trial.
Effectiveness			

Criteria	Does not meet the criteria	Partially meets the criteria	Fully meets the criteria
The extent to which the project achieved its stated objective/s	Not Assessed The project began in August 2020 and is expected to be completed by 31 August 2022. More time needs to elapse before the extent to which the project achieved its stated objectives can be assessed.		
The project delivered benefits across the full range of potential value streams available within its project context	Not Assessed The project began in August 2020 and is expected to be completed by 31 August 2022. More time needs to elapse before the full range of benefits from the project can be assessed.		
A qualitative assessment suggests the TRL of the project technology has progressed as a result of the ARENA funding. Note that formal TRL / CRI assessment of the projects shall be completed by Aurecon	Not Assessed The project began in August 2020 and is expected to be completed by 31 August 2022. More time needs to elapse before an assessment of the extent to which the TRL of the project technology has advanced can be made. That said, given the technology was for the most part ready at the start of the trial, we expect that not much progress will be made by the end of the project.		
A qualitative assessment suggests the CRI of the project technology has progressed as a result of the ARENA funding. Note that formal TRL / CRI assessment of the projects shall be completed by Aurecon	Not Assessed The project began in August 2020 and is expected to be completed by 31 August 2022. More time needs to elapse before an assessment of the extent to which the CRI of the project technology has advanced can be made.		
The project maps to the DER Technology Integration Functional Framework functional areas which are applicable to VPPs			Fully meets the criteria The project maps to most of functional areas which are applicable to VPPs. Project was not captured as a project within the State of Distributed Energy Resources Technology Integration Report.
The project data was provided and collected as contractually required to ARENA	Not Assessed Given the recent start to the project, data collection requirements as set out in the contract for static and time series data cannot yet properly be assessed.		
The funding recipient will continue its activities beyond the funded project			Fully meets the criteria Tesla is expected to continue its activities beyond the funding period given they own the batteries and the activity lies squarely within its business model. The trial is helping Tesla strengthen relationships with the South Australian Housing Authority as well as other government agencies which are expected to assist Tesla in future ventures.
There is evidence of direct beneficiaries of the VPP funding			Fully meets the criteria Most of the funding has gone towards battery costs, with Tesla the main beneficiary of this.

Criteria	Does not meet the criteria	Partially meets the criteria	Fully meets the criteria
The knowledge sharing activities enhanced the competitiveness of renewable energy technologies (such activities include, but are not limited to, reports, presentations, workshops, interviews and working groups)	Not Assessed Given the recent start to the project, assessing the impact of knowledge sharing activities is premature, with most activities not yet having taken place.		
The knowledge sharing activities better informed the public about renewable energy technologies and the role they can play in Australia's energy transition	Not Assessed Given the recent start to the project, assessing the impact of knowledge sharing activities is premature, with most activities not yet having taken place.		
ARENA's responsiveness to communications requested by the funding recipient was appropriate			Fully meets the criteria So far ARENA has proven to be a collaborative partner and easy to work/communicate with.
The timeliness of the milestones / progress report assessment process was appropriate	Not Assessed Given the recent start to the project, assessing the timeliness of milestone assessments is untimely.		
Efficiency			
Overall, the program was delivered efficiently, in terms of net benefits per MW of VPP capacity deployed			Fully meets the criteria The benchmark used was the cost to deploy a large-scale battery at $827,000/MW. The cost effectiveness of the project was comparable to the benchmark. With project hardware included, the project costs were $713,000 compared to the benchmark.
The project was efficiently delivered across stakeholders including ARENA			Fully meets the criteria So far ARENA has aptly gauged the complexity of the project, getting involved when needed. The funding application was considered to be straightforward by the funding recipient.

5.7.8 Horizon Power VPP Evaluation

Table 19 – Horizon Power VPP Project Specific Evaluation

Criteria	Does not meet the criteria	Partially meets the criteria	Fully meets the criteria
Appropriateness – ARENA's legislated objectives			
The project objectives tangibly link to ARENA's legislative objective to improve the competitiveness of renewable energy technologies	**Fully meets the criteria** Project objectives clearly align to ARENA's legislative objectives to improve the competitiveness of renewable energy technologies. In Australia, VPPs focus on coordinating rooftop photovoltaic (PV), battery storage and controllable load devices to deliver services traditionally performed by a conventional power plant. The project has driven innovation in managing the grid of the future – a grid with high levels of DER penetration – which enables increased integration of renewable energy sources, helping improve the technologies' competitiveness.		
The project objectives tangibly link to ARENA's legislative objective to increase the supply of renewable energy in Australia	**Fully meets the criteria** The project objectives are clearly tied and link to increasing the supply of renewable energy in Australia. The project has helped demonstrate value streams that can be obtained from managing microgrids with high levels of DER penetration, and by doing so, has promoted the uptake of renewable energy in Australia.		
Appropriateness – ARENA's Performance Framework			
The funding provided to the project by ARENA supports technologies that align to ARENA's 'Priority Areas'	**Fully meets the criteria** The project aligns well to ARENA's Priority 1 and Priority 3 as presented in the 2020/21 Corporate Plan, helping integrate renewables and supporting industry reduce emissions.		
Private sector invested in the project	**Fully meets the criteria** Leverage is within the target range of 1:2 to 1:3. Project leverage was 1:2.69.		
The project intends to advance the TRL and CRI of the proposed technology	**Fully meets the criteria** The project intended to advance the TRL and CRI of the proposed technology. Through the trial, Horizon Power sought to resolve the economic and technical barriers of a DER system, furthering the understanding of microgrids with high penetration of solar PV and enabling technologies such as battery storage and communication platforms.		
Contractual obligations of the individual projects included knowledge sharing products	**Fully meets the criteria** Knowledge sharing products were contractually required including knowledge sharing reports, participation in knowledge sharing workshops and project data. The requirements were very clearly detailed and explained, with consideration towards the information to be shared, the intended audience and the frequency of sharing among others.		
The frequency of reporting required (milestones, finances and knowledge sharing) under the funding agreement relative to the nature of the project was sufficient	**Fully meets the criteria** The frequency of reporting was overall sufficient and adequate, with due dates for each specific activity set out in the contract.		
Effectiveness			

Criteria	Does not meet the criteria	Partially meets the criteria	Fully meets the criteria
The extent to which the project achieved its stated objective/s	Fully meets the criteria The project achieved its stated objectives, with VPPs for microgrids becoming a cornerstone of Horizon Power's strategy. The trial has enabled Horizon Power to be in a strong position to target zero refusals for PV connections by 2025.		
The project delivered benefits across the full range of potential value streams available within its project context	Fully meets the criteria The project delivered benefits across the full range of potential value streams. The trial delivered benefits by way of helping identify the most cost-effective way of designing and maintaining a future microgrid with high levels of DER penetration. Horizon Power was able to resolve several economic and technical barriers of a DER system.		
A qualitative assessment suggests the TRL of the project technology has progressed as a result of the ARENA funding. Note that formal TRL / CRI assessment of the projects shall be completed by Aurecon	Fully meets the criteria The TRL of the project technology has clearly progressed as a result of the project. There was a clear step change in the technology over the course of the project. Horizon Power worked with Reposit to improve their technology to address power quality issues in microgrids. In addition, some of the data science and inverter audit processes have become BAU.		
A qualitative assessment suggests the CRI of the project technology has progressed as a result of the ARENA funding. Note that formal TRL / CRI assessment of the projects shall be completed by Aurecon	Fully meets the criteria The project has progressed the CRI of the technology. Horizon Energy has materially improved in its data gathering and processing, allowing it to make better decisions from large amounts of data. The trial also provided the opportunity for Horizon Power to deepen working partnerships with suppliers (such as Reposit).		
The project maps to the DER Technology Integration Functional Framework functional areas which are applicable to VPPs	Fully meets the criteria The project maps to most of the functional areas which are applicable to VPPs. Project was not captured as a project within the State of Distributed Energy Resources Technology Integration Report.		
The project data was provided and collected as contractually required to ARENA	Fully meets the criteria Horizon Power were contractually required to provide extensive and detailed data as part of this trial, including sharing data with CSIRO to be made public through a CSIRO database. Horizon Power provided the data in a clear and engaging manner, with infographics that enhanced the reader's experience and understanding. Partnering with Murdoch University brought a strong data science aspect to the project.		
The funding recipient will continue its activities beyond the funded project	Fully meets the criteria Horizon Power will continue exploring improvements to managing grids with high levels of DER penetration beyond the funding agreement. Horizon power is targeting zero refusals for PV connections by 2025.		

Criteria	Does not meet the criteria	Partially meets the criteria	Fully meets the criteria
There is evidence of direct beneficiaries of the VPP funding	Fully meets the criteria Benefits to Horizon Power comprised a better understanding of the interaction between inverters and network needs, the effects of solar radiation on inverters, including the impact of cloud events on PV fluctuations and how best to manage those impacts, and the amount of PV hosting capacity that the grid can handle. From a customer point of view, benefits flow from Horizon Power being in a better position to assist customers through tariff reform, better network practices for renewable energy integration, and a better understanding of batteries and their performance.		
The knowledge sharing activities enhanced the competitiveness of renewable energy technologies (such activities include, but are not limited to, reports, presentations, workshops, interviews and working groups)	Fully meets the criteria Clear evidence of knowledge sharing activities enhancing the competitiveness of renewable energy technologies. The project provided a strong learning opportunity on how to manage microgrids with high penetration of DER. Horizon Power joined AEMO's API working group which is looking at adapting IEEE 2030.5 to the Australian context. The learnings emanating from the trial have been instrumental for AEMO in its talks with market aggregators.		
The knowledge sharing activities better informed the public about renewable energy technologies and the role they can play in Australia's energy transition	Fully meets the criteria The knowledge sharing activities informed the public about renewable energy technologies. Horizon Power published four papers in journals and have participated in local and international conferences. Their technical reports on ARENA's portal were downloaded both in Australia and abroad, gaining broad interest in the project. ARENA provided good opportunities for Horizon Power to present to industry and create relationships with stakeholders.		
ARENA's responsiveness to communications requested by the funding recipient was appropriate	Fully meets the criteria ARENA was fully responsive and supportive throughout the duration of the trial, proving to be a strong positive force for the project.		
The timeliness of the milestones / progress report assessment process was appropriate	Fully meets the criteria ARENA's assessment process of milestone reports was timely. The funding recipient did not experience any delays in communications, receiving milestone payments, or feedback on milestone reports.		
Efficiency			
Overall, the program was delivered efficiently, in terms of net benefits per MW of VPP capacity deployed	Not Assessed Project not deemed suitable for benchmarking against a large scale battery and the VPP aggregation projects.		
The project was efficiently delivered across stakeholders including ARENA	Fully meets the criteria The project was efficiently delivered across stakeholders. Horizon Power was the main point of contact with ARENA and with Murdoch University which streamlined communications. The partnership and working relationship with ARENA were very strong.		

5.7.9 LO3 VPP Evaluation

Table 20 – LO3 VPP Project Specific Evaluation

Criteria	Does not meet the criteria	Partially meets the criteria	Fully meets the criteria
Appropriateness – ARENA's legislated objectives			
The project objectives tangibly link to ARENA's legislative objective to improve the competitiveness of renewable energy technologies	**Fully meets the criteria** Project objectives clearly align to ARENA's legislative objectives to improve the competitiveness of renewable energy technologies. In Australia, VPPs focus on coordinating rooftop photovoltaic (PV), battery storage and controllable load devices to deliver services traditionally performed by a conventional power plant. The project has assessed the viability of creating a local energy marketplace which enables increased integration of renewable energy sources, helping improve the technologies' competitiveness.		
The project objectives tangibly link to ARENA's legislative objective to increase the supply of renewable energy in Australia	**Fully meets the criteria** The project objectives are clearly tied and link to increasing the supply of renewable energy in Australia. The project intended to demonstrate how local distributed energy resources and demand response can be incorporated into a local energy marketplace to improve the efficiency, security and resiliency of the electricity grid whilst providing economic benefits for participants.		
Appropriateness – ARENA's Performance Framework			
The funding provided to the project by ARENA supports technologies that align to ARENA's 'Priority Areas'	**Fully meets the criteria** The project aligns well to ARENA's Priority 1 and Priority 3 as presented in the 2020/21 Corporate Plan, helping integrate renewables and supporting industry reduce emissions.		
Private sector invested in the project	**Partially meets the criteria** Leverage is outside the target range of 1:2 to 1:3. Project leverage was 1:1.41.		
The project intends to advance the TRL and CRI of the proposed technology	**Fully meets the criteria** The project intended to advance the TRL and CRI of the proposed technology. The trial expected to enable new business models for distribution networks, retailers and other service providers, as well as unlocking additional value for DER owners through the use of innovative technology.		
Contractual obligations of the individual projects included knowledge sharing products	**Fully meets the criteria** The contract required a single knowledge sharing report with the final milestone and at least one presentation at an industry conference. LO3 met these requirements.		
The frequency of reporting required (milestones, finances and knowledge sharing) under the funding agreement relative to the nature of the project was sufficient	**Partially meets the criteria** The frequency of reporting was mostly sufficient given the scale of the project. However, more knowledge sharing reports during the trial would have improved the dissemination of information.		
Effectiveness			

Criteria	Does not meet the criteria	Partially meets the criteria	Fully meets the criteria
The extent to which the project achieved its stated objective/s		Partially meets the criteria The project performed a feasibility on a new operating model for peer to peer trading. The feasibility study tested what was and wasn't economically feasible with the LO3 platform. In doing so, provided lessons on what does and does not work.	
The project delivered benefits across the full range of potential value streams available within its project context	Does not meet criteria The project found insufficient benefits for retailers to obtain support for implementing the technology. Retailers found the payback period of 3 years to be too long and felt that there was not an active role for them to play in the marketplace. Marginal benefits were demonstrated for prosumers.		
A qualitative assessment suggests the TRL of the project technology has progressed as a result of the ARENA funding. Note that formal TRL / CRI assessment of the projects shall be completed by Aurecon		Partially meets the criteria The TRL of the project technology has somewhat progressed as a result of the project. Although the funding went mostly into the feasibility study, an allocation went into refining the technology, with aspects of the auction algorithms and blockchain platforms influenced by the study as well as testing of the data collection capability of LO3's API. The project encountered challenges with achieving interoperability of the technology, aspects of which still require resolving.	
A qualitative assessment suggests the CRI of the project technology has progressed as a result of the ARENA funding. Note that formal TRL / CRI assessment of the projects shall be completed by Aurecon	Does not meet criteria It is unclear how the CRI of the technology progressed as a result of the project. The technology has not yet been proven commercially with costs outweighing benefits.		
The project maps to the DER Technology Integration Functional Framework functional areas which are applicable to VPPs	Does not meet criteria The project maps poorly to the functional areas which are applicable to VPPs. Project was not captured as a project within the State of Distributed Energy Resources Technology Integration Report.		
The project data was provided and collected as contractually required to ARENA			Fully meets the criteria The contract only required relevant data to be included in the milestone report. LO3 met this requirement. More stringent data collection requirements could have been made by ARENA to ensure the appropriate data was collected.
The funding recipient will continue its activities beyond the funded project		Partially meets the criteria It is unclear how LO3 intends on continuing its activities beyond the trial period. It has reduced its presence in Australia to a single part-time employee. That said, LO3 is looking to continue in the Australian market by exploring not just peer-to-peer trading but also communications with inverters to control PV output.	

Criteria	Does not meet the criteria	Partially meets the criteria	Fully meets the criteria
There is evidence of direct beneficiaries of the VPP funding	**Does not meet criteria** There are no clear direct beneficiaries of the VPP funding. The benefits were insufficient for retailers to support the implementation of the technology and prosumers achieved marginal benefits only during the trial.		
The knowledge sharing activities enhanced the competitiveness of renewable energy technologies (such activities include, but are not limited to, reports, presentations, workshops, interviews and working groups)	**Does not meet criteria** It is unclear how the knowledge sharing activities enhanced the competitiveness of renewable energy technologies.		
The knowledge sharing activities better informed the public about renewable energy technologies and the role they can play in Australia's energy transition	**Fully meets the criteria** The knowledge sharing activities informed the public about renewable energy technologies. Competitor firms of LO3 and other parties showed an interest in the knowledge sharing report and L03 received a flurry of queries following a media release as well as invitations to speak at conferences.		
ARENA's responsiveness to communications requested by the funding recipient was appropriate	**Fully meets the criteria** ARENA was good to work with and showed an expedient and responsive approach to interactions.		
The timeliness of the milestones / progress report assessment process was appropriate	**Fully meets the criteria** ARENA's assessment process of milestone reports was timely.		
Efficiency			
Overall, the program was delivered efficiently, in terms of net benefits per MW of VPP capacity deployed*	**Not Assessed** Project not deemed suitable for benchmarking against a large-scale battery and VPP aggregation projects.		
The project was efficiently delivered across stakeholders including ARENA	**Fully meets the criteria** The project was efficiently delivered across stakeholders. Although LO3 found it challenging to work with several project partners, ARENA was not responsible for this. The contracting process was a considerable cost for LO3 being a start up. That said, ARENA was accommodating around IP concerns/requirements from LO3.		

5.7.10 Curtin University VPP Evaluation

Table 21 – Curtin University VPP Project Specific Evaluation

Criteria	Does not meet the criteria	Partially meets the criteria	Fully meets the criteria
Appropriateness – ARENA's legislated objectives			
The project objectives tangibly link to ARENA's legislative objective to improve the competitiveness of renewable energy technologies	**Fully meets the criteria** Project objectives clearly align to ARENA's legislative objectives to improve the competitiveness of renewable energy technologies. In Australia, grid-connected VPPs focus on coordinating rooftop photovoltaic (PV), battery storage and controllable load devices to deliver services traditionally performed by a conventional power plant. The project has driven innovation in governance models to allow shared solar PV, battery and monitoring systems to be used in medium density apartments, helping improve the technologies' competitiveness.		
The project objectives tangibly link to ARENA's legislative objective to increase the supply of renewable energy in Australia	The project objectives are clearly tied and link to increasing the supply of renewable energy in Australia. The project developed a governance framework that overcomes barriers that preclude the uptake of solar PV panels in medium and high density residential developments., and by doing so, has promoted the uptake of renewable energy in Australia.		
Appropriateness – ARENA's Performance Framework			
The funding provided to the project by ARENA supports technologies that align to ARENA's 'Priority Areas'	**Fully meets the criteria** The project aligns well to ARENA's Priority 1 and Priority 3 as presented in the 2020/21 Corporate Plan, helping integrate renewables and supporting industry reduce emissions.		
Private sector invested in the project	**Partially meets the criteria** Leverage is outside the target range of 1:2 to 1:3. Project leverage was 1:1.88.		
The project intends to advance the TRL and CRI of the proposed technology	**Fully meets the criteria** The project intended to advance the TRL and CRI of the proposed technology. The project aimed to provide the basis for unlocking market uptake for solar PV energy solutions within strata developments in Australia, through innovative design, technology and shared governance.		
Contractual obligations of the individual projects included knowledge sharing products	**Fully meets the criteria** Knowledge sharing products were contractually required including knowledge sharing reports, participation in knowledge sharing workshops and project data.		
The frequency of reporting required (milestones, finances and knowledge sharing) under the funding agreement relative to the nature of the project was sufficient	**Partially meets the criteria** The frequency of reporting was overall sufficient and adequate (tied to project milestones). That said, the funding recipient felt that report writing requirements were excessive, with 8 milestone reports over 3 years too demanding of resources.		
Effectiveness			

Criteria	Does not meet the criteria	Partially meets the criteria	Fully meets the criteria
The extent to which the project achieved its stated objective/s	Partially meets the criteria The project mostly achieved its stated objectives by developing a scalable and generalisable model for shared ownership of solar and storage in medium density developments. That said, grid consumption was high during winter (mostly for heating) given insufficient amount of storage and subpar building standards.		
The project delivered benefits across the full range of potential value streams available within its project context	Partially meets the criteria The project attempted to realise benefits to developers, owners, tenants, strata bodies and utilities. The trial benefited developers and the utility by increasing their understanding of how to manage energy systems. However, it was unclear whether customer bills reduced as a result of the trial and challenges emerged for strata in managing the system efficiently and effectively.		
A qualitative assessment suggests the TRL of the project technology has progressed as a result of the ARENA funding. Note that formal TRL / CRI assessment of the projects shall be completed by Aurecon	Fully meets the criteria The TRL of the project technology has clearly progressed as a result of the project. Previous research had developed a governance framework for solar and batteries on small scale strata. The ARENA trial provided a scalable generalisable model for the medium density precinct market. By the end of the project the three trials had been approved by Western Power and were fully implemented.		
A qualitative assessment suggests the CRI of the project technology has progressed as a result of the ARENA funding. Note that formal TRL / CRI assessment of the projects shall be completed by Aurecon	Partially meets the criteria The project has somewhat progressed the CRI of the technology. It implemented a governance framework for batteries greater than 10kWh for the first time, integrating electric vehicle charging and electricity sharing and trading approaches. That said, the trial found there is a need for an intermediary to determine the fair distribution of energy across homes and how the common areas should be treated, two aspects which remained unresolved.		
The project maps to the DER Technology Integration Functional Framework functional areas which are applicable to VPPs	Partially meets the criteria The project maps to some of functional areas which are applicable to VPPs. Project was not captured as a project within the State of Distributed Energy Resources Technology Integration Report.		
The project data was provided and collected as contractually required to ARENA	Fully meets the criteria The contract required real time data as well as qualitative data to be shared through reports and presentations. Curtin University met these requirements.		
The funding recipient will continue its activities beyond the funded project	Fully meets the criteria Curtin University is continuing its activities in this space. It is involved in a new precinct being built which is the next innovation by demonstration project. Curtin University is also building a legacy living lab.		

Criteria	Does not meet the criteria	Partially meets the criteria	Fully meets the criteria
There is evidence of direct beneficiaries of the VPP funding	Partially meets the criteria The main benefits of the trial lie with Development WA who have gained a better understanding of energy orchestration for homes in new precincts. The trial also produced benefits for builders who can market net zero buildings. Benefits to customers were unclear, in particular due to the project not tracking customer bills. Subpar building standards, in terms of insulation and double glazing requirements, meant customers drew high amounts of energy from the grid during winter.		
The knowledge sharing activities enhanced the competitiveness of renewable energy technologies (such activities include, but are not limited to, reports, presentations, workshops, interviews and working groups)	Partially meets the criteria Some evidence of knowledge sharing activities enhancing the competitiveness of renewable energy technologies. The project provided a strong learning opportunity to increase the uptake of solar PV in strata residential developments through governance models. This was pioneering and is being further explored in a subsequent project. The commercial readiness of the models and the extent to which they have enhanced the competitiveness of renewable energy technologies to date is unclear.		
The knowledge sharing activities better informed the public about renewable energy technologies and the role they can play in Australia's energy transition	Fully meets the criteria The knowledge sharing activities informed the public about renewable energy technologies. All the data collected during the trial was shared with 5 universities and with people coming through a living lab in a community hall which was attended by approximately 25,000 people from community groups to developers, local and state government representatives, universities, diplomats among many others.		
ARENA's responsiveness to communications requested by the funding recipient was appropriate	Fully meets the criteria ARENA was highly engaged in project interactions.		
The timeliness of the milestones / progress report assessment process was appropriate	Fully meets the criteria ARENA's assessment process of milestone reports was timely.		
Efficiency			
Overall, the program was delivered efficiently, in terms of net benefits per MW of VPP capacity deployed	Not Assessed Project not deemed suitable for benchmarking against a large-scale battery and VPP aggregation projects.		
The project was efficiently delivered across stakeholders including ARENA	Does not meet criteria The project was not efficiently delivered. The funding recipient found ARENA to be quite bureaucratic to deal with and felt that the project was micromanaged. The contracting period was protracted and seemed unnecessarily complex while project partners were ready to make a start.		

5.7.11 Ergon Retail VPP Evaluation

The funding recipient declined the request to be interviewed. The project evaluation relies exclusively therefore on information held in the public domain and on project-specific documentation received from ARENA. Aspects of the evaluation could not be completed as a result of the lack of an interview.

Table 22 – Ergon Retail VPP Project Specific Evaluation

Criteria	Does not meet the criteria	Partially meets the criteria	Fully meets the criteria
Appropriateness – ARENA's legislated objectives			
The project objectives tangibly link to ARENA's legislative objective to improve the competitiveness of renewable energy technologies	**Fully meets the criteria** Project objectives clearly align to ARENA's legislative objectives to improve the competitiveness of renewable energy technologies. In Australia, grid-connected VPPs focus on coordinating rooftop photovoltaic (PV), battery storage and controllable load devices to deliver services traditionally performed by a conventional power plant. The project has driven innovation in solar plus storage management which enables increased integration of renewable energy sources, helping improve the technologies' competitiveness.		
The project objectives tangibly link to ARENA's legislative objective to increase the supply of renewable energy in Australia	**Fully meets the criteria** The project objectives are clearly tied and link to increasing the supply of renewable energy in Australia. The project has helped demonstrate value streams that can be obtained from solar plus storage, and by doing so, has promoted the uptake of renewable energy in Australia.		
Appropriateness – ARENA's Performance Framework			
The funding provided to the project by ARENA supports technologies that align to ARENA's 'Priority Areas'	**Fully meets the criteria** The project aligns well to ARENA's Priority 1 and Priority 3 as presented in the 2020/21 Corporate Plan, helping integrate renewables and supporting industry reduce emissions.		
Private sector invested in the project		**Partially meets the criteria** Leverage is outside the target range of 1:2 to 1:3. Project leverage was 1:5.55.	
The project intends to advance the TRL and CRI of the proposed technology		**Partially meets the criteria** The project mostly intended to progress the CRI of the proposed technology. Ergon Retail trialled a new business model for providing grid-connected PV and battery systems to residential customers which involved installing the systems at customer premises but retaining ownership and charging the customer a fixed service fee. Although some optimisation to the technology took place as part of the trial, the technology was commercially ready.	
Contractual obligations of the individual projects included knowledge sharing products	**Fully meets the criteria** The contract identifies the data, information and knowledge that would be generated and shared through milestone reports and presentations.		
The frequency of reporting required (milestones, finances and knowledge sharing) under the funding agreement relative to the nature of the project was sufficient		**Partially meets the criteria** The frequency of reporting was overall sufficient and adequate (tied to project milestones) from a contractual point of view. Due to the lack of an interview, we were unable to assess the funding recipient's impression on the frequency of reporting.	

Criteria	Does not meet the criteria	Partially meets the criteria	Fully meets the criteria
Effectiveness			
The extent to which the project achieved its stated objective/s		**Partially meets the criteria** The project somewhat achieved its stated objectives. The pilot identified a number of key success factors that provide a roadmap for refining hybrid energy services as a commercially viable customer offer in future. However, the pilot did not prove commercially viable and customer experience was unsatisfactory overall.	
The project delivered benefits across the full range of potential value streams available within its project context	**Does not meet criteria** Although the pilot was highly informative, benefits did not materialise. Concerns around the reliability of systems and their high ongoing costs, alongside limited customer savings and unsatisfactory customer experience, mean the trial failed to deliver benefits across the potential value streams.		
A qualitative assessment suggests the TRL of the project technology has progressed as a result of the ARENA funding. Note that formal TRL / CRI assessment of the projects shall be completed by Aurecon	**Does not meet criteria** The TRL of the project technology was ready prior to the trial, with Ergon Retail assessing it at the maximum TRL of 9.		
A qualitative assessment suggests the CRI of the project technology has progressed as a result of the ARENA funding. Note that formal TRL / CRI assessment of the projects shall be completed by Aurecon		**Partially meets the criteria** The project has somewhat progressed the CRI of the technology. The pilot demonstration drew on real customer and operational experiences, providing a deeper understanding of the costs and benefits of the model. However, the trial could not prove the viability of this type of model and the pilot was discontinued following the completion of the trial.	
The project maps to the DER Technology Integration Functional Framework functional areas which are applicable to VPPs		**Partially meets the criteria** The project maps to some of functional areas which are applicable to VPPs. Project was not captured as a project within the State of Distributed Energy Resources Technology Integration Report.	
The project data was provided and collected as contractually required to ARENA			**Fully meets the criteria** A detailed data management and transfer plan was specified in the contract. We have no reason to believe Ergon did not meet its requirements.

Criteria	Does not meet the criteria	Partially meets the criteria	Fully meets the criteria
The funding recipient will continue its activities beyond the funded project	**Does not meet criteria** Ergon Energy Retail did not continue the pilot and removed the batteries and associated equipment from customers' premises, with customers offered the option to keep the solar PV systems. Key reasons for not continuing the pilot included: • Concerns over the on-going reliability of the systems • High ongoing costs • Limited customer savings • Risk of continuing poor customer experience.		
There is evidence of direct beneficiaries of the VPP funding	**Fully meets the criteria** The pilot demonstration was highly beneficial for Ergon Retail to assess the commercial and operational viability of the model and help inform it as to when it could proceed to a full commercial launch and scale-up of the service.		
The knowledge sharing activities enhanced the competitiveness of renewable energy technologies (such activities include, but are not limited to, reports, presentations, workshops, interviews and working groups)	**Fully meets the criteria** The trial was innovative and provided important learnings to Ergon which it shared via presentations at key industry conferences and at project-specific workshops, as well as via the final report. Ergon shared information such as the technical performance of the system, the value to the network and its willingness to pay for the services, and key learnings relating to customer response, safety, regulations, and battery standards. These activities are deemed to have enhanced the competitiveness of renewable energy technologies.		
The knowledge sharing activities better informed the public about renewable energy technologies and the role they can play in Australia's energy transition	The knowledge sharing activities seem to have informed the public about renewable energy technologies. Due to the lack of an interview, we were unable to provide specific detail to support the claim further.		
ARENA's responsiveness to communications requested by the funding recipient was appropriate	**Not Assessed** Due to the lack of an interview, we were unable to make an assessment of ARENA's responsiveness.		
The timeliness of the milestones / progress report assessment process was appropriate	**Not Assessed** Due to the lack of an interview, we were unable to make an assessment of the timeliness of reports.		
Efficiency			
Overall, the program was delivered efficiently, in terms of net benefits per MW of VPP capacity deployed	**Does not meet criteria** The benchmark used was the cost to deploy a large-scale battery at $827,000/MW. The cost effectiveness of the project was well in excess of the benchmark. With project hardware included, the project costs were $5,292,929 compared to the benchmark.		

Criteria	Does not meet the criteria	Partially meets the criteria	Fully meets the criteria
The project was efficiently delivered across stakeholders including ARENA	Not Assessed Due to the lack of an interview, we were unable to make an assessment of the efficiency of project delivery.		