Project EDGE

Lesson Learnt Report #2

November 2022

This report has been developed with the support of:

Important notice

PURPOSE

The purpose of this document is to provide an update to the Australian Renewable Energy Agency (ARENA) and the industry regarding progress, preliminary findings, and lessons learnt to date on Project Energy Demand and Generation Exchange (Project EDGE).

This publication has been prepared by AEMO and is generally based on information available to AEMO at 30 November 2022, unless otherwise indicated.

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VERSION CONTROL

Version	Release date	Changes
#1	15/12/2022	Initial release

Executive summary

Project EDGE has entered the operational phase of the trial. Field tests and various research activities are underway to build the evidence base on the most efficient approach to implementing a distributed energy resources (DER) Marketplace that benefits all consumers and industry. The field trial and research activities are testing the core functions of a DER Marketplace that supports the efficient and scalable integration of DER into electricity markets and systems. These functions are wholesale services, local services, and scalable data exchange.

Analysis from the field trial and other complementary research activities such as the consumer insights studies, techno-economic modelling and cost benefit analyses will facilitate the development of insights against research questions and hypotheses. Project EDGE has begun to build the evidence base to inform current and future regulatory reform, market design, and business strategies and investment decisions.

Consumers value financial benefits, trust, transparency, and being able to use their devices when needed

In addition to Mondo, three more aggregators have been onboarded to participate in Project EDGE:

- Discover Energy and Rheem and Combined Energy Technologies (Rheem-CET) are actively operating with their own systems and consumers.
- AGL Energy will be providing insights as a research participant but will not be actively operating in the field trial. AGL is an established Virtual Power Plant (VPP) retailer whose experience will complement Project EDGE learnings with valuable insights from its own VPP trials.

These additional aggregators have diversified the consumer base and DER technologies participating in the trials and will strengthen the robustness of project insights.

The onboarding and consumer acquisition experience of the two new active aggregators has provided preliminary insights into drivers, factors, and business models that encourage consumers to enter and actively participate in a DER Marketplace.

The insights from both new active aggregators in acquiring consumers to their VPP programs and participation in the project largely align with the insights from a consumer insight study conducted by Deakin University (Deakin). While the aggregators' insights reflect a smaller sample and are based on anecdotal evidence, the insights from the consumer study comprise of professional research and a larger sample from all National Electricity Market (NEM) states except Victoria. Nonetheless, similar consumer insights were observed that begin to indicate the primary drivers for consumers joining and participating in VPPs and the business models that could potentially encourage participation.

In terms of consumer segments, the consumer research indicates that innovators, early adopters, and early majority consumer categories appear to have strong interest, and more positive attitude towards adopting DER compared to consumers in the late majority and laggard categories. The earlier adopter categories also tend to be more optimistic about the positive outcomes of DER, and have more positive emotional attitudes towards adopting DER. This indicates that the earlier adopter

categories of consumers are likely to be the initial priority target consumer segments in a nascent DER Marketplace. It also suggests additional work is required to demonstrate the value of adopting DER and participating in VPPs for the late majority and laggard consumer categories.

The aligned insights are summarised in the table below.

Table 1 Summary of aligned insights from the new active aggregators' experience in acquiring consumers and the consumer insights study

Drivers and factors	Description
Reducing electricity bills (financial)	• The primary driver for consumers was reducing electricity bills (monetary savings). Consumers wanted reassurance they would not be financially worse-off and value both immediate (i.e. sign-up and other rewards) and longer-term (i.e. reduce bills and optimisation of their devices) financial benefits. • Overall, business models that are better at reassuring consumers that they will save money and continue to have a reliable supply of power (related to behavioural factors and availability of devices) are more likely to be successful than business models that focus on community and reducing carbon emissions. This is particularly the case for later adopter consumer categories.
Trust (cultural)	• Familiarity with, and trust of, the service provider was a motivating factor. Consumers value reassurance that the aggregator will deliver the value promised. The appeal of a trusted brand could give consumers the confidence that benefits promoted and promises made will be delivered and they will be provided adequate consumer protections. • Consumers in the early majority category were especially likely to identify consumer control, transparency, and consumer safeguards as factors that would enhance their trust in an aggregator. • This indicates that strategies aimed at providing consumers with reassurance in relation to control of their devices (e.g. when and how much energy is exported), transparency (notification for how and when devices are being used) and guaranteed earning will be particularly important to build trust among the early majority.
Transparency and simplicity (financial)	• Consumers valued transparency and simplicity in the business models and service offerings. Consumers are willing to let aggregators utilise their assets if offers are presented to them simply and provide sufficient value over time. Unless a compelling value proposition is clearly and simply communicated, residential consumers are unlikely to perceive a benefit from joining and participating in a VPP. • The early majority consumer group were particularly eager for information to help them decide whether to join an aggregator. Therefore, increasing information availability could help the early majority decide whether to join an aggregator. This suggests additional work is required to enhance the perceived value proposition of adopting DER and joining an aggregator.
Availability of devices (behavioural)	• Consumers wanted reassurance that participation would not affect their daily living standards and use of the DER appliances when they need to use them.

Aggregators can follow AEMO intervention targets when directed during unexpected events, but coordination among actors will be needed to ensure targets are achieved within dynamic network limits

During the declared market suspension in the NEM in June 2022, Project EDGE reacted quickly to establish a test plan to learn from this rare event. AEMO conducted four tests to understand what would need to be considered when directing the market in a high DER future where a greater portion of supply and demand is represented by VPPs.

The key insights from the tests were:

- Aggregators can hit AEMO intervention targets when directed.
- Distribution Network Service Providers (DNSPs) can calculate Dynamic Operating Envelopes (DOEs) to achieve a set point under certain conditions. However, DOEs alone may not elicit an aggregator response that is as accurate as dispatch instructions, because they provide a permissible limit rather than specific instructions.
- In aggregator VPP orchestration, DOEs took priority over dispatch targets to keep the network operating within secure limits (as intended).
- In designing directions to VPPs in future, coordination will be required between AEMO and DNSPs to ensure dispatch targets provided to VPPs are able to be achieved within the DOEs provided by the network.
- Visibility for AEMO of the DOEs was provided by the data exchange hub being trialled in Project EDGE. This scalable data exchange approach allows multiple subscribers to receive certain data, including AEMO and aggregators.
- The importance of AEMO receiving DOEs via a data exchange hub rather than direct point to point integration between each DNSP would be more pronounced for a future where many VPPs need to be directed across many DNSP boundaries.

Early data analysis suggests a gradual approach to achieving aggregator participation in the wholesale electricity market may be appropriate and aligns with the Scheduled Lite approach

One hypothesis being tested in the project is that gradual participation by aggregators allows them to develop their capabilities and sophistication in how they participate in wholesale markets. Gradual participation is the approach proposed by the Scheduled Lite reform[1].

Under that approach, aggregators begin by participating in a Visibility Model and submit information about forecast behaviour and actual consumption and generation to provide operational visibility. Once their portfolio of DER reaches a minimum aggregated capacity threshold, the aggregator can become eligible to participate in the dispatch and scheduling process through a Dispatchability Model.

Analysis of the field trial is at early stages – not all available data has been analysed in detail yet – and is limited to one aggregator to date. While the two most recently enrolled aggregators have begun operating in the field trial, analysis so far has not included their data. Future analysis will include the activities of all three aggregators. Noting that caveat, early results suggest that dispatch target compliance improved as the trial progressed.

[1] AEMO, Scheduled Lite

For some of the first analysis conducted, performance in the second week of the field trial did not improve as expected. However, overall performance gradually improved from week to week. This suggests that aggregators will need time to improve their forecasting and operational capabilities to reach the sophistication required for a dispatchability model, so a stepping-stone approach to participation proposed by Scheduled Lite is likely to be the most appropriate.

The Energy Security Board (ESB) recommended reforms that would open up the ability for consumers with DER to be rewarded for their flexibility through participation in electricity markets via a Trader (an aggregator in the Project EDGE context)[2]. Scheduled Lite is one of these reforms. The reforms would likely see many new entrant aggregators participating in the electricity market who will need time to test the market and their understanding of it, understand their customer base and their DER fleet, and run research and development on their strategies, processes and software.

Early results are beginning to suggest progressive participation will facilitate this process. It is hypothesised that the two new aggregators now actively operating in the trials will have a similar experience with respect to performance gradually improving (noting AGL is not actively operating in the field trial but will be interviewed about its journey into building its VPP capability). Such results would strengthen the primary hypothesis but would also create the need to re-test and analyse once they have developed and refined their processes to appropriately compare field trials.

A theoretical evaluation of the data exchange approaches indicates a data hub approach represents the higher value option for industry and consumers

The evaluation of the three different approaches (point-to-point integration, a centralised data hub, and a decentralised data hub) highlighted that traditional point-to-point data exchange solutions are not efficient and scalable in a high DER future such as that envisaged by the 2022 *Integrated System Plan* (ISP), which estimates greater than 100 gigawatts (GW) of DER in the electricity system by 2050 under the Step Change scenario.[3]

Meanwhile, a data hub – either centralised or decentralised – could make it easier for industry participants to exchange data across various use cases, at lower cost and in a more secure way, resulting in a more affordable and secure system for consumers.

Centralised and decentralised data hub options have relative advantages and disadvantages, but the evaluation identified that theoretically a decentralised hub has the potential to deliver greater benefits in terms of:

- Scalability, stability and resilience.
- Interoperability and being modular and flexible.
- Security, trustworthiness and auditability.
- Accessibility, fairness in terms of cost can be more directly allocated to consumers that benefit from it, and ability to adopt ecosystem wide standards.

If a DER data hub approach is recognised as a more efficient and scalable way to facilitate data exchange, then the following realistic options may be considered:

[2] Energy Security Board, Integration of consumer energy resources (CER) and flexible demand

[3] AEMO, 2022 Integrated System Plan

- Centralised approach: adding DER data exchange use cases (such as DOEs) to the existing e-Hub and Shared Market Protocol.[4]
- Decentralised approach: establishing an alternative decentralised data hub for DER use cases that can operate in parallel, and separately, to the e-Hub.

A cyber security threat assessment on the data exchange approaches reviewed potential cyber security risks associated with DER data exchange and outlined mitigating controls that could lower the residual risk level.

The most material risks, and their mitigating controls, are:

- Vulnerabilities and weakness in the multiple software ecosystems leveraged by DER which could lead to unauthorised access to, and disclosure of, sensitive information.
  - This risk could be mitigated through secure application development processes and appropriate application security controls for all key software components across the DER ecosystem.
- Lack of appropriate management of supply chain risks could lead to data disclosure or unavailability of key DER resources.
  - This risk could be mitigated by cyber security requirements for key suppliers and monitoring information sources to identify and address supply chain risks and threats.
- In an event of a security incident affecting critical assets in the DER marketplace ecosystem, lack of appropriate security controls could lead to significant impact to the confidentiality or availability of the affected DER marketplace entity.
  - Each entity across the DER Marketplace should perform a Business Impact Analysis (BIA) to understand the criticality of its assets and thereby implement appropriate controls to ensure critical assets have the right level of protection against cyber-attacks.

The cyber security assessment identified that with appropriate mitigating controls, a decentralised data hub could deliver a range of benefits for industry and consumers.

Although decentralised approaches may offer greater benefits in theory, it is important to note that decentralised approaches remain relatively immature in the energy sector and will need to develop enterprise grade maturity to realise these benefits for the industry. This could be effectively achieved through a phased implementation of decentralised capabilities.

Implementing a technology approach for scalable data exchange that is novel for the industry will require careful planning and clear information on the deployment experience and long-term benefits for participants

Aggregators were asked to provide feedback on their onboarding experience to the proof-of-concept data exchange platform being tested in Project EDGE. The technology is different to that currently used to integrate with the existing e-Hub used by retailers, network service providers, metering coordinators and others in the Retail market.

[4] The Shared Market Protocol defines the standard for business-to-business communications between the systems of different parties using the e-Hub application programming interface.

The two new active aggregators provided early observations on considerations that will need to be addressed if this data exchange technology is to be implemented operationally after Project EDGE:

- The deployment experience for initial set-up and configuration will need to be streamlined as an 'out-of-the-box product that is easy to install to minimise barriers to adopt the technology for small participants; for example, developing the ability for a container to be created quickly akin to 'platform as a service'.
- Intensive engagement and technical support will be required initially for the first few participants, with clear supporting information setting out the steps required for deployment and ongoing operations.
- Long-term benefits and value to both participants and consumers will need to be clearly demonstrated and communicated as will potential risks and mitigating actions.

The theoretical evaluation, the cyber security threat risk assessment, and the aggregators' experience in implementing the proof-of-concept platform indicate that establishing a new decentralised data exchange approach can only be achieved if the long-term net benefits of doing so are clearly articulated to the industry, including the additional functionalities that could be enabled by decentralised technologies (such as digital identities). The actual transition, however, does not need to be done in a single 'big bang' approach. It could start with specific DER use cases, established on a voluntary basis with a trusted centralised host and with functionality or new use cases added over time as required by industry. In the long run, if a decentralised approach proves its efficiency and scalability benefits, then use cases could be migrated from the e-Hub to the decentralised hub following extensive consultation on practical elements of implementation.

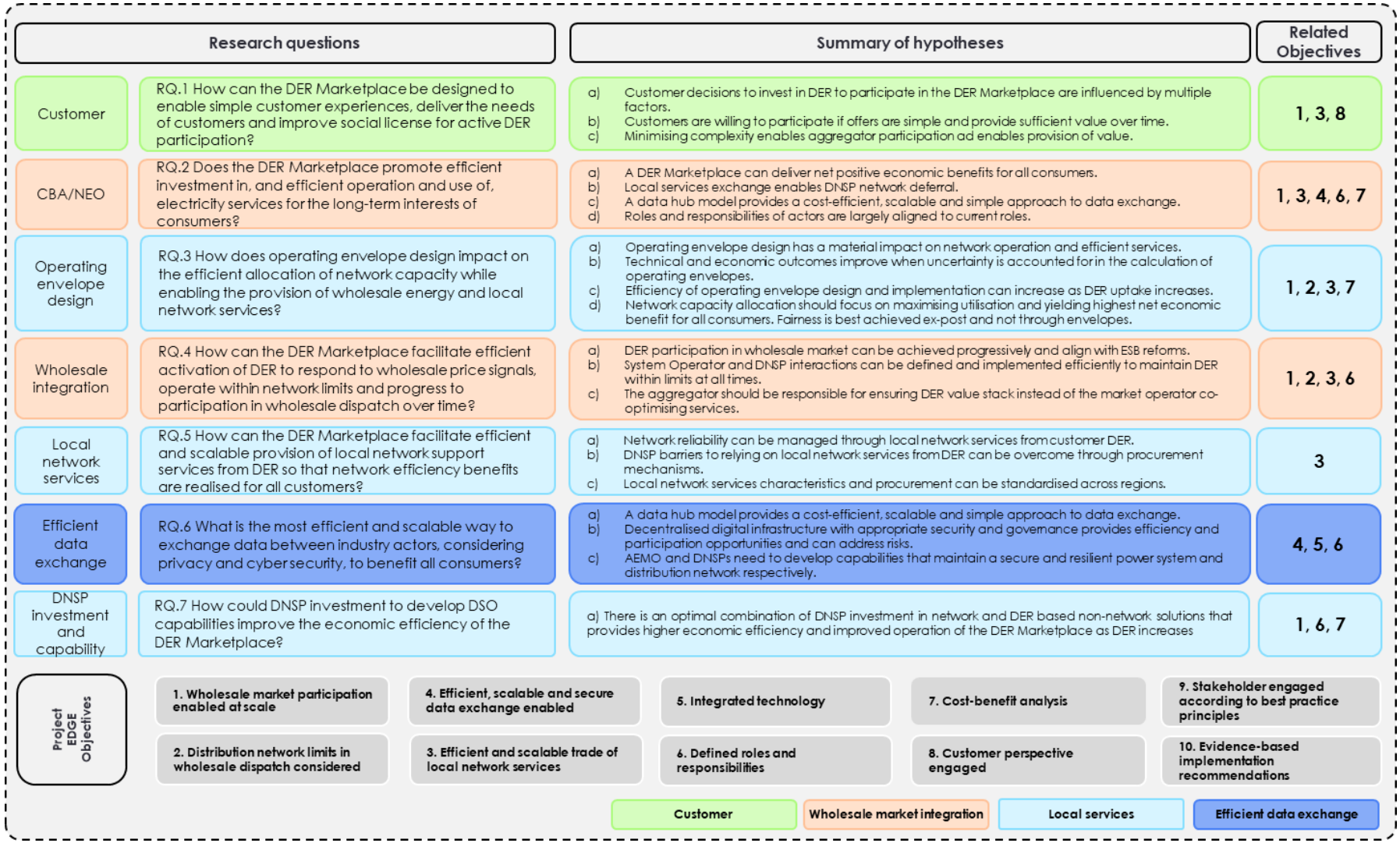
Research questions and their hypotheses are guiding the delivery of the project's objectives

Project EDGE developed and published a research plan that is guiding the delivery of the project and creates a pathway to generating an empirical evidence base[5]. It identifies the activities that are essential and achievable to test research questions and their hypotheses.

Figure 1 summarises the seven research questions, their hypotheses and the related project objectives. Icons denoting these research questions and hypotheses are also in the header of each chapter in this report that contains content relevant to addressing them, for ease of reader navigation.

[5] Project EDGE, Master Research Plan

Figure 1 Summary of Project EDGE research questions, hypotheses and related objectives



Glossary of terms

Term	Definition
AEMO	Australian Energy Market Operator
DOE	Dynamic Operating Envelope
DNSP	Distribution Network Service Provider
EWF	Energy Web Foundation
NEM	National Electricity Market
NEO	National Electricity Objective
UoM	University of Melbourne
VPP	Virtual Power Plant

ARENA summary

Activity title	Project EDGE
Contract Number	2019/ARP051
Recipient	Australian Energy Market Operator Limited, in participation with AusNet Electricity Services Mondo Power
Sub-contractors	Ernst & Young (EY) Nous Group Energy Web Foundation The University of Melbourne Deakin University Opus One Solutions PXiSE Energy Solutions Deloitte Energeia Rheem Combined Energy Technologies Discover Energy AGL Energy
Ref	Lessons Learnt Report #2
Applicable time period	Milestone 5
AEMO contact	Nick Regan

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1 Introduction

Project EDGE has entered the operational phase of the trial to understand how best to implement the Hybrid Model for a DER Marketplace to maximise the efficiency and benefits for consumers and industry. Under the Hybrid Model, wholesale market operation functions are allocated to AEMO while Distribution Network Services Providers (DNSPs) optimise the operation of the distribution system.

Project EDGE is demonstrating an efficient model to operationalise a DER Marketplace by testing the core functions that support efficient and scalable DER integration in the long-term interests of all consumers. These core functions are wholesale services, local services, and scalable data exchange.

The DER Marketplace is not a single, AEMO-run platform or capability. Rather, it is an integrated digital ecosystem that links many systems and capabilities across various industry actors to enable the efficient and scalable exchange of data and services.

The field trial has begun to build the evidence base to demonstrate how a DER Marketplace could be implemented at scale and to inform current and future regulatory reform, market design, and business strategies. The field trial and other research activities are guided by the Research Plan, which is underpinned by the National Electricity Objective (NEO)[6]. They are also guided by a structured trial schedule that maps out research activities and stories that will help in addressing the project's research questions and hypothesis. The project's scientific approach to research and analysis will develop a robust evidence base that can be trusted by government, industry and the community and will be supported by a cost benefit analysis (CBA).

This report builds on the work outlined in the first Lessons Learnt Report[7] and learnings shared in the Project EDGE Interim Report (June 2022)[8].

The Lessons Learnt Report #1 was published in May 2021. It outlined five key challenges, learnings and new practices implemented from the project's inception through to agreement on the design thinking that would be applied to Project EDGE. The lessons provided valuable insights to industry on the formulation of DER market operating models for testing. The key takeout for future design is that the combined knowledge and experience of subject matter experts from the market operator, the DNSPs and the consumer agents (the aggregator in Project EDGE) is critical to appropriately develop and frame the design.

- Effectively collaborating under remote working conditions: The mandatory restrictions in place during the Covid-19 pandemic required the establishment of new ways of working which the project team was able to manage and use to its advantage. For example, virtual workshops and digital tools proved effective at enabling large numbers of participants to join and collaborate. These ways of working have been continued as hybrid working has become common across many organisations. It has become particularly valuable now that additional aggregators have been onboarded and there is a need for broader engagement.

[6] Project EDGE Research Plan

[7] Project EDGE Lessons Learnt Report #1

[8] Project EDGE Interim Report

- Project design requires close collaboration: The relationships among the different functions and design elements of Project EDGE highlighted the importance of effective collaboration and engagement with industry. This led to the establishment of four key stakeholder forums – the Consumer Advisory Group, DER Demonstrations Insights Forum, DER Market Integration Consultative Forum, and Network Advisory Group. Regular engagement continues with these forums to support knowledge sharing.
- Technology development and procurements created challenges that were addressed to support the operation of the project: The project required new technology and platforms to be built or procured to support the scalable data exchange functions being tested and the management of DER within the operating envelopes set by the DNSP. Both AusNet and AEMO successfully procured systems and platforms that are now enabling the operation of the field trial. AusNet procured a DER management system (DERMS) software product for the trial as a tactical solution for BAU needs within the business. AEMO procured a technology solution to facilitate the three core functions of the DER Marketplace being tested. Energy Web Foundation (EWF) was the successful applicant from the procurement process and is playing a critical role in developing a data hub implementation plan.

The Interim Report was published in June 2022.[9] It outlined preliminary findings and lessons learnt and challenges for three key topics:

- The report summarised the finished design of the project. It provided findings from the development of the detailed design, platform builds, and key policy questions and challenges industry will need to work through.
- Summary of the roles and responsibilities of the market and system operator, the distribution system operator (DSO), and the aggregator in Project EDGE and their interaction in the DER Marketplace. It outlined challenges and early findings from each actor (AEMO, AusNet, and Mondo) regarding their development of capabilities required to interact and participate in the DER Marketplace, including aspects of design and technology.
- Outline of the need for scalable data exchange in a decentralised power system and the theoretical efficiencies of the different approaches to data exchange.

While the first Lessons Learnt Report and the interim report highlighted learnings from the development of the design and the final design of the project, now that the field trial has begun and new aggregators are onboarded, this Lessons Learnt Report focuses on sharing early insights and preliminary observations aligned to research questions and hypothesis. The figure below outlines the research questions and hypotheses discussed in this report, and the chapter in which they are discussed.

[9] Project EDGE, Public Interim Report.

Figure 2 Outline of the research questions, hypothesis discussed in this report

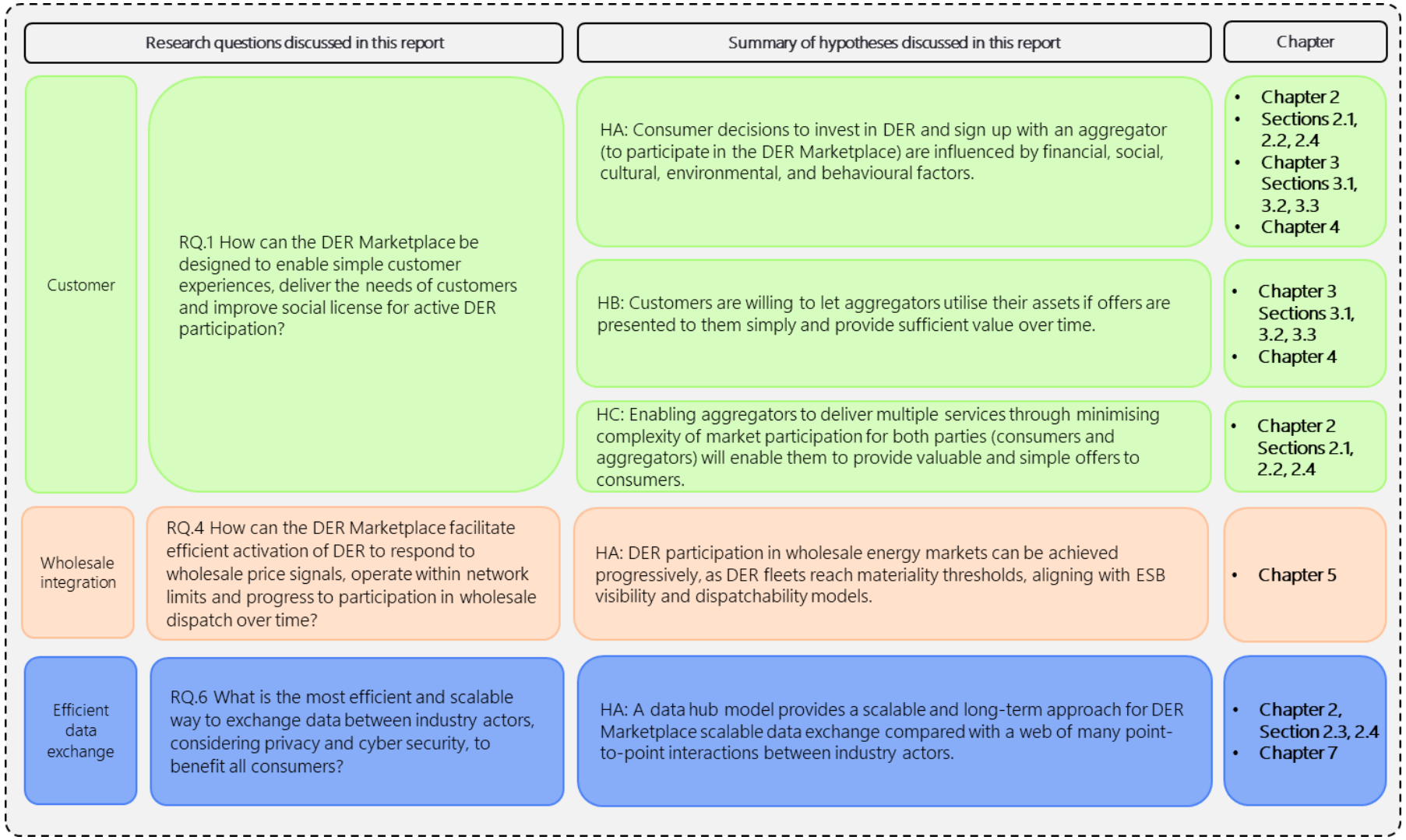
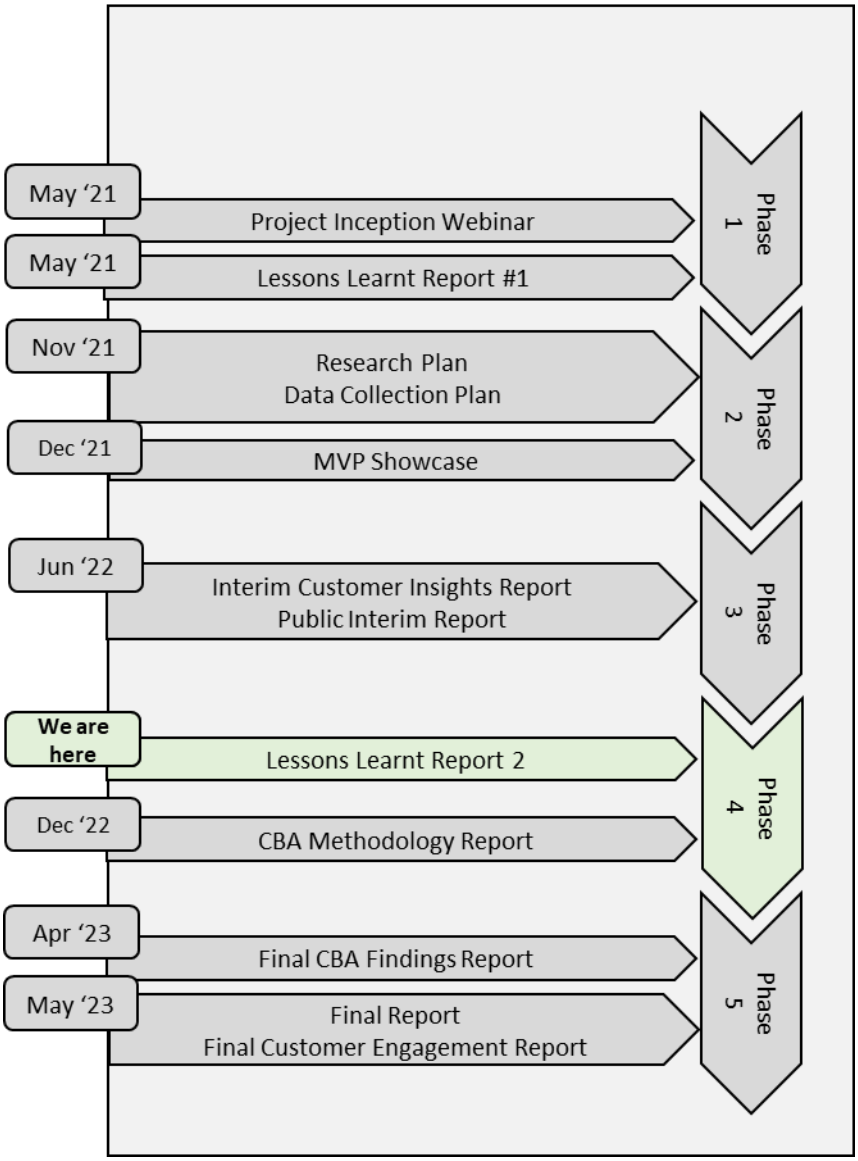


Figure 3 below illustrates where this report fits into the knowledge sharing process.

Figure 3 Knowledge sharing deliverables and this Lessons Learnt Report



Below is an outline of the structure of this report.

- Chapter 2 discusses insights from the experiences of the two additional aggregators participating in the operation of the trial, specifically in relation to consumer acquisition in the context of factors, barriers, and drivers to entry and active participation by consumers. It also focuses on the experience of onboarding to the data hub platform.
- Chapter 3 summarises early insights from Deakin University's consumer insight research, specifically in relation to consumer drivers for joining and participating in a Virtual Power Plant (VPP), and incentives and business models that could encourage participation.
- Chapter 4 aligns the insights from the aggregator consumer acquisition activities and the consumer insight research.

- Chapter 5 summarises early observations from field trial data analysis of aggregator performance with dispatch targets.
- Chapter 6 outlines findings from tests conducted during the National Electricity Market (NEM) suspension event. It focusses on learnings from this rare event to understand what would need to be considered when directing the market in a high DER future where a greater portion of supply and demand is represented by VPPs.
- Chapter 7 provides the findings from a theoretical evaluation of the data exchange options being tested for Project EDGE. Specifically, the evaluation assesses whether a point-to-point architecture or data hub (centralised or decentralised) would best support the NEO and ensure a secure scalable, and interoperable DER Marketplace.
- Chapter 8 outlines the next steps for the project and the next set of knowledge sharing deliverables.
- Appendix 1 provides a visual update on the progress of answering the research questions discussed in this report based on the insights identified to date.
- Appendix 2 provides links to reference material, prior reading, and post-reading related to the subjects discussed in this report.

Icons have been included in the page headers of some chapters. The icons indicate the research question and hypothesis discussed in that chapter and reference the research questions and hypotheses in Figure 2.

RQ.1 HA HC RQ.6 HA

2 Early insights from new participants

Project EDGE entered an exciting new phase in September 2022 with the onboarding of additional aggregators to participate in the DER Marketplace trial alongside Mondo:

- Discover Energy, an energy retailer whose participating consumers have solar photovoltaic (PV) and battery storage systems.
- Rheem and Combined Energy Technologies (CET) (together, Rheem-CET), a hot water systems and services provider whose participating consumers have solar PV, battery storage systems, electric vehicle (EV) chargers, smart hot water systems and energy management systems that can respond to wholesale electricity prices and deliver demand response.
- AGL Energy (AGL) will also be involved as a research participant but will not be actively operating in the field trial. AGL is an established VPP retailer whose experience will provide Project EDGE with valuable insights from its own VPP tests and operations.

The additional aggregators reflect the diversity of potential participant types: Discover Energy and AGL are energy retailers, and Rheem-CET, like founding EDGE aggregator Mondo, is a behind-the-meter aggregator.

This is important because it broadens perceptions of the type of businesses and business models that could participate in a DER Marketplace. Retailers have different risks (e.g. wholesale price exposure for their passive load) and revenue streams to manage. They also have more experience in the market, and in managing risk and consumers. Meanwhile, behind-the-meter aggregators currently have limited ability to participate. The Energy Security Board (ESB) reforms are seeking to address these limitations, and Project EDGE is testing behind-the-meters' ability to participate in practice.

Additionally, this combination of aggregators will diversify the consumer base and DER technologies participating in the trial, and deliver further insights for the Project EDGE evidence base.

The onboarding process for the additional aggregators has provided early insights for some of the research questions and hypotheses relating to:

- Enabling simple aggregator and consumer experiences and participation in a DER Marketplace.
- Connecting to and using the DER data hub being tested for Project EDGE.

This section of the Lessons Learnt Report focuses on early insights for two research questions and associated hypotheses.

Table 2 Research questions and hypotheses in focus for aggregator onboarding and consumer acquisition

Research Question 1	**How can the DER Marketplace be designed to enable simple aggregator and consumer experiences, deliver the needs of consumers, and improve social licence for active DER participation?**
Hypothesis A	Consumer decisions to invest in DER and sign up with an aggregator (to participate in the DER Marketplace) are influenced by financial, social, cultural, environmental, and behavioural factors.
Hypothesis C	Enabling aggregators to deliver multiple services through minimising complexity of market participation for both parties (consumers and aggregators) will enable them to provide valuable and simple offers to consumers.
Research Question 6	**What is the most efficient and scalable way to exchange data between industry actors, considering privacy and cyber security, to benefit all consumers?**
Hypothesis A	A data hub model provides a scalable and long-term approach for DER Marketplace scalable data exchange compared with a web of many point-to-point interactions between industry actors.

To begin answering the research questions and test the hypotheses, Discover Energy and Rheem-CET were consulted to understand their experiences in:

- Attempting to acquire, and successfully acquiring, consumers to participate in the trial.
- Onboarding to the Energy Web Foundation (EWF) data exchange platform.

Mondo was not interviewed for this section because its consumer acquisition experience was discussed in the Project EDGE Public Customer Insight and Engagement Study Interim Report (June 2022)[10].

2.1 Consumer drivers for joining a VPP

Reducing electricity bills, familiarity and trust are key drivers motivating consumers to join a VPP and allow their devices to be used in delivering electricity services

The experience from both aggregators indicates a key driver motivating consumer entry and participation is the potential to reduce electricity bills. Familiarity – either through partnerships with DER device installers and local teams or through a direct existing relationship with the aggregator – appears to be another motivating factor.

Each aggregator's consumer acquisition strategy and value propositions are:

- Discover Energy's consumer acquisition is facilitated by solar PV installers recommending the benefits of joining Discover's VPP program to consumers who are also purchasing a battery.

[10] Project EDGE Public Customer Insight and Engagement Study Interim Report

  - The benefits promoted are a reduction in electricity bills and joining an electricity trading program – specifically by highlighting the ability to trade excess battery capacity and free charging when wholesale prices are negative.
- Rheem-CET acquired consumers under the brand of a subsidiary, Solarhart (referred to as Rheem-CET throughout the rest of this report for consistency with the name of the aggregators participating in Project EDGE).
  - Local teams engaged with existing and new consumers to promote products and offers, including a VPP offer.
  - The benefits highlighted when Rheem-CET was selling its product (a solar-smart electric water heater that works with a consumer's solar panels to capture excess electricity and use it to heat water instead of sending it back to the grid) were also a reduction in electricity bills, and the opportunity for the consumer to optimise solar self-consumption.

Rheem-CET engaged with existing consumers for participation in Project EDGE, highlighting the benefits of greater optimisation of their devices through participation in a marketplace and providing network services.

Consumers were also informed that they would be participating in a ground-breaking trial that could shape the future of DER markets and management of the electricity grid. For new consumers, Rheem-CET promoted its original value proposition with the additional benefits of participation in Project EDGE and its first-of-its-kind concept as an add-on benefit proposition.

Rheem-CET's experience also suggests that familiarity with and trust in the service provider is a motivating factor. It found the appeal of Rheem-CET as a trusted brand gave consumers confidence that benefits promoted and promises made would be delivered and that they would be provided adequate consumer protections.

With respect to participation in Project EDGE, Discover Energy has chosen to enrol its VPP under existing Terms and Conditions and has not used the project as a specific selling point to date, but has shared a $200 bill credit with all participants. Discover Energy's experience as a small electricity retailer during the recent high price events and market suspension in the NEM further strengthen the significance to customers of reducing electricity bills. Discover Energy is a small electricity and gas retailer without a generation or gas portfolio, and as a result given its growth profile more exposed to fluctuations in wholesale prices and given the persistent high gas and electricity prices had no choice but to pass these on to its customers and pulling all market offers from July 2022. This resulted in Discover Energy not acquiring as many consumers as trial participants as it had anticipated. It even led to some consumers switching to other VPP service providers based on its increased usage rates. This indicates that above all, consumers appear to value lower electricity bills and getting the best deal as the main drivers for participation.

Financial benefits and trust, combined with other factors such as transparency and access to devices when required, create better value for consumers

Other factors that are important to consumers when joining a VPP include:

- **Availability of devices and financial reassurance:** Rheem-CET found that another main motivating factor is providing consumers with confidence that participation will not affect their daily living standards. Ultimately consumers wanted availability and use of their DER appliances when they needed them. They also wanted reassurance that they would not be financially worse-off. For example, Rheem-CET's consumers wanted reassurances that they would never run out of hot water and that participation would not lead to higher electricity bills.
- **Financial rewards:** Discover Energy's standard VPP program terms and conditions allow it to take control of their consumers' batteries from time to time to vary the output sent into the grid. Consumers participating in Project EDGE were given the option to opt-out and were provided with a credit on their bill as an incentive to participate.
  - Rheem-CET provides monthly financial incentives that make the program more appealing. This indicates that both immediate (i.e. sign-up and other rewards) and longer-term (i.e. reduced electricity bills and optimisation of their devices) financial benefits can encourage participation.
- **Transparency and simplicity:** Consumers appear to value transparency and simplicity, suggesting that acquisition activities need to be tailored with clear information and a hassle-free onboarding experience.

Further strengthening the significance of trust as a motivating factor, Discover Energy's, and Rheem-CET's experience in acquiring consumers for their VPP programs and the trial highlighted that some consumers have high levels of mistrust for electricity retailers. Consumers were initially reluctant to participate because they were concerned about significant increases in their electricity bills.

Education is also important for many consumers, particularly regarding industry roles and responsibilities; for example, some consumers do not understand the difference between the distributor and the retailer. As most consumers will not buy into something they do not understand, VPP offers should provide simple explanations for how VPPs interact with other industry participants to deliver value.

Consumers also need information about data protection, system security and visibility

Rheem-CET's experience also suggests that, in addition to information about cost reduction and use of their devices, consumers wanted information relating to:

- Data protection.
- Security.
- Visibility of their participation activities.

Consumers wanted assurances that their information and DER appliances would be safe and secure. This was driven by concerns about data breaches and theft, and cybersecurity in terms of their connected devices being hacked. This suggests that service providers will need to provide clear information about the controls that will be established to ensure security of personal data and systems.

Rheem-CET provides consumers with a web app that allows the consumer to see their home management system's activities in real time. This allows consumers to see how the system is performing, view their electricity generation, consumption and savings, and easily communicate with Rheem-CET.

2.2 Incentives and business models encouraging participation

Transparent and well-designed business models that provide consumers with promises of no financial or amenity loss and clear financial value appeal more to consumers

Some of the key elements and incentives of an appealing business model appear to include:

- Assurances to consumers on being able to use their devices when they need it.
- Consumers not being out of pocket.
- Monetary incentives that are sufficient to cover any potential negative financial impacts.

An observation made by Rheem-CET is that most of its consumers were reluctant to enrol their battery systems for aggregation and were only willing to allow their solar-smart electric water heater to be orchestrated. Rheem-CET was unable to identify the reason, but it is something the consumer interviews conducted by Deakin University may be able to answer in due course.

This suggests that business models need to develop a clear value proposition and assurances regarding all devices capable of being controlled. It may be that consumers trusted Rheem-CET to orchestrate its own product but needed more confidence and assurances that the same benefits and protections would be afforded for other devices.

The service offerings and incentive structures offered for Project EDGE are simple and all consumers receive the same incentives regardless of the number and type of DER devices enrolled to participate.

However, Rheem-CET has noted it may develop more complex structures in future such as linking rewards to the type of DER and level of participation in the market. For a nascent market and based on the insights from aggregators relating to familiarity and trust, simpler business models may be more appropriate for new consumers until broader consumer awareness on the benefits of DER market participation are better understood.

Regardless of the simplicity or complexity of incentive structures, Rheem-CET found that consumers value low involvement (but value access to visibility). Consumers appeared to prefer minimum involvement with respect to their participation and orchestration of their DER devices. For example, not having to activate (turn on and off) their appliances.

Discover Energy provided information about Project EDGE to consumers but has generally kept technical terms such as 'bids', 'offers', and 'operating envelopes' out of consumer messaging. Rather, its narrative and business model has been simple. Discover Energy has assured its consumers it will manage the orchestration on their behalf and will maintain 'normal' operation of their devices to the extent possible.

2.3 Data hub onboarding

Implementing a DER data hub beyond Project EDGE would need to be supported by clear and simple information on the benefits to participants and the steps required for efficient deployment

Noting it is a proof-of-concept implementation, the aggregators' onboarding experience and initial use of the EDGE DER Data Exchange Hub (data hub) indicates that if it were to be implemented at scale for use in live energy markets, there will be a need to facilitate easier initial set-up and configuration, and clearer communication to industry of its long-term benefits. While aggregators understood some of the benefits such as simplified coordination and communication among a large volume of participants, there are opportunities to better share the broader benefits and values which a data hub can provide to industry.

Discover Energy found the onboarding experience a smooth process overall. However, it notes improvement opportunities to:

- Centralise all supporting documentation into a single document.
- Develop a clear high-level step-by-step installation and configuration guide for initial setup and full deployment. This would mitigate the need for clarification questions that absorb time and resources.

CET (responsible for the technology in the Rheem-CET partnership) notes the Project EDGE data hub is a different technology implementation than a traditional application programming interface (API) (which is common in the industry) and includes technological elements which are less unfamiliar to industry (including digital identities and decentralised software).

A lack of previous deployment knowledge can lead to setup challenges, so the setup documentation should be clear, simple, and targeted to those with no prior knowledge. This will enable a smoother learning curve and reduce the time and resources required to deploy new technology solutions.

As installation challenges may influence industry perceptions of data hub benefits, the adoption of the specific technological elements from the trial in a data hub for DER beyond Project EDGE will require strong engagement supported by accessible technical support and up-to-date and clear information. Any deployment challenges experienced, and solutions applied to resolve them, need to be recorded to build the knowledge base for industry and make future deployments more efficient and easier. This may require dedicated support by technology providers and market bodies initially until the process is refined to be more efficient. It also suggests that a phased implementation approach for moving toward a decentralised data hub is likely to benefit industry and allow it to progressively implement the necessary systems and capabilities required.

RQ.1 HA HC RQ.6 HA

2.4 Preliminary insights on the hypotheses being tested

Consumer drivers for joining a VPP appear to be influenced primarily by financial, cultural, and behavioural factors and simple offers and experiences

RQ.1 HA HC

The aggregators' experiences so far are supporting two of the hypotheses relating to the research question: How can the DER Marketplace be designed to enable simple aggregator and consumer experiences, deliver the needs of consumers, and improve social licence for active DER participation?

Hypothesis A is that consumer decisions to invest in DER and sign up with an aggregator are influenced by financial, social, cultural, environmental, and behavioural factors. Rheem-CET's experience with selling its solar-smart electric water heater, and later to enrol consumers in its VPP program and Project EDGE suggest the following were influencing factors:

- Financial.
- Behavioural (no impact to daily living standards).
- Cultural (transparency, and trust and familiarity with providers).

Similarly, Discover Energy's value proposition on financial benefits, and its experience during the unprecedented high price events in energy markets, further indicate financial factors are a key driver for participation.

The experience of both aggregators also begins to support hypothesis C that enabling aggregators to deliver multiple services by minimising complexity of participation (for both aggregators and consumers) facilitates valuable and simple offers. Both aggregators observed that consumers value simple and transparent offers, and an experience that minimises complexity of participation on their part. However, this hypothesis cannot be fully tested without the local services exchange function being tested (since that involves multiple services). Field trials testing the local services exchange have been scheduled.

Enabling simple aggregator experiences can be achieved by simplifying the process to exchange data to support gigawatt-scale aggregated DER delivering electricity services

RQ.6 HA

Research question 6 seeks to identify the most efficient and scalable way to exchange data between industry actors, considering privacy and cyber security, to benefit all consumers. The desired benefits of an approach could be undermined if the initial implementation in live energy markets is not efficient. If significant challenges compound implementation costs and effort, this will in turn create challenges for bringing industry along on the journey to adopting new technological elements in a DER data hub if they are different to the existing retail market data hub, the e-Hub. A decentralised data hub introduces new technological elements to industry to make the existing concept (the e-Hub, with which participants are familiar) more efficient and scalable. This suggests that benefits of the preferred approach need to be clearly demonstrated and communicated, and supported by clear information and an efficient deployment experience.

RQ.1 HA HB

3 Early insights from consumers

Consumers are the heart of a DER Marketplace. It is critical that trust and social licence is established to facilitate active participation. It is also critical that a DER Marketplace is designed to incentivise consumer participation through compelling offers and services that optimise the value of consumer's investments.

To better inform the design of a future DER Marketplace, Project EDGE engaged Deakin University (Deakin) to conduct several consumer research activities as part of a multi-year program. Deakin recently (November 2022) completed and shared findings from a survey of 893 residents of New South Wales, Queensland, South Australia, and Tasmania[11]. The objective of the survey was to understand how the general community (those not participating in Project EDGE, which is being trialled in Victoria) perceive DER and aggregators. The study used innovation adopter categories to enable a focus on drivers of intention to purchase DER and join an aggregator within the early majority. This study built on an extensive literature review of Industry, Government Report and Academic literature to capture the current state of Australian knowledge of customer insights relating to Distributed Energy Resources[12]. The literature review found a range of research gaps including that substantially more is known about early adopters than about other customer segments.

Understanding this cohort's drivers is of critical importance for the industry to reach the critical mass of consumers required to propel the activation of DER within VPP portfolios into the mainstream and realise the associated benefits of consumer rewards, overarching power system stability and decarbonisation at scale.

The key focus areas of the research were:

- Whether perceptions differed by consumer segment (solar panel status and innovation adopter category).
- What factors predict intention to purchase DERs and join an aggregator.
- What strategies could enhance trust in aggregators.
- The perceived fairness of different policy options for integrating DER into the NEM.

In June 2022, Deakin also shared findings from interviews with residential consumers with varying experience with VPP trials and programs, including Project EDGE. The key objective of this research was to understand the motivators and barriers for joining a VPP and to examine perceptions of VPPs more broadly[13]. In this section of the report, when discussing key learnings from the most recent survey, reference to 'participants' means consumers who participated in the survey.

[11] Project EDGE and Deakin University, General Community Perceptions of Distributed Energy Resources

[12] Project EDGE and Deakin University, Gaps in Existing DER Customer Insights Research

[13] Project EDGE and Deakin University, Consumer Insights Interim Report

RQ.1 HA HB

These focus areas provide early insights for the research questions and associated hypotheses outlined in the table below.

Table 3 Research questions and hypotheses in focus for aggregator onboarding and consumer acquisition

Research Question 1	**How can the DER Marketplace be designed to enable simple aggregator and consumer experiences, deliver the needs of consumers, and improve social licence for active DER participation?**
Hypothesis A	Consumer decisions to invest in DER and sign up with an aggregator (to participate in the DER Marketplace) are influenced by financial, social, cultural, environmental, and behavioural factors.
Hypothesis B	Customers are willing to let aggregators utilise their assets if offers are presented to them simply and provide sufficient value over time.

3.1 Early adopters and early majority consumers have stronger interest in adopting DER

RQ.1 HA

Deakin's research on general community perceptions segmented participating consumers on their self-identified adopter category[14]. Consumers were asked to select one of the labels below that they believed best represented their pattern of energy technology adoption.

- Innovator: 'I like to be one of the very first to try new energy technologies.'
- Early adopter: 'I like to be a leader in trying new energy technologies.'
- Early majority: 'I like to hear about other peoples' experiences before I try new energy technologies.'
- Late majority: 'I only try new energy technologies when the people I trust have already done so.'
- Laggard: 'I don't see much need for trying new energy technologies.'

Participating consumers were also categorised into two segments – those who already have rooftop solar panels on their primary place of residence and who do not. This is on the basis that consumers who already have direct experience with DER may hold different perceptions and intentions toward adopting other DER and joining an aggregator. Additionally, consumers who already own solar panels are closer to having the necessary DER to join VPP programs.

Deakin's research identified that among consumers who do not own solar panels, innovators, early adopters and early majority categories had stronger interest in, and more positive attitude towards. adopting DER compared to consumers in the late majority and laggard categories. This suggests that consumers in the late majority and laggard categories are unlikely to be initial priority target consumer segments for businesses seeking to rapidly increase the uptake of DER technology.

[14] Project EDGE and Deakin University, General Community Perceptions of Distributed Energy Resources

RQ.1 HA HB

Emotional attitude, rather than rational attitude, towards adopting DER is another differentiator among the innovators, early adopters and the early majority consumer categories, and the other adopter categories. This indicates that building excitement and other positive emotional attitudes may be more persuasive among the earlier adopter categories. Similarly, innovators, early adopters and the early majority tend to be more optimistic about the benefits from their adoption of DER compared to the other adopter categories This indicates the earlier adopter categories are likely to be more optimistic about the potential for DER technologies to increase personally relevant outcomes.

Additional insights regarding perceptions of DER based on consumer category segments is outlined in the Project EDGE knowledge sharing report, General Community Perceptions of Distributed Energy Resources[15].

3.2 Consumer drivers for joining a VPP

Key drivers for joining a VPP are different for different types of consumer groups

RQ.1 HA HB

Monetary savings and trust are key drivers for potential residential consumers. On average, participants that are not current consumers for a VPP program, were 'moderately interested' in both adopting DER and joining an aggregator. However, interest was higher among participants who perceived 'saving money' and 'having a reliable supply of power' as key outcomes associated with adopting DER and joining an aggregator.

While 25% of participants indicated that they would trust an aggregator to access and export their stored power, the majority (60%) were unsure. However, three key mechanisms were identified by participants as ways to enhance their trust in an aggregator:

- Consumer control (the ability to determine when and how much power could be exported).
- Transparency (pre- and post-export notifications).
- Consumer safeguards (guaranteed financial earnings).

Meanwhile, social, environmental and behavioural factors are key drivers for consumers already participating in a VPP. For this consumer group, participation in Project EDGE was motivated by a desire to support the community, help the environment, and enhance energy self-sufficiency. Conversely, the major barrier to participation was the cost of purchasing a battery.

Commercial and industrial (C&I) consumers appear to have a broader set of drivers ranging from financial through to environmental. C&I consumers perceived a range of current or potential benefits for adopting energy offerings like Project EDGE, including taking tangible climate action, enhancing energy resilience, sharing power across dispersed facilities, sharing power with the community, and receiving energy consumption insights. Despite these benefits, however, most interviewees indicated that adoption interest within their organisation would likely be limited.

[15] Project EDGE and Deakin University, General Community Perceptions of Distributed Energy Resources

RQ.1 HA HB

3.3 Incentives and business models encouraging participation

RQ.1 HB

For potential residential consumers, adopting DER and joining an aggregator were seen as yielding similar outcomes. This suggests that little incremental benefit was perceived for joining an aggregator over and above adopting DER. The one exception was 'helping the community', which was seen as more likely to occur from joining an aggregator (versus simply adopting DER). Additional work is therefore required to both develop and communicate a compelling value proposition for joining an aggregator.

Consumers already participating in a VPP were prepared to trade their stored energy, but only once their own household energy requirements were assured. Feeding into this attitude was the sense of ownership that some participants felt over the power they had generated. Many participants also expressed a concern that their current battery had insufficient capacity to meet their existing needs, let alone to also support trading.

C&I consumers saw the financial case for participation as being weak, driven primarily by the current cost of batteries and their lengthy associated payback periods. However, the payback periods that C&I boards were willing to accept was not uniform. For example, while some boards required payback periods of two-to-five years, others would potentially be comfortable with payback periods of up to ten years, provided adoption was strongly aligned with the C&I consumer's mission. This indicates that business models for C&I consumers need to provide compelling financial incentives and value propositions to encourage participation. The needs of C&I consumers may help to improve the financial attractiveness of adoption in certain contexts, particularly if financial value can be attached to the broader benefits that adoption can bring. Grant funding, community support for adoption, and successful C&I adoption case studies were also seen as helping internal champions more effectively advocate for adoption.

3.4 Preliminary insights on the hypotheses tested

Consumer drivers for joining a VPP appear to be influenced by a spectrum of drivers, including financial, environmental and behavioural but differ across different consumer groups

RQ.1 HA HB

The consumer research conducted by Deakin so far is supporting two of the hypotheses relating to the research question: How can the DER Marketplace be designed to enable simple aggregator and consumer experiences, deliver the needs of consumers, and improve social licence for active DER participation?

Hypothesis A is that consumer decisions to invest in DER and sign up with an aggregator are influenced by financial, social, cultural, environmental, and behavioural factors. The consumer research on potential residential consumers, existing VPP program consumers, and C&I consumers suggests all five are influencing factors

- Financial ('saving money' and guaranteed financial earnings).

- Social ('helping the community').
- Cultural (trust).
- Environmental (climate action).
- Behavioural (no impact to daily living standards).

However, the influencing factors were different depending on the consumer group. Potential consumers are primarily driven by monetary savings and financial incentives, and trust. Meanwhile, consumers with experience participating in a VPP program appear to primarily be influenced by social, environmental and behavioural factors. There are various perceived benefits for C&I consumers, yet despite these, most indicated there is likely to be limited interest within organisations unless business models have a compelling value proposition – suggesting the primary driver for C&I consumers is financial.

The consumer research also begins to support hypothesis B, that consumers are willing to let aggregators utilise their assets if offers are presented to them simply and provide sufficient value over time. This was the view shared by both residential and C&I consumers. However, potential residential consumers did not perceive incremental benefit from joining a VPP over and above adopting DER suggesting that business models need to communicate a compelling value proposition clearly and simply. Similarly, business models for C&I consumers may be more successful if financial value is attached to the broader benefits that adoption can bring.

In terms of consumer segments, the consumer research indicates that innovators, early adopters, and early majority consumer categories appear to have strong interest, and more positive attitude towards adopting DER compared to consumers in the late majority and laggard categories. The earlier adopter categories also tend to be more optimistic about the positive outcomes of DER, and have more positive emotional attitudes towards adopting DER. This indicates that the earlier adopter categories of consumers are likely to be the initial priority target consumer segments in a nascent DER Marketplace. It also suggests additional work is required to demonstrate the value of adopting DER and participating in VPPs for the late majority and laggard consumer categories.

RQ.1 HA HB

4 Alignment between EDGE aggregator and consumer insights

The insights provided by aggregators in the trial (summarised in Chapter 2) and Deakin's consumer study (summarised in Chapter 3) largely align in relation to the early adopter consumer categories. The consumer insights research conducted by Deakin comprises professional research conducted with a large sample from all NEM states except Victoria. Meanwhile, the consumer insights provided by the new active aggregators' (Discover and Rheem-CET) comprises anecdotal evidence from their consumer recruitment and from a much smaller sample. Nonetheless, aggregators observed similar consumer insights. The alignment between the insights is outlined in this chapter.

4.1 Consumer drivers for joining a VPP

Financial and behavioural factors are key drivers for joining a VPP

RQ.1 HA HB

Deakin's study identified key drivers for joining are different for different types of consumer groups. Potential residential consumers are influenced by monetary savings and trust of the aggregator. Three elements were identified as building trust:

- The ability to retain ultimate control over when and how much stored power can be exported.
- Transparency and notifications on when export will be, and has been, activated.
- Guaranteed financial earnings.

Consumers in the early majority category were especially likely to identify consumer control, transparency, and consumer safeguards as factors that would enhance their trust in an aggregator. This indicates that strategies aimed at providing consumers with reassurance in relation to control of their devices (e.g. when and how much energy is exported), transparency (notification for how and when devices are being used) and guaranteed earning will be particularly important to build trust among the early majority.

This aligns with the experience of both Discover and Rheem-CET and their acquisition of residential consumers. The aggregators' insights indicate that the potential to reduce electricity bills and trust of the service provider is a motivating factor for consumers joining a VPP. Consumers also appear to value the availability of devices (use of their devices when they need it) and financial reassurance they

RQ.1 HA HB

will not be financially worse off. The aggregators' experience also indicates consumers value financial rewards, and visibility of their participation activities.

4.2 Incentives and business models encouraging participation

Business models need to communicate compelling and simple offers and provide a 'hassle-free' consumer experience

RQ.1 HB

A key insight from the consumer study was that potential residential consumers perceived little incremental benefit for joining an aggregator over and above adopting DER, the exception being a driver to help the community which was perceived as a more likely outcome from joining an aggregator rather than simply adopting DER. The early majority consumer group was particularly eager for information to help them decide whether to join an aggregator. Therefore, increasing information availability could help the early majority decide whether to join an aggregator. This suggests additional work is required to enhance the perceived value proposition of adopting DER and joining an aggregator.

Meanwhile, consumer insights from EDGE aggregators were that consumers value financial rewards, transparency and simplicity. This suggests some alignment between the consumer research insights and aggregator experience insights, in that acquisition activities need to be tailored with clear information and an easy onboarding experience to encourage participation. The consumer research insights and aggregator experience insights also indicates business models need to clearly communicate a simple and compelling offer that provides value to consumers.

A key consumer study insight regarding consumers already participating in a VPP is that they want to maintain ultimate control over their devices and for participation not to impact their regular behaviour and use of devices. This was evident in the finding that consumers were willing to agree to trade stored energy but only once their household energy needs were assured. Consumers wanted reassurance their battery would be able to meet their day-to-day needs. This presents another alignment with the insights from the EDGE aggregators' experience. Aggregators identified a key element of an appealing business model appears to include assurances to consumers on being able to use their devices when they need it (i.e. that participation will not affect their daily living standards).

Overall, business models that are better at reassuring consumers that they will save money and continue to have a reliable supply of power are more likely to be successful than business models that focus on community and reducing carbon emissions. This is particularly the case for later adopter consumer categories. Deakin's research, and the aggregators' experience indicates that considerations around cost savings are likely to play a central role influencing whether consumers choose to adopt DER or join an aggregator. Perceptions identified regarding reliable power supply and being able to use devices and appliances when consumers need them, also indicates that additional work is needed to better explain the benefits and capabilities of DER and aggregators to the broader community through enhance energy resilience both at a household level and for the NEM.

RQ.1 HA HB

4.3 Alignment of preliminary insights on the hypotheses being tested

RQ.1 HB

Both the consumer study insights and the aggregator customer acquisition experience insights related to the research question: How can the DER Marketplace be designed to enable simple aggregator and consumer experiences, deliver the needs of consumers, and improve social licence for active DER participation?

The alignment of insights so far between the consumer insights study and the acquisition experience of the two new aggregators in the trial is indicating that:

- Simple consumer experiences that deliver the needs of consumers and improve social licence can be enabled through simple and compelling offers that provide sufficient value to consumers.
- Aggregators are more able to provide simple and compelling offers to consumers if they are able to deliver electricity services (both wholesale and local) in a simple and consistent way across jurisdictions.
- A consumer's decision to sign up with an aggregator and participate in the DER Marketplace is influenced by a range of factors, but the primary drivers are:
  - Financial (monetary savings, and financial rewards and incentives).
  - Cultural (trust that the aggregator will deliver the value promised and the consumer will not be worse off).
  - Behavioural (assurances that participation will not impact the daily living standards of consumers and devices will be available for use when needed).
- Consumers are willing to let aggregators utilise their assets if offers are presented to them simply and provide sufficient value over time. The critical insight here however is that unless a compelling value proposition is clearly and simply communicated, consumers are unlikely to perceive a benefit from joining and participating in a VPP.
- These factors are generally consistent among the early adopter categories and the later adopter categories. However, early adopters are more likely to have stronger interest in, and more optimistic and positive attitudes towards, adoption of DER and participating in a VPP compared to later adopters.

5 Early data observations

The Project EDGE field trial began in early May 2022. The field trial involves 24/7 operation of the EDGE marketplace and dispatch of aggregators with AEMO, DNSP and aggregator functionality kept in synch by cycling though different trial 'modes' across weekdays, weekends and seasons. Modes are a set of DNSP and aggregator system settings designed to separate variables for testing. These include different approaches to the construction of bi-directional offers (boffers) that aggregators submit to the market operator via the trial's data exchange hub. The different modes also vary in terms of the DOE frequency and calculation and whether it comprises active or reactive power, or both. The modes also change with the bidding purpose of the boffer. This reflects a gradual approach for aggregator participation, ranging from:

- Visibility to provide operational visibility with no market participation.
- Self-dispatch to provide operational visibility and with passive market participation.
- Scheduled to provide operational visibility and with active market participation.

Mode	OE Frequency	DOE calculation	OE Active vs. Reactive	DOE Objective function	Bidding Type	Bidding	Bidding Qty	Dispatch instruction
1	Day ahead	Network + approximation	Active only	Equal allocation	Scheduled bidding	Visibility	Net NMI	Not actioned
2	Day ahead	Network only	Active only	Max service	Scheduled bidding	Visibility	Net NMI	Not actioned
3	Day ahead	Approximation only	Active only	Max service	Scheduled bidding	Visibility	Net NMI	Not actioned
4	Day ahead	Network + approximation	Active only	Max service	EFL	Self-dispatch	Net NMI	Actioned
5	Day ahead	Network + approximation	Active only	Max service	Scheduled bidding	Scheduled	Net NMI	Actioned
6	Day ahead	Network + approximation	Active only	Max service	Scheduled bidding	Scheduled	Flex	Actioned
7	Intra-day	Network + approximation	Active only	Max service	Scheduled bidding	Scheduled	Net NMI	Actioned
8	Intra-day	Network + approximation	Active + Reactive	Max service	Scheduled bidding	Scheduled	Net NMI	Actioned
9	Intra-day	Network + approximation	Active + Reactive	Max service	Scheduled bidding	Scheduled	Flex	Actioned

The table above describes the mode schedules that will be tested through the field trial tests.

Table 4 below describes in detail the various characteristics that comprise a mode, and it shows which modes apply different approaches to each characteristic.

Table 4 Description of mode characteristics

Characteristic	Description	
DOE frequency	The frequency of publication of DOEs. NMI level DOEs are published by the DNSP and provided to the aggregator and AEMO for the purpose of applying distribution network limits to customer imports and exports during wholesale and local network services provision.	
	Approach 1	Approach 2

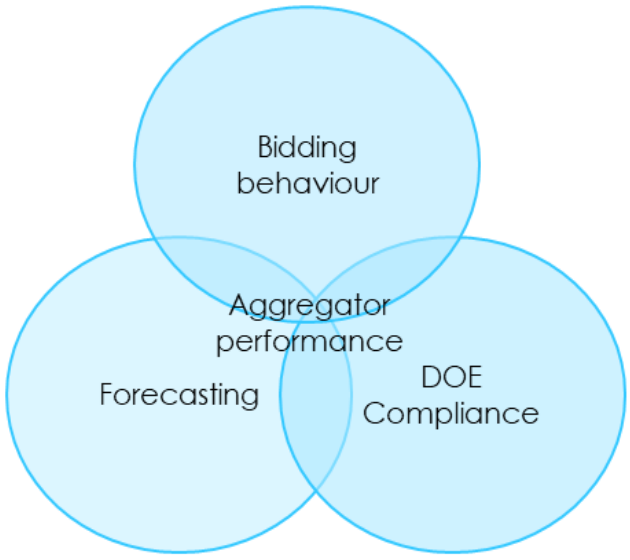
Characteristic	Description		
	Published once a day – a day-ahead of trading day.	Intra-day updates – day ahead and trading day updates. The frequency is yet to be determined.	
DOE calculation	Two methods of calculating the available network capacity are tested – one uses an iterative linearised load flow calculation to determine the export and import power limits using accurate LV network electrical model data and passive customer load/generation forecasts (Network). The other (Approximation) estimates the capacity in a heuristic manner by using data analytics relying on historical network data and smart meter measurements plus forecasting.		
	Approach 1	Approach 2	
	Network and approximation.	Approximation only.	
DOE active vs reactive	Whether the DOE comprises active power or both active and reactive power. Active power (real power) is the actual amount of power being transferred and used. Reactive power is the 'non-real' power (Var) that is needed to support the transport of Active power in the network. By injecting or absorbing Var in a supporting manner, Active power DOEs can be enlarged.		
	Approach 1	Approach 2	
	Active power import and active power export.	Active power import and active power export. Reactive power injection and absorption.	
DOE objective function	The objective function of the DOE calculation. It is how allocation of network access capacity to a network connection point is determined.		
	Approach 1	Approach 2	
	Equal allocation: This aims to ensure a fair allocation of network capacity among multiple active customers. Each customer is allocated with the same DOE.	Maximise service: This aims to maximise the total volume of export/imports from active customers.	
Bidding type	A boffer represents the aggregator's whole portfolio (i.e. all registered NMIs). The boffer can contain prices and band availability or only quantity. A boffer communicates the aggregator's intent to the market and provides visibility of the price responsiveness of the portfolio and an operational forecast.		
	Approach 1	Approach 2	
	Price/quantity pairs in 20 price bands.	Energy Fixed Load (EFL) which is quantity only. The boffer provides Dispatchable Unit Identifier (DUID) level forecast and the aggregator self-forecast is often the dispatch target for the dispatch interval.	
Bidding	This represents the purpose of the boffer and ranges from passive participation to active participation.		
	Approach 1	Approach 2	Approach 3
	Visibility: Bidding provided for operational visibility.	Self-Dispatch: Passive market participation and prices submitted do not influence clearing price calculation.	Scheduled: Active market participation and price setting boffers.

Characteristic	Description		
Bidding quantity	This is the definition of where the offering quantity is measured.		
	Approach 1	Approach 2	
	Net NMI: the aggregated net connection point flow measured at the NMI (Net NMI). Includes both controllable and uncontrollable assets.	Flex: the aggregate of all controllable devices measured at a real or virtual measurement point.	
Dispatch instruction	AEMO will generate and send dispatch instructions as it does currently in the NEM. The Bidding characteristic will determine if aggregators are required to act on and respond to the dispatch instructions.		
	Visibility	Self-Dispatch	Scheduled
	The aggregator is not required to act on or respond to dispatch instructions.	The aggregator is required to act on and respond to the dispatch target.	The aggregator is required to act on and respond to the dispatch target.

The data provided from the field tests of the various modes will be used to analyse multiple research activities, each aligned to at least one research question and hypothesis.

Analysis so far has focused on analysing aggregator performance against targets within dispatch instructions. There are several other research activities connected to this set of results. Overall aggregator performance to dispatch targets has intersection points that have implications on accurately forecasting and DOE compliance. As analysis progresses, these other activities will be viewed collectively to identify intersecting insights. The Venn diagram below illustrates the various intersections with aggregator performance.

Figure 4 Intersection points with aggregator performance in wholesale market participation



One of the first research questions and hypothesis the analysis is seeking to contribute to answering is outlined in the table below.

RQ.4 HA

Table 5 Research question and hypothesis in focus for early field trial data analysis

Research Question 4	**How can the DER Marketplace facilitate activation of DER to respond to wholesale price signals, operate within network limits and progress to participation in wholesale dispatch over time?**
Hypothesis A	DER participation in wholesale energy markets can be achieved progressively, as DER fleets reach materiality thresholds, aligning with ESB visibility and dispatchability models.

One element of the hypothesis being tested is that gradual participation by aggregators would allow them to develop their capabilities and sophistication in how they participate in wholesale dispatch.

With the important caveat that analysis so far has been limited to some modes and one aggregator, early results are beginning to suggest that performance with dispatch target improved over time overall (noting for early trials, improvement from week 1 to week 2 within each trial did not always improve). This suggests two key points that will be explored in further analysis:

a) A stepping-stone approach to achieving participation of aggregators and their DER portfolios as scheduled resources in wholesale electricity markets is likely to be the most appropriate. Progressive participation from visibility to active scheduled resources will allow aggregators to test, develop and refine their process to achieve the necessary sophistication and operational capability needed to perform reliably. This aligns with the proposed design for the Scheduled Lite reform. Scheduled Lite proposed gradual participation beginning with a Visibility Model and graduating toward a Dispatchability Model[16].

b) Because the aggregator gradually improved as it refined its processes, it's too early to develop insights into whether a particular mode (i.e. the elements that define how a bi-directional offer (boffer) is constructed) facilitates more reliable participation.

If the hypothesis holds true, the challenges faced by the aggregator during the early field trial would likely have occurred regardless of the mode being tested. Therefore, it is not yet appropriate to develop insights on whether a particular mode facilitates performance over another.

It is hypothesised that the two new aggregators now operating in the trials will have a similar experience with respect to performance gradually improving. Such results would strengthen the primary hypothesis but would also create the need to re-test and analyse once they have developed and refined their processes to appropriately compare modes.

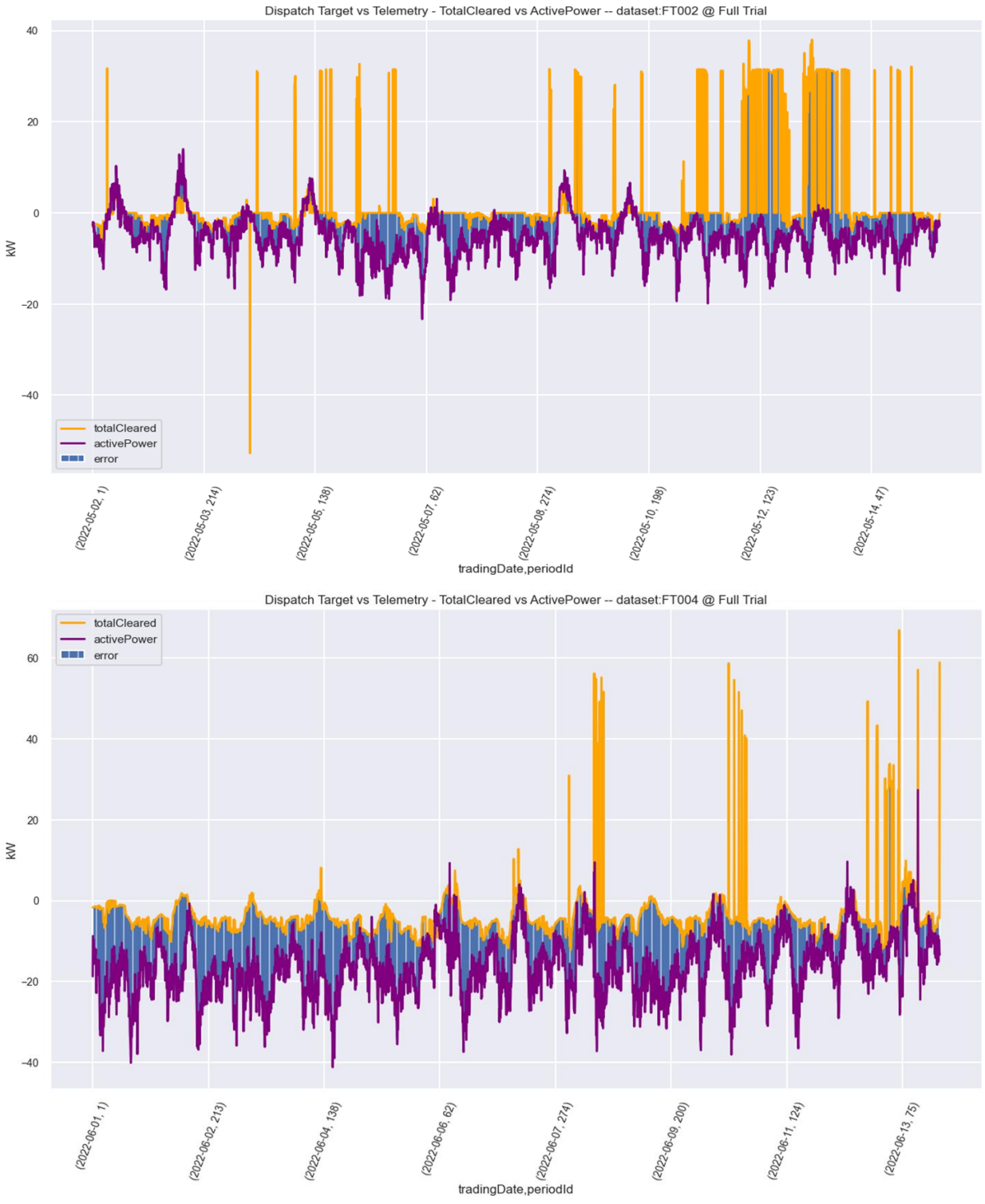
That further analysis will also seek to answer many of the 'so what' questions that early results have raised and once 'teething' challenges have less impact on performance. This will require deeper dives into the other contributing factors such as price events and time of day. This analysis will also be facilitated by discussions with the aggregators.

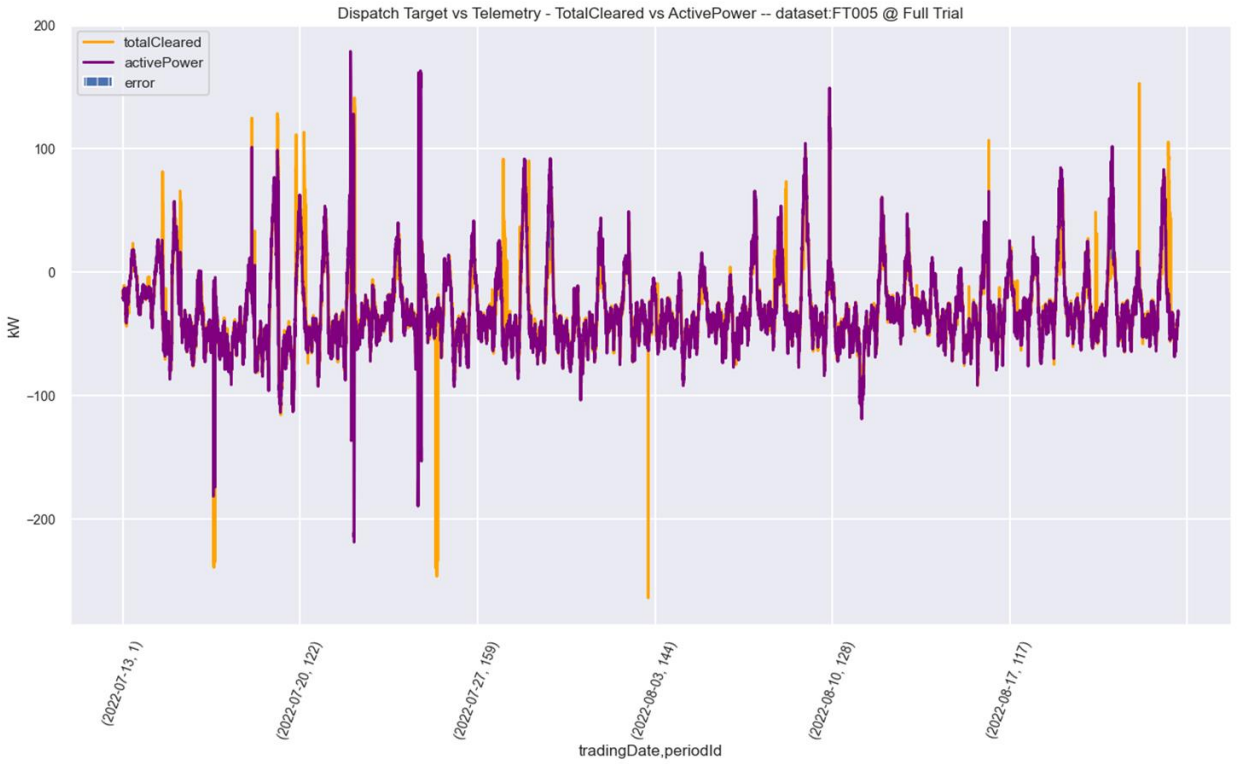
Figure 5 below sequences the modes in the order they were tested. The figure shows performance with dispatch target for each mode. Without focusing on the specific results, the objective of showing them in sequence is to illustrate that performance improved gradually as the various trials progressed. The yellow line represents the dispatch target (aggregate net NMI energy flow), and the purple line represents actual performance (DER portfolio telemetry – active power of aggregate net NMI energy flow). The blue shaded area shows the difference between the target and performance. Viewing each

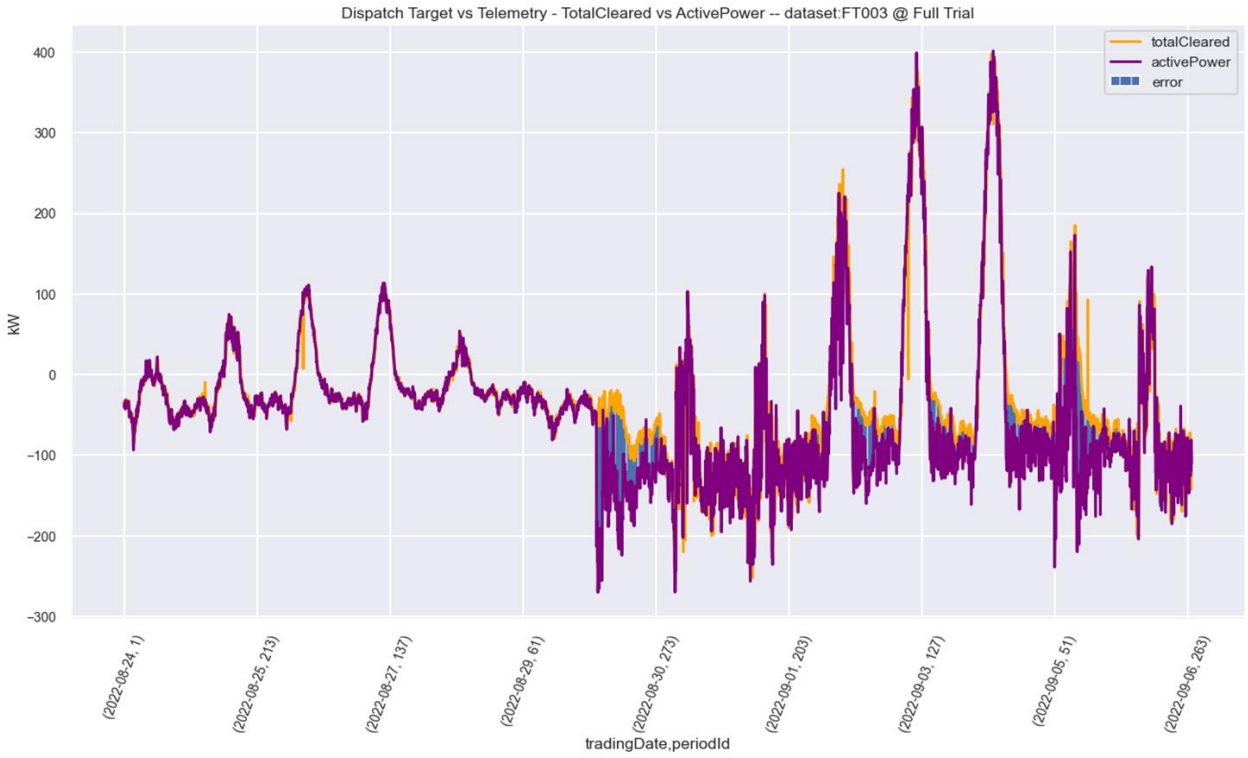
[16] AEMO, Scheduled Lite Consultation Paper – Draft High Level Design for Scheduled Lite

mode in the figure from top to bottom illustrates there is more alignment between target and performance (closer alignment between the yellow and purple lines, and less blue shaded area) for the last two field trials compared to the first two.

Figure 5 Progression of performance across the field trial, sequenced in order of testing







The two graphs in Figure 6 below also illustrate the difference in performance between the first mode tested and a more recent mode. These graphs visualise the correlation between dispatch targets and telemetry.

- The top bar graph within the figure represents the distribution of dispatch target quantities.

- The right-hand side bar graph with the figure represents the distribution of DER portfolio telemetry (actual) quantities.
- The blue line represents the best fit line, which is a straight line that shows the direction of correlation. The proximity of points to the line shows the strength of correlation between dispatch target (total cleared) and telemetry (DER portfolio telemetry).
- A negative slope (i.e. from the left of the graph going down towards the right) equals negative correlation.
- A positive slope (i.e. from the left of the graph going up towards the right) equals positive correlation.
- A wide spread of points from the line equals weak correlation and most points close to the line equals strong correlation.
- Applying the Pearson Correlation Coefficient measures the correlation. A higher value (r value) closer to +1 or -1 indicates a stronger correlation.
- While this graph does not speak in terms of 'performance', it helps to see if there is a relationship or correlation between dispatch target and telemetry.

The first graph in the figure shows the results for mode 2, which was the first mode tested. It has an r value of -0.076 and has little to no correlation. This is also shown by the negative slope and most points not being very close to the best fit line. The spread is segmented and wide. Meanwhile, the second graph in the figure shows the results for field trial 5, which was the most recent tested out of those analysed so far. This has stronger correlation. It has an r value of 0.843 and a positive slope with most points close to the best fit line.

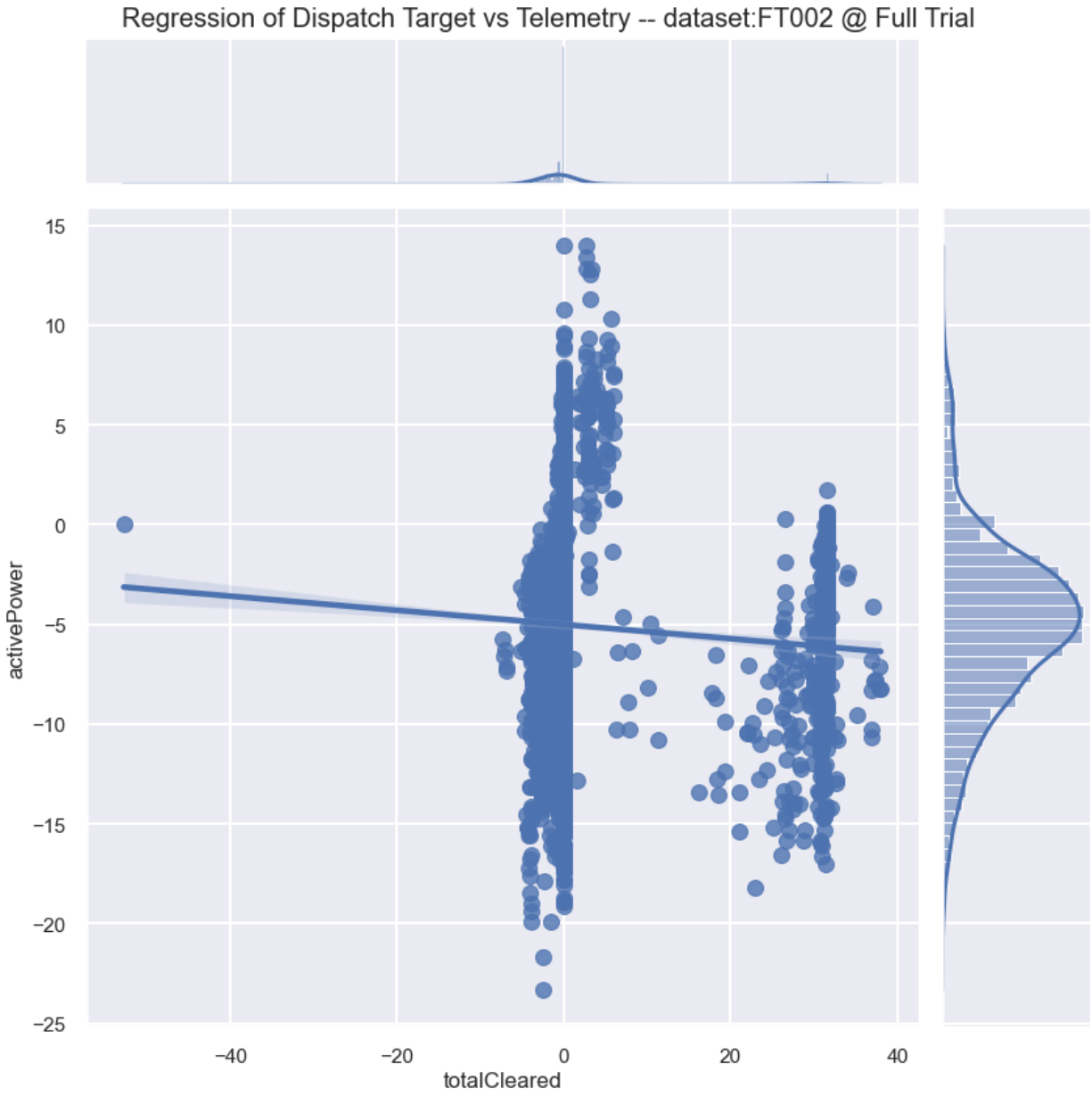
The performance between the two trials shows performance improved over time. Discussions with the aggregator identified two key drivers supporting improved correlation:

- Deliberate improvements in the forecasting and dispatch algorithms.
- Increased portfolio size (number of customers).

This early anecdotal evidence suggests the size of the fleet is an important factor because it increases the diversity of consumers that the aggregator can draw upon to meet its dispatch targets. It also suggests deliberate improvements in algorithms led to improvements in forecasting, bidding quantities and meeting dispatch targets. These two factors may therefore contribute to better aggregator performance over time. Accordingly, the two factors will be explored further with additional data and with aggregators over the course of the trial.

It supports the hypothesis that aggregators need stepping-stones in terms of gradual participation in the market in order to develop and refine their processes.

Figure 6 Contrast of progression of correlation between dispatch target and actual between the first trial test and the most recent



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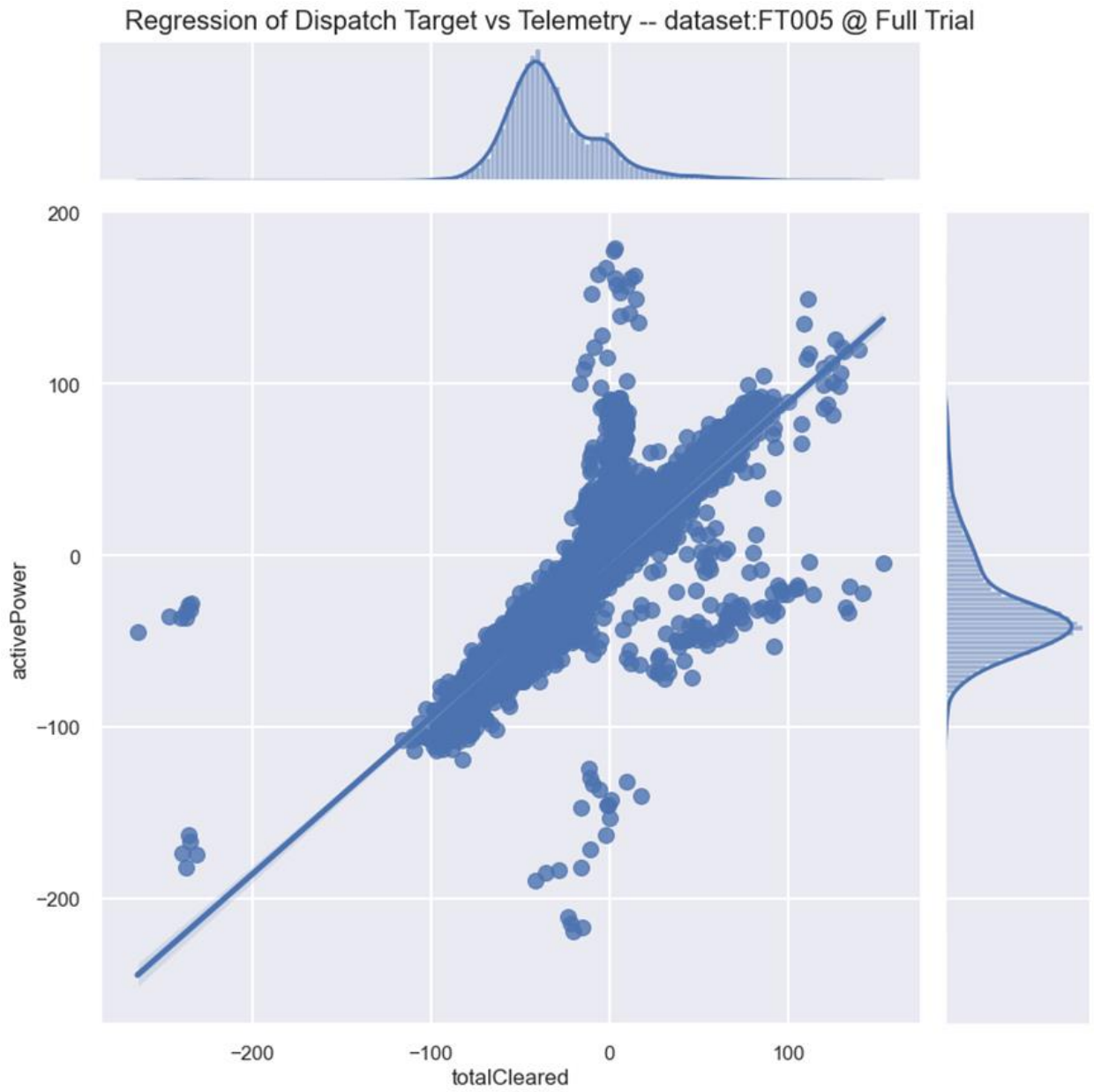


Future analysis will include other research activities and research questions, including performance under different DOE approaches and their impact on DER availability and network utilisation, as well as technical performance of the data exchange platform in terms of reliability and latency.

6 NEM Market suspension event

On 15 June 2022, AEMO declared a market suspension in the NEM. Leading up to the suspension, the large number of directions necessary to manage supply shortages at times resulted in up to 50 per cent of 5-minute intervals being over constrained and requiring manual resolution. This situation became unsustainable for AEMO systems and processes to manage and made ongoing operation of the market under the National Electricity Rules practically impossible. The full details of the event are summarised in AEMO's incident report.[17]

The 'why'

Project EDGE reacted quickly to establish a test plan to learn from this rare event **to understand what would need to be considered when directing the market in a high DER future where a greater portion of supply and demand is represented by VPPs.**

The project team formulated two hypotheses:

1. AEMO Dispatch Instructions that give a 'target' are more reliable than DOEs which give 'permissible limits'.
2. These two signals together will conflict at times and this needs to be understood to be managed in future operations.

The 'what'

The project conducted four tests to answer the following questions in addressing the above hypotheses:

- Test 1: What do VPPs do without AEMO direction?
- Test 2: How reliably can VPPs follow AEMO directions that differ from market incentivised behaviour?
- Test 3: Are DOEs a better mechanism than directing VPPs under a non-market use case such as market suspension?
- Test 4: Is it worth building capability to do both mechanisms for redundancy?

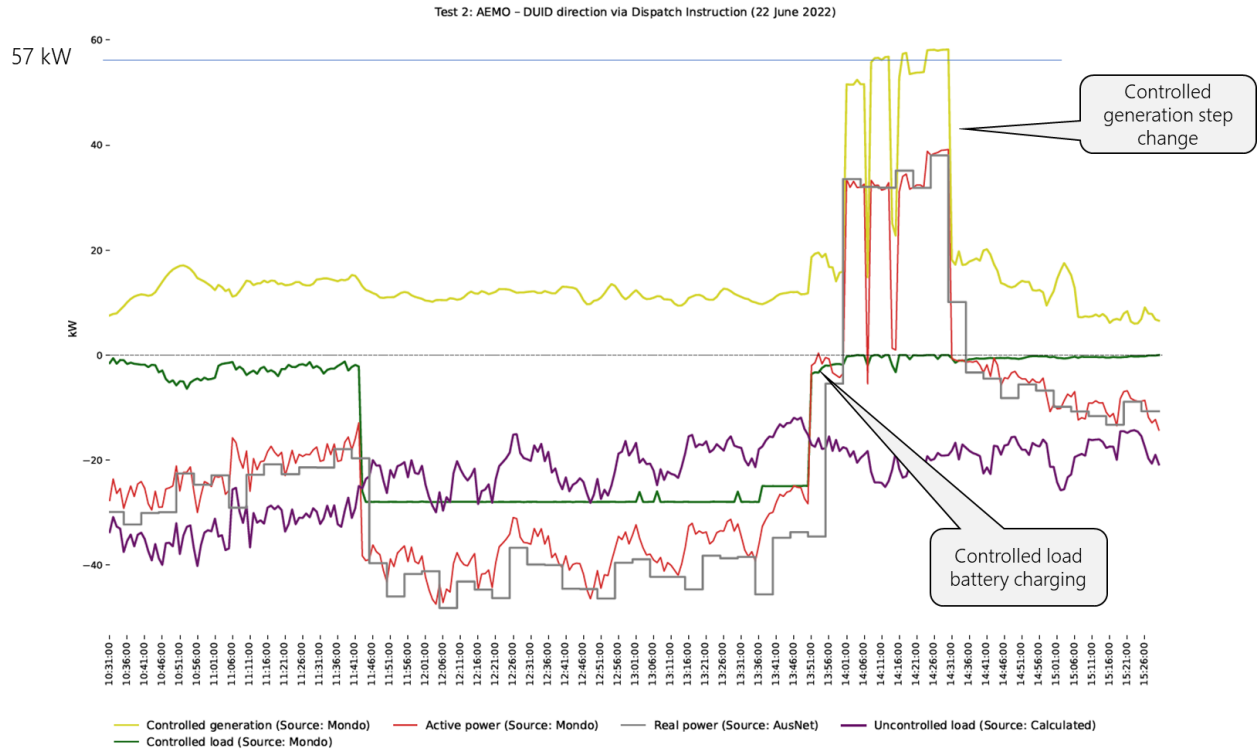
[17] AEMO, NEM market suspension and operational challenges in June 2022.

Test 1: What do VPPs do without AEMO direction?

In Project EDGE, aggregators submit a bi-directional offer (boffer) as a mechanism to participate in the wholesale market dispatch process. A boffer is an offer that can include both generation and load capacity the aggregator is willing to offer in the market. In Project EDGE, a boffer represents the whole of the aggregator's portfolio (i.e. all registered NMIs). A boffer communicates the aggregator's intent to the market and provides visibility of the price responsiveness of the portfolio, and an operational forecast to AEMO.

In the absence of a capability to dispatch VPPs at scale, AEMO needs visibility (telemetry) and predictability (forecast via boffers) to consider when it is directing large scale resources. Aggregators continued to submit self-dispatch (i.e. no AEMO direction) boffers with business as usual site optimisation observed. Prices were set according to a pre-published schedule during market suspension; therefore, an aggregator knew where it would be cleared.

Figure 7 Results of simulated trial directing 57 kW of flexible generation from 14:00-14:30



Note: DUID = Dispatchable Unit Identifier

Test 2: How reliably can VPPs follow AEMO directions that differ from market incentivised behaviour?

To assess this test, the Project team verified the aggregator's telemetry (red line, Figure 7) against smart meter data (grey line, Figure 7) and identified that the two correlated reasonably well. In the test, the aggregator achieved their dispatch target. This demonstrated that the aggregator was able to meet the intervention targets when directed. In other words, aggregators can follow directions that are not aligned to usual market signals or business as usual behaviour.

During the test, the aggregator was directed to follow a 57 kW generation target for flexible controllable DER capacity from 14:00 to 14:30 hours. This required the aggregator to exert and sustain

a step change, not just business as usual. This was also enabled because there was a sufficient operational DOE limits window at the time of the test. Therefore, the aggregator was able to meet the step change required to meet their dispatch target within DOE limits. Figure 7 above shows the aggregator was able to meet the target (the yellow line represents the controlled generation, which hits the 57 kW target). Preparation for this step change in generation can be observed in the sustained step change in controlled load (green line, Figure 7) which represents home battery storage systems charging from 11:40 to 13:50 hours.

The results also demonstrated that the aggregator was able to forecast its DER capacity and prepare for the event.

Test 3: Are DOEs a better mechanism than directing VPPs under a non-market use case such as market suspension?

In Project EDGE, DOEs are applied for net flows at each connection point (NMI). The test set DOEs of 9.5 kW aggregated across a subset of 19 sites (i.e. 0.5 kW export from each NMI).

The test demonstrated that DOEs can be set to limit aggregation export at a set point, but this would only be able to occur under certain conditions:

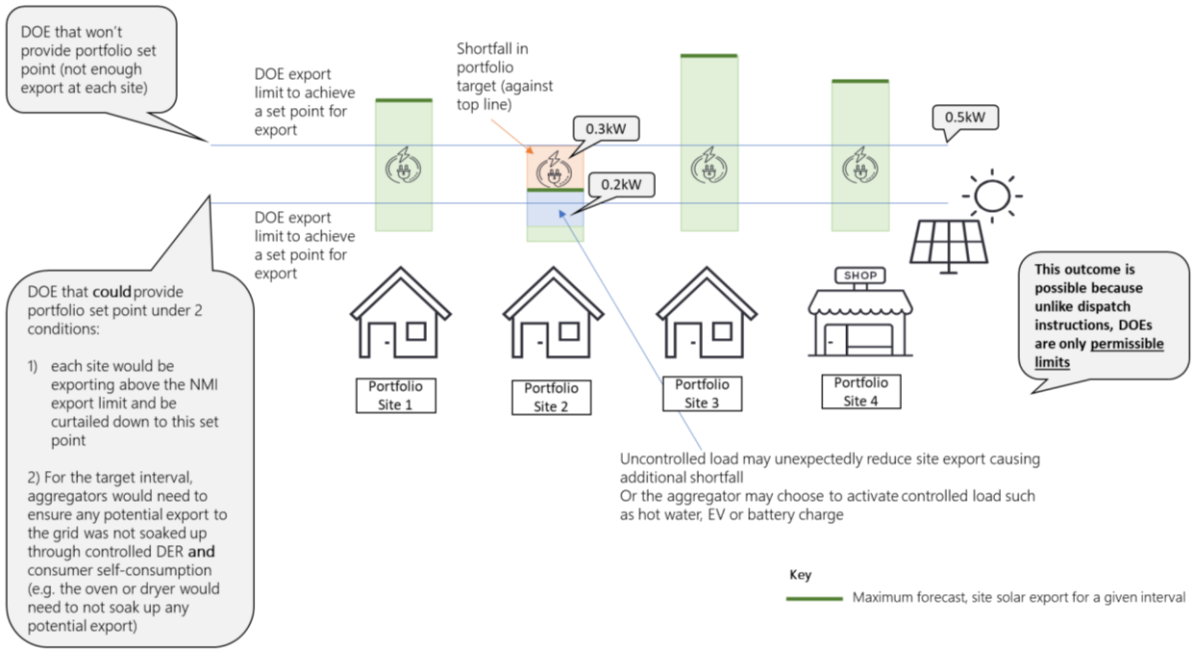
1. Each site in an aggregator's portfolio would need to be exporting above each site's DOE export limit and be curtailed down to this set point.
2. For the target interval, aggregators would need to ensure any potential export to the grid was not soaked up through:
   - controlled DER, and/or
   - uncontrollable consumer self-consumption (e.g. appliances like the oven or dryer would need to not soak up any potential export).

A DOE export limit would not provide a portfolio set point if some sites were not utilising their full export capacity (e.g. 0.2 kW out of 0.5 kW in Portfolio Site 2 in the conceptual example in Figure 8 below). The additional generation (0.3 kW) would not be available from elsewhere in the portfolio to meet the portfolio level target, because these other sites (Portfolio Site 1, 3 and 4) would already be constrained (to a limit of 0.5 kW per site).

Another element to consider is that uncontrolled load may unexpectedly reduce site export causing additional shortfall. Or the aggregator may choose to activate controlled load such as hot water, EV, or battery charge.

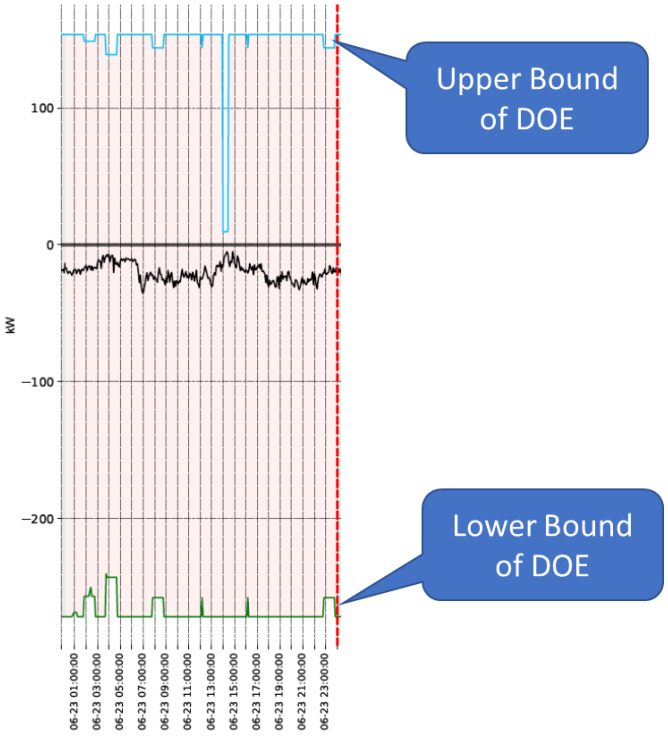
This is illustrated in Figure 8 below.

Figure 8 Possible outcomes for DOE export limits applied to achieve a set point for portfolio export



Therefore, DOE limits could provide a firm response across an aggregator portfolio, but are not as reliable as dispatch instructions because they provide operating limits (permissible limits) as opposed to specific directions. The results of the test are illustrated in Figure 9 below, showing the real power (black line) below the upper bound of the DOE limit (blue line). This would require either controlled load to decrease or generation to increase.

Figure 9 Results of simulated trial of AEMO providing Dispatchable Unit Identifier (DUID) direction via Dynamic Operating Envelopes (DOEs)



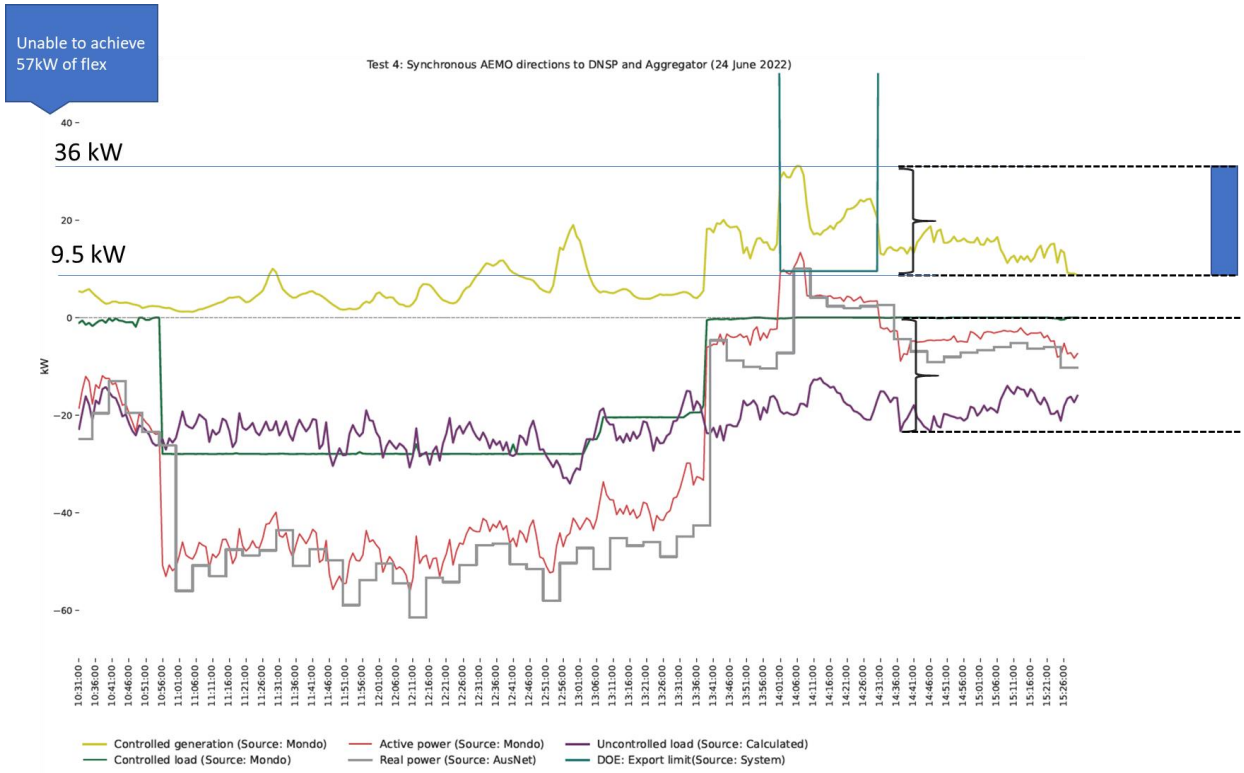
Test 4: Is it worth building capability to do both mechanisms for redundancy?

The DOE limit set for test 3 was also tested alongside test 4, which tested simultaneous instructions from AEMO to the DNSP and aggregator to see if this helps reduce potential conflicts. The test results showed there can be a conflict between DNSP DOEs and AEMO dispatch instructions. The test involved bringing in the 57kW instruction for flexible generation (from test 2) with the DOE export limit (set at Net NMI) from test 3.

The results identified a conflict between the bid for 57 kW and the Net NMI DOEs between 14:00 hours and 14:30 hours. The aggregator charged its battery energy storage system for the event and discharged. The Net NMI DOEs took priority (seen by the alignment between the meter (real power) (grey line, Figure 10) and the connection point telemetry (active power) (red line, Figure 10). This meant the aggregator constrained its flexible generation response to 36 kW, and therefore, the 57 kW dispatch target was not achieved. Given the uncontrolled load in the aggregator portfolio was very similar in both tests 2 and 4, if the DOEs had permitted 36 kW at the connection point, it is plausible the aggregator would have achieved the 57 kW flexible generation target.

Figure 10 below shows that the 57 kW target was not met (reflected by the grey line showing real power – smart meter) but staying within the DOE export limit was prioritised (the grey line closely aligning with the teal line).

Figure 10 Results of simulated trial directing 57kW of flexible generation within set DOE limit from 14:00-14:30



Summary of take away learning for these tests

- Aggregators can hit AEMO intervention targets in the absence of market signals, when directed.
- DNSPs can calculate DOEs to achieve a set point under certain conditions.

- However, DOEs alone may not elicit an aggregator response that is as accurate as dispatch instructions because they provide a permissible limit rather than a specific target.
- DOEs take priority to keep the network operating within secure limits, but need to be communicated to AEMO to ensure they do not issue directions that exceed DOEs.
- Visibility for AEMO of the DOEs was provided by the data exchange hub being trialled in Project EDGE. This scalable data exchange approach allows multiple subscribers, including AEMO and Aggregators to receive certain data.
- This highlights the importance of AEMO receiving DOEs via a data exchange hub rather than direct point to point integration with each DNSP and aggregator as DOEs will be produced and communicated from multiple DNSPs by 2024-25[18].
- This supports market suspension hypothesis 1 that AEMO dispatch instructions that give a 'target' are more reliable than DOEs which give 'permissible limits'.
- The tests were inconclusive regarding market suspension hypothesis 2 that these two signals will conflict at times and this needs to be understood to be managed in future operations. Accordingly, further investigation is needed into the role DOEs could potentially play in power system events that risk system security.

[18] Energy Security Board, Interoperability Policy for Consultation Directions Paper

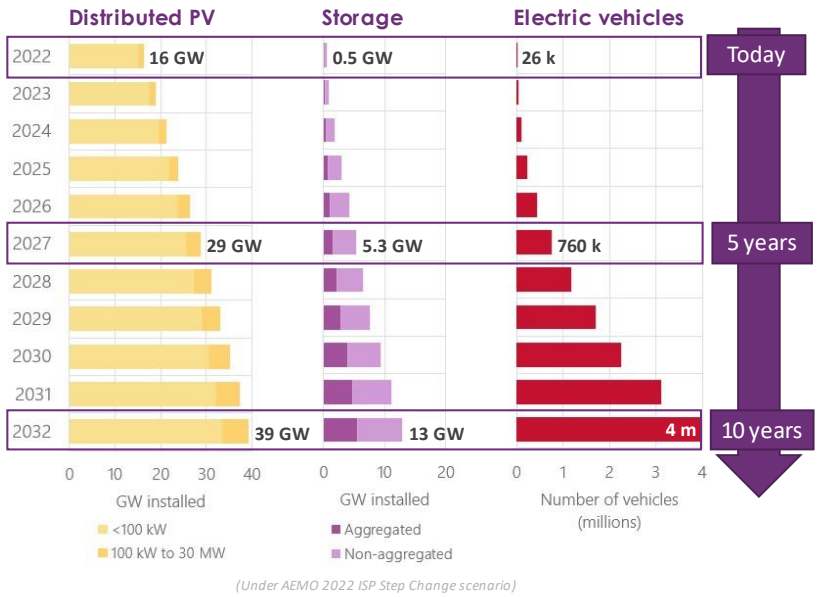
7 Preliminary data exchange findings

This chapter provides preliminary insights from a broader technology and cyber work stream within Project EDGE. Ernst & Young (EY) has been engaged to conduct independent assessments for this work stream. In-depth reports from the assessments independently conducted by EY for this work stream will be published in the near future.

One of the core functions of the DER Marketplace concept is to facilitate efficient and scalable data exchange between industry actors. The primary business to business (B2B) use cases being tested in Project EDGE are the exchange of DOEs and trade of local network support services between DNSPs and consumer agents/aggregators, but the use cases could expand as retailers seek to communicate with consumer agents/aggregators to manage PV exports during negative price periods, and EV consumer models proliferate.

Efficient and scalable data exchange can ultimately deliver an easier user experience for consumer agents/aggregators using consumers' DER to deliver electricity services, leading to more efficient outcomes for all electricity consumers as well as greater value shared with the participating DER owners. This is particularly important given the forecasts in AEMO's 2022 *Integrated System Plan* (ISP) for over 100 gigawatts (GW) of DER in the NEM by 2050, and >50 GW in the next 10 years (under the Step Change scenario)[19].

Figure 11 AEMO 2022 ISP DER forecasts in next 10 years



[19] AEMO, 2022 Integrated System Plan

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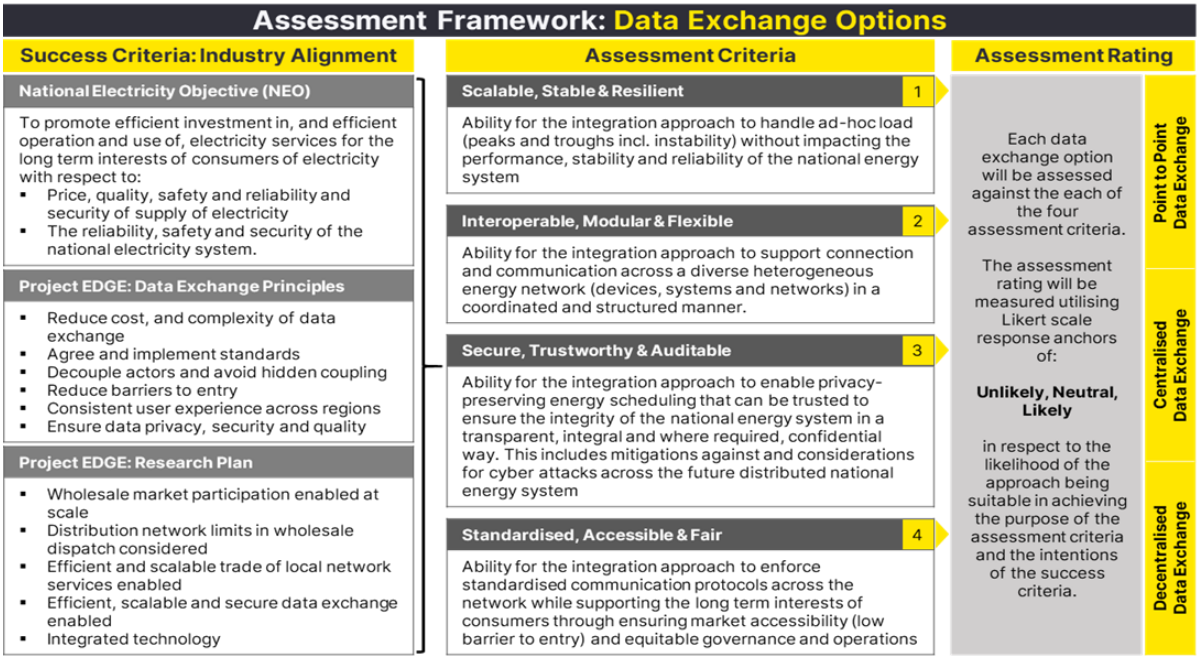
The Project EDGE principal hypothesis relating to data exchange is that an industry data hub is a more efficient way to facilitate DER data exchange at scale for various use cases than continuing with a point-to-point exchange approach. Project EDGE is testing two versions of an industry data hub-centralised data hub (conceptually akin to the existing e-Hub operated by AEMO and used for the retail market) and a decentralised data hub.

7.1 Theoretical evaluation of the data exchange options

One of the project's research activities is to conduct a theoretical evaluation of the data exchange options at the industry actor level. To evaluate all the data exchange options, EY conducted an independent assessment seeking to understand which option (a data exchange hub – either centralised or decentralised – or a point-to-point architecture) would best support the NEO and ensure a secure, scalable, and effective DER Marketplace.

An overarching evaluation framework was developed that considers the NEO, the Project EDGE data exchange principles, and considers four data exchange criteria as shown in Figure 12.

Figure 12 Data exchange assessment framework



The assessment scored point-to-point data exchange solutions lowest in each of the criteria, indicating they are not suitable in a very high DER future envisaged by the ISP and the NEO.

Point-to-point integrations may be manageable for individual use cases at small scale, such as a small number of aggregators integrating with one DNSP to obtain DOEs, but the following factors associated with a high DER future mean point-to-point approaches could lead to adverse outcomes for consumers:

- Proliferation of aggregators needing to obtain DOEs from all DNSPs across the NEM.
- Proliferation of new use cases, such as:

- Retailers sending zero export limits to consumer agents/aggregators to manage negative price exposure
- DNSPs sending dynamic network prices to EV charge point operators to manage peak charging risks.
- DNSPs seeking to procure DER-based local network support services from aggregators

The assessment found centralised and decentralised approaches both offer more efficient long-term outcomes for consumers, but a decentralised approach can theoretically deliver greater benefits than centralised in each of the four criteria assessed, including:

- **Scalable, stable, and resilient**: Decentralised architectures can be highly scalable, have no single source of failure by design, and are highly resilient as integrated mechanisms for data storage and access enabling easy restoration if there is an infrastructure node outage.
- **Interoperable, modular, and flexible**: Decentralised architectures are highly interoperable, modular, and flexible as any party can design, implement, and maintain their system or project in line with the feature set provided by the decentralised ecosystem. Furthermore, the underlying decentralised infrastructure can support any data model or communication protocol that is chosen by the governing body (e.g. 2030.5 CSIP-AUS).
- **Secure, trustworthy and auditable**: A decentralised integration method offers the most trustworthy system of all three approaches as it utilises a public distributed ledger (DLT) platform for identity management under which no single entity has complete control to view, write, or modify the protocol. In a permissioned platform, any change conducted can be seen and verified by other parties which results in a highly transparent ecosystem. Furthermore, any change or modification is also immutable, increasing user trust and auditability in the platform.
- **Standardised, accessible and fair**: Decentralised architectures adopt ecosystem wide standards that are not easily changed or manipulated. Accessibility for a permissioned decentralised system (a specific type of the decentralised approach) could be similar to a centralised approach as the governing body would determine access. With regard to cost recovery, in a decentralised approach the infrastructure and associated costs are decentralised to participants. As a result, their costs to host the infrastructure can be allocated more directly (and fairly) to the consumers that benefit from it.

Although decentralised approaches offer greater benefits in theory, it is important to note that decentralised approaches remain relatively immature in the energy sector and will need to develop enterprise grade maturity to realise these benefits for the industry. This may be effectively achieved through a phased implementation of decentralised components, potentially with a trusted centralised host, which is outlined further below. More detail on this assessment will be available in reports from the dedicated technology and cyber work stream in the near future.

7.2 Cyber security threat assessment

A cyber security threat assessment on the data exchange approaches was also undertaken. This assessment reviewed a number of potential cyber security risks associated with DER data exchange and outlined a number of mitigating controls that could result in a lower residual risk level.

The most material risks identified related to:

- Vulnerabilities in the multiple layers of software across the different participants the DER ecosystem/supply chain could lead to unauthorised access and disclosure of sensitive information. For instance, a DER aggregator's control platform being hacked resulting in unusual and rapid changes to its VPP operations that, at scale, may cause system security risks.
  - **Mitigating control:** Secure application development processes should be leveraged wherever possible, and appropriate application security controls should be developed and administered for all key software components across the entire DER ecosystem, from DER devices, to aggregator control platforms, and industry data exchange infrastructure.
- Lack of appropriate management of supply chain risks could lead to data disclosure or unavailability of key DER resources.
  - **Mitigating control:** Each entity across the DER Marketplace would have their own supply chains based on their business requirements. Cyber security requirements should be established for key suppliers of DER devices and DER operators (e.g. aggregators/consumer agents) according to industry best practices and information sources should be monitored to identify and address supply chain threats and risks. This could include implementing a third-party risk management framework which aligns to business requirements.
- In an event of a security incident affecting critical assets in the DER marketplace ecosystem, lack of appropriate security controls could lead to significant impact to the confidentiality or availability of the affected DER marketplace entity.
  - **Mitigating control:** Each entity across the DER Marketplace should perform a Business Impact Analysis (BIA) to understand the criticality of their assets and thereby implement appropriate controls to ensure critical assets have the right level of protection against cyber-attacks.

The scope of Project EDGE was limited to considering DER data exchange between key industry actors (aggregators, DSOs and AEMO), and not exchanges from aggregators to devices. However, the critical risks identified above considered the full supply chain for data exchange that includes aggregator/consumer agent to device communications.

Project EDGE has tested some of the key concepts of a decentralised approach to DER integration, such as decentralised identities (DIDs) and a decentralised data hub, in order to automatically assign DOEs sent by DNSPs (assigned at the NMI level) to the right aggregator without the need for a centralised broker.

However, the full potential of a decentralised approach, that includes aggregator to device communication, has not been comprehensively and practically examined as Project EDGE has focused on data exchange amongst industry participants.

Nevertheless, a comprehensive application of DIDs at the device level, which could deliver a range of further benefits for the industry and consumers, have been considered in the mitigating controls element of this assessment, including:

- **Secure integration with the DER ecosystem**: Devices and entities with a DID could automatically upload their standing data and credentials to an updated DER Register as they first connect to the internet, saving time, effort and errors in manually uploading data.
- **End to end visibility and auditability across the DER ecosystem**: DIDs and Verifiable Credentials (VCs) at each level of the supply chain (e.g. device and aggregator/retailer level)

enables greater integrity checking and isolation of operation via revocation of VCs if a security threat is identified.

- **Secure interoperability across the DER ecosystem**: An extended capability of DIDs and VCs can enable any retailer/aggregator to send control signals to compatible devices if they have correct VCs and consumer consent. This would give consumers freedom to switch between providers and enable aggregators to easily coordinate numerous and different device types within their portfolio.
- **Compliance with industry standards:** DIDs and VCs can provide traceability of settings and firmware upgrades for compliance to standards (e.g. AS 4777.2.2020 or CSIP-AUS).

7.3 Feasibility of establishing a decentralised data exchange hub

Without mandated communication of DER data transactions through a data hub, the industry is currently on a path of point-to-point data exchange proliferation. The first priority is to recognise:

- The long-term inefficiencies for consumers in remaining on this path.
- The long-term benefits to consumers of a DER data hub and Register.

If a DER data hub approach is recognised as a more efficient and scalable way to facilitate data exchange across numerous use cases, then the following realistic options may be considered:

- **Centralised approach:** adding DER data exchange use cases (such as the DOEs) to the existing (or adapted) e-Hub and Shared Market Protocol[20].
- **Decentralised approach**: establishing an alternative decentralised data hub for DER use cases that can operate in parallel, and separately, to the e-Hub.

Establishing a decentralised data exchange approach can only be achieved if the long-term net benefits of doing so are clearly articulated to the industry, including the additional functionalities that could be enabled by decentralised technologies (such as digital identities).

The actual transition however does not need to be done in a single 'big bang' approach. It could start with specific DER use cases, established on a voluntary basis, potentially hosted centrally by a trusted body, with functionality or new use cases added over time as required by industry.

A conceptual roadmap of how use cases could be added in phases is outlined in Figure 13 below, but this would need to be consulted on at various stages.

[20] AEMO, Guide to MSATS B2B

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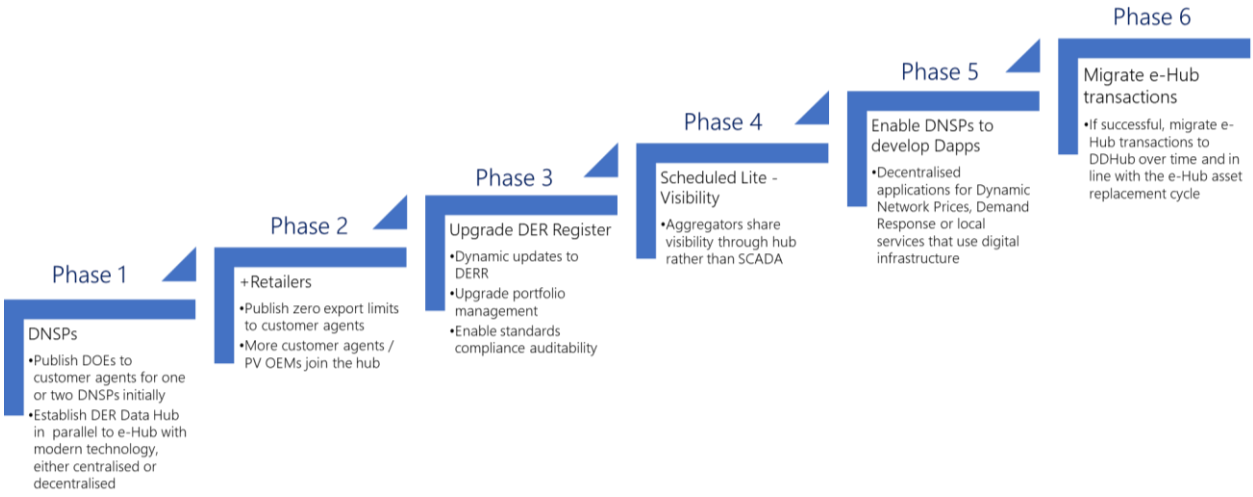
Figure 13 Conceptual roadmap for phased implementation of DER data hub



In the long run, if a decentralised approach proves its efficiency and scalability benefits, then use cases could be migrated from the e-Hub to the decentralised hub as appropriate.

Implementing a new decentralised data hub (DDHub) would need to consider a number of practical considerations to establish the feasibility of successful implementation, including but not limited to:

- **Establishment**: What will the first applications/use cases be for the DDHub, at what scale and who will use it?
  - If a DDHub is first established as a small initiative for specific use cases/participants, then regulatory change may not be necessary. If the DDHub sees more participants utilising it across a growing number of use cases, then it may support a case for a rule change that may be needed to facilitate the adoption of a DDHub across industry.
- **Governance:** How should the establishment and operation of a DDHub be governed?
  - For decentralised infrastructure this includes whether the infrastructure should be public (completely open for all to access) or permissioned (requiring authorised access). Due to the critical nature of the energy system and consumer data protection considerations, it is envisaged that a DDHub for the energy industry would be permissioned, in which case it would require a governance structure that may be similar to a centralised model. For instance, the Information Exchange Committee that governs the e-Hub is comprised of industry representatives and chaired by AEMO. A DDHub could equally be governed by a committee of industry representatives. This structure would need to be consulted on extensively and represent an opportunity to redesign a streamlined governance process.
- **Ownership and cost recovery:** Who would ultimately own a DDHub and how should its establishment and operational costs be recovered?
  - A centralised model, for example the e-Hub, would involve AEMO establishing and operating the hub and passing costs onto all consumers through NEM participant fees. A decentralised model could see the hosting and operation of DDHub infrastructure decentralised to include market participants and non-energy participant service providers who may be able to recover costs from DER customers specifically or share in participant fees for the provision of data exchange infrastructure services.

- **Stakeholder engagement and education:** Even with a small implementation of a DDHub for a few use cases, there would need to be clear information sharing about the benefits of this approach, the practical experience, and the steps participants need to take to implement this approach. This is important for both:
  - Participants directly involved in the DDHub to receive a seamless implementation experience, and mitigate the risk of implementation errors eroding trust in the new infrastructure.
  - Broader industry stakeholders who may be interested to determine if this approach would suit their use cases.

7.4 Links to cost benefit analysis

Though applied elsewhere, decentralised technology is still relatively new in the Australian electricity industry. Different decentralised technology components could be introduced over time as the technology maturity scales and develops.

Decisions to adopt this technology beyond Project EDGE would require a cost benefit analysis (CBA) to verify the adoption of the appropriate data exchange approach that will be in the long-term interests of consumers.

One of Project EDGE's deliverables is a CBA assessing the conditions under which a DER Marketplace would be in the long-term interests of all electricity consumers. This will be tested through a base case and scenarios of varying complexity and sophistication across several areas, including the inclusion or exclusion of a data hub[21]. The methodology testing the scalable data exchange approaches includes:

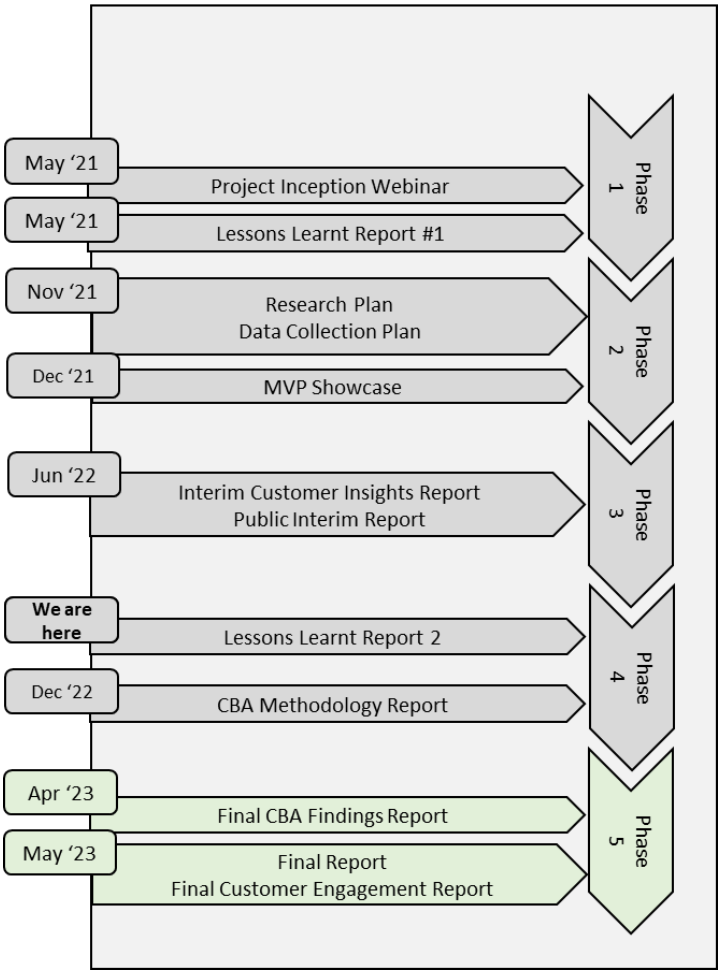
- Identifying the functionality and use cases associated with each data exchange approach.
- Identifying the cost and benefit categories associated with each data exchange approach.
- Calculating the costs and benefits associated with each data exchange approach.
- Assessing the hypothesis of whether the data hub model provides a scalable and long-term approach compared to point-to-point, and whether a decentralised data hub model is the more efficient solution that could deliver the greatest net benefit to all electricity consumers.

[21] Deloitte Access Economics, Project EDGE CBA – Draft Methodology for Consultation

8 Next steps

The remainder of the Project will continue to undertake the field trial to test the various research questions and hypothesis in the Research Plan. The insights into research questions will be summarised in a final report expected to be published in May 2023. The Final Customer Engagement Report will be published around the same time. It will share key insights and lessons learnt on the customer study activities undertaken by Deakin. These major reports will be accompanied by public webinars. Figure 14 outlines the next steps in terms of knowledge sharing materials.

Figure 14 Next set of knowledge sharing deliverables for Project EDGE



In late 2022, the final CBA methodology report is expected to be released. This will include feedback, resolution of finding and method finalisation. Once the methodology is finalised, formal CBA analysis and modelling will begin and continue through to mid-February 2023. The final CBA findings report is expected to be shared in March 2023.

A1. Research questions progress

The table below provides an update on the progress of answering the research questions discussed in this report based on the insights identified to date.

Element/function	Research question	Progress
Customer	RQ.1 How can the DER Marketplace be designed to enable simple customer experiences, deliver the needs of customers and improve social license for active DER participation?	
Wholesale integration	RQ.4 How can the DER Marketplace facilitate efficient activation of DER to respond to wholesale price signals, operate within network limits and progress to participation in wholesale dispatch over time?	
Efficient data exchange	RQ.6 What is the most efficient and scalable way to exchange data between industry actors, considering privacy and cyber security, to benefit all consumers?	

A2. Additional knowledge material

The table below includes reference material, prior reading, and post reading related to the insights shared in this report.

Source	Description
Project EDGE, General Community Perceptions of Distributed Energy Resources	Insights from a survey of different consumer groups in different Australian states conducted by Deakin to understand general community perceptions of DER and aggregators.
Project EDGE, Literature Review – DER Customer Insights Research	Literature review of industry, government reports and academic literature to capture the current state of Australian knowledge of customer insights relating to DER. The review provides an understanding for Australian DER stakeholders for how best to develop their products and services that meet the needs and expectations of customers.
Project EDGE, Customer Insights Interim Report	Insights from consumer research conducted by Deakin with residential consumers with varying experience with VPP trials to understand motivators and barriers to joining a VPP.
Project EDGE, Public Interim Report	Report providing progress, preliminary findings, and lessons learnt relating to the development and design of Project EDGE.
Project EDGE – Lessons Learnt Report #1	Report providing the initial update regarding the progress and lessons learnt on Project EDGE
Project EDGE - various webinars	Webinars presenting research updates, including work conducted by University of Melbourne.
University of Melbourne – various project related research papers	University of Melbourne is developing algorithms, and conducting research for the operating envelopes and the service co-optimisation. It has published various research papers, including the calculation architecture, objective functions, network optimisation and sensitivity analysis
Deloitte Access Economics, Project EDGE CBA – Draft Methodology for Consultation	Report outlining the draft methodology that will underpin the CBA.
AEMO, Scheduled Lite	Various documents outlining the proposed Scheduled Lite mechanisms, including a consultation paper on the draft high-level design, related projects, use cases, and stakeholder submissions and feedback.