Project EDGE Research Plan

February 2022

This Research Plan has been developed with the support of the independent Knowledge Sharing Partner, The University of Melbourne.

Acknowledgements and Disclaimer

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

The Project EDGE partners thank The University Of Melbourne for their expertise and guidance in the development of this Research Plan. The information contained herein has been developed by The University Of Melbourne with input from the project partners and industry stakeholders.

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Glossary of Terms

Term	Definition
Australian Energy Market Operator (AEMO)	In its current role, AEMO has overarching responsibility for the security of the power system, including the distribution system. It has responsibility for establishing the central dispatch process in the wholesale energy market and ensuring transmission and distribution network limits are considered in the process. In Project EDGE, AEMO is acting in its current role of the Market and Power System Operator.
Aggregator	Aggregators represent consumers in a DER Marketplace and delivery multiple services on their behalf, including wholesale services to AEMO and local network services to distribution networks. Aggregators are granted permission by consumers to use their DER and data to deliver services according to the consumer's preferences.
DER Marketplace	An integrated digital ecosystem linking many systems and capabilities across various industry actors to exchange data and services provided by DER
Distribution Network Service Provider (DNSP)	The DNSP manages the distribution network, ensuring efficient operation to provide safe, reliable, and secure supply and maintains overall electricity system stability. In a DER Marketplace, the DNSP role evolves to take on additional functions of a Distribution System Operator (DSO)
Distribution System Operator (DSO)	The DSO role represents the existing DNSP role, but with augmented or new functions/capabilities, such as matching DER access to available network capacity and procuring local network services to meet specific network needs.
Local Services Exchange (LSE)	The LSE function of the DER Marketplace facilitates visible, scalable and competitive trade of local DER services that enables the DSO to manage local distribution network power security and reliability. The function enables aggregators to stack local and wholesale value streams efficiently and deliver them simultaneously.

Executive Summary

Executive Summary

Project EDGE is an innovative, first of its kind, collaboration to demonstrate a proof-of-concept DER Marketplace

Project EDGE (Energy Demand and Generation Exchange) is a collaboration between the Australian Energy Market Operator (AEMO), AusNet Services (AusNet) and Mondo (collectively, the Project Partners), with financial support from the Australian Renewable Energy Agency (ARENA).

Project EDGE seeks to understand, test, and demonstrate a proof-of-concept Distributed Energy Resources (DER) Marketplace that enables efficient and secure coordination of aggregated DER to provide wholesale and local network support services within the constraints of the distribution network in a way that promotes the National Electricity Objective (NEO). The primary intent is to identify capabilities that can be replicated at scale across the National Electricity Market (NEM).

Project EDGE will test the Hybrid model proposed by the Open Energy Networks initiative to develop practical evidence demonstrating how AEMO could collaborate with industry to efficiently integrate DER at scale and deliver long-term value to the national electricity system and promote the interests of all customers. Building on the outcomes of other projects testing concepts in this area, the evidence base generated by Project EDGE seeks to inform and guide technical, commercial and regulatory changes.

Project EDGE will test key functions and elements of an efficient DER Marketplace through research questions underpinned by the NEO

Project EDGE will demonstrate three key function sets that are vital to the efficient and scalable integration of DER, and that will ultimately deliver value to customers:

1. DER wholesale energy market integration
2. Scalable DER data exchange
3. Local Service Exchange for network support services.

Project EDGE will test these functions, and their interaction, in a DER Marketplace. The DER Marketplace is not a single platform or capability, but rather an integrated digital ecosystem that links many systems and capabilities across various industry actors so that they can exchange data and services in an efficient and scalable way in the long-term interests of all consumers.

Project EDGE is taking a scientific approach to developing robust evidence that can be trusted

Key components of this approach include the development of a robust and clearly defined Research Plan (this report), an evidence-based cost-benefit analysis, and regular knowledge sharing and stakeholder engagement.

Executive Summary

The Research Plan will guide the delivery of Project EDGE and creates the pathway to generating an empirical evidence base

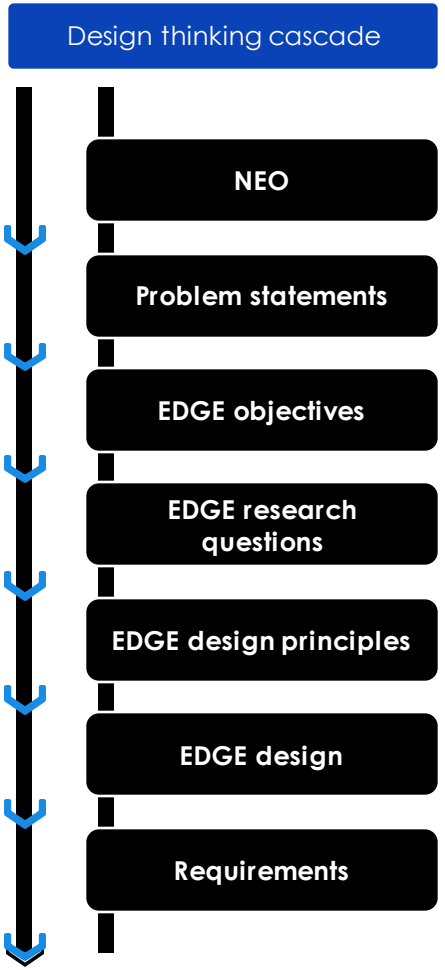
The Research Plan was developed by the University of Melbourne (UoM), as an independent world-class research organisation applying its design capability and expertise.

The Research Plan applies the design thinking approach adopted by Project EDGE, which begins with the NEO and cascades through multiple steps to guide the Project EDGE design. Ultimately, the design of Project EDGE (and any future iteration of the DER Marketplace concept) must promote the long-term interests of consumers through lower system cost, maximised market efficiency, and appropriately allocated risks to the actors best suited to manage them without compromising the quality, reliability, safety, and security of the national electricity system.

The Research Plan is important because it prioritises and identifies the activities that are essential and achievable to test research questions and their hypotheses. The Research Plan clearly defines these activities and sets out the pathway to systematically progressing toward demonstrating the trial's purpose with clear actions, inputs, and outputs at each step. The Research Plan will inform the Project Partners regarding research questions, hypotheses, theoretical and practical exercises, and the data analysis plan required to address Project EDGE's objectives.

To this end, the Research Plan adopted an iterative approach that refined and prioritised research questions, hypotheses, and test cases based on the scope of Project EDGE, literature review, subject-specific expertise from the Project Partners, and feedback received from various stakeholders during several engagement activities. The result is a pathway to generating an empirical evidence base to test hypotheses to answer research questions, and develop a data analysis plan.

By applying this approach, the evidence base generated by Project EDGE will enable recommendations that inform regulatory decisions and facilitate the Energy Security Board's (ESB) Post 2025 market reforms design and implementation[1], support AEMO with prudent planning for a high DER future, provide clarity to DNSPs and aggregators on roles and responsibilities, and systems, processes and technology required. Underpinning all of this will be the identification of efficient DER integration pathways that promote the long-term interests of all consumers, including those without DER.



1 Energy Security Board, Final advice July 2021, https://esb-post2025-market-design.aemc.gov.au/final-advice-july-2021.

Executive Summary

Seven research questions have been identified and prioritised to be addressed by Project EDGE.

	Research questions	Summary of hypotheses	Related Objectives
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?	a) Customer decisions to invest in DER to participate in the DER Marketplace are influenced by multiple factors. b) Customers are willing to participate if offers are simple and provide sufficient value over time. c) Minimising complexity enables aggregator participation ad enables provision of value.	1, 3, 8
CBA/NEO	RQ.2 Does the DER Marketplace promote efficient investment in, and efficient operation and use of, electricity services for the long-term interests of consumers?	a) A DER Marketplace can deliver net positive economic benefits for all consumers. b) Local services exchange enables DNSP network deferral. c) A data hub model provides a cost-efficient, scalable and simple approach to data exchange. d) Roles and responsibilities of actors are largely aligned to current roles.	1, 3, 4, 6, 7
Operating envelope design	RQ.3 How does operating envelope design impact on the efficient allocation of network capacity while enabling the provision of wholesale energy and local network services?	a) Operating envelope design has a material impact on network operation and efficient services. b) Technical and economic outcomes improve when uncertainty is accounted for in the calculation of operating envelopes. c) Efficiency of operating envelope design and implementation can increase as DER uptake increases. d) Network capacity allocation should focus on maximising utilisation and yielding highest net economic benefit for all consumers. Fairness is best achieved ex-post and not through envelopes.	1, 2, 3, 7
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?	a) DER participation in wholesale market can be achieved progressively and align with ESB reforms. b) System Operator and DNSP interactions can be defined and implemented efficiently to maintain DER within limits at all times. c) The aggregator should be responsible for ensuring DER value stack instead of the market operator co-optimising services.	1, 2, 3, 6
Local network services	RQ.5 How can the DER Marketplace facilitate efficient and scalable provision of local network support services from DER so that network efficiency benefits are realised for all customers?	a) Network reliability can be managed through local network services from customer DER. b) DNSP barriers to relying on local network services from DER can be overcome through procurement mechanisms. c) Local network services characteristics and procurement can be standardised across regions.	3
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?	a) A data hub model provides a cost-efficient, scalable and simple approach to data exchange. b) Decentralised digital infrastructure with appropriate security and governance provides efficiency and participation opportunities and can address risks. c) AEMO and DNSPs need to develop capabilities that maintain a secure and resilient power system and distribution network respectively.	4, 5, 6
DNSP investment and capability	RQ.7 How could DNSP investment to develop DSO capabilities improve the economic efficiency of the DER Marketplace?	a) There is an optimal combination of DNSP investment in network and DER based non-network solutions that provides higher economic efficiency and improved operation of the DER Marketplace as DER increases	1, 6, 7

Project EDGE Objectives

1. **Wholesale market participation enabled at scale**
2. **Distribution network limits in wholesale dispatch considered**
3. **Efficient and scalable trade of local network services**
4. **Efficient, scalable and secure data exchange enabled**
5. **Integrated technology**
6. **Defined roles and responsibilities**
7. **Cost-benefit analysis**
8. **Customer perspective engaged**
9. **Stakeholder engaged according to best practice principles**
10. **Evidence-based implementation recommendations**

Customer | **Wholesale market integration** | **Local services** | **Efficient data exchange**

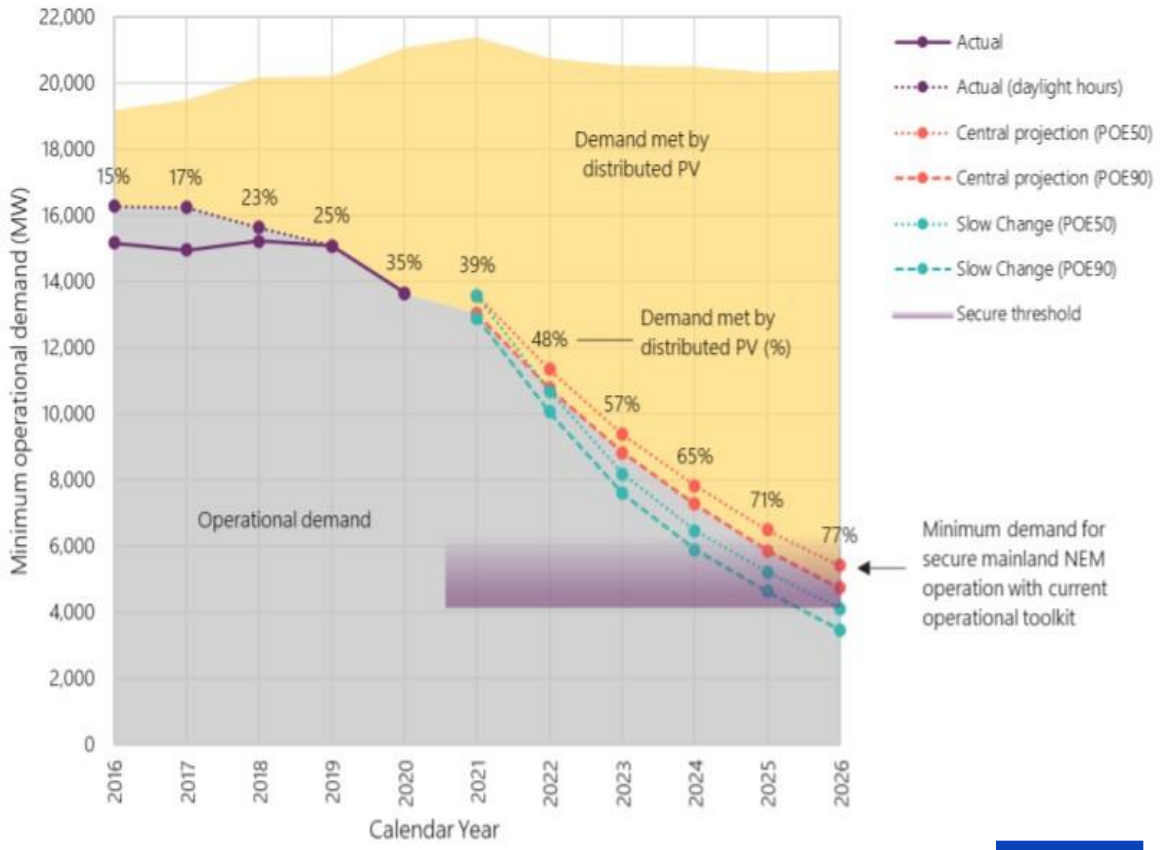
Introduction

A fundamental shift towards decentralisation

The Australian energy sector is rapidly transitioning towards a de-centralised electricity system. A key driver is the strong uptake of DER, such as rooftop PV, by consumers. Distributed solar now collectively represents the largest generator of electricity in the NEM.

AEMO's Electricity Statement of Opportunities (ESOO) for the NEM identifies that a further 8.9 gigawatts (GW) of commercial and residential solar PV is expected to be installed by 2025 in the NEM[2].

As a result, rooftop PV systems alone could supply up to 77 per cent of total electricity demand at times by 2026 and minimum demand across the NEM mainland is expected to drop from 15 GW (2019) down to 4 to 6 GW. This is the limit for its secure operation with the current operational toolkit.



The distribution network must accommodate the demands of empowered customers and a rapidly evolving digital grid where power and information flow in both directions

2 Australian Energy Market Operator, AEMO's reliability outlook 2021, p.5, https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/nem_esoo/2021/2021-nem-esoo-summary.pdf?la=en&hash=33C0EE66FEF1A225C3BDB680D0C57AE0.

A two-sided power system and market informed by a robust evidence base

This transformation represents benefits and opportunities for consumers and the NEM, however it also creates challenges in ensuring secure and reliable electricity. The existing energy structures and systems were designed for the one-way flow of electricity from large-scale dispatchable thermal generators to consumers. DER means that energy now also flows back from consumers to the grid. If DER are not effectively integrated into the grid it creates system security risks and impacts the ability of Distribution Network Services Providers (DNSPs) and AEMO (the system and market operator) to cost-effectively maintain power system security and reliability.

The Energy Security Board's (ESB) NEM redesign advice identified Integration of DER and Flexible Demand as one of four key reform packages. The ESB has identified the clearest opportunity from DER in the energy transition is the development of a two-sided market[3]. Energy Ministers have accepted the ESB's advice and the DER Implementation Plan will enable the reforms needed.

Building on Open Energy Networks (OpEN)

In 2018, AEMO and Energy Networks Australia (ENA) initiated the Open Energy Networks Project, which sought to identify the most appropriate framework for building a two-sided marketplace[4]. The Hybrid model was identified as the most appropriate, in which market operation functions are allocated to AEMO and DNSPs optimise the distribution system operation.

It was also recognised that there is no single definition of the Hybrid model, and that it would need to be trialled to understand its most efficient implementation and to optimise the efficiency and benefits for industry and consumers.

AEMO Energy Networks Australia

OPEN ENERGY NETWORKS

Project EDGE builds on OpEN to trial how AEMO and DNSPs can collaborate in a Hybrid model, developing an evidence base to inform regulatory reforms, industry capability development, investment decisions and innovation

3 Energy Security Board, Clean and Smart Power in the New Energy System: Unlocking benefits of change for consumers, July 2021. https://esb-post2025-market-design.aemc.gov.au/32572/1629954551-esb-final-report-explainer-clean-and-smart-power-der-pathway.pdf.
4 Energy Networks Australia and CSIRO, Electricity Network Transformation Roadmap, https://www.energynetworks.com.au/resources/reports/entr-final-report-summary/.

Project EDGE will test the core functions of a digitised, decentralised power system and market

To generate an evidence base that supports the development of market structures appropriate for a high DER future, Project EDGE will test the three key function sets that are vital elements of efficient and scalable DER integration that delivers value to customers. Project EDGE is testing the interaction of these function sets in a concept called the DER Marketplace.

This Research Plan outlines how Project EDGE aims to demonstrate that an integrated digital ecosystem linking many systems and capabilities across various industry actors to exchange data and services is an efficient and scalable model in the long-term interests of consumers

1. DER wholesale integration function

Project EDGE will test how to enable large-scale DER portfolios to operate on the grid whilst remaining:

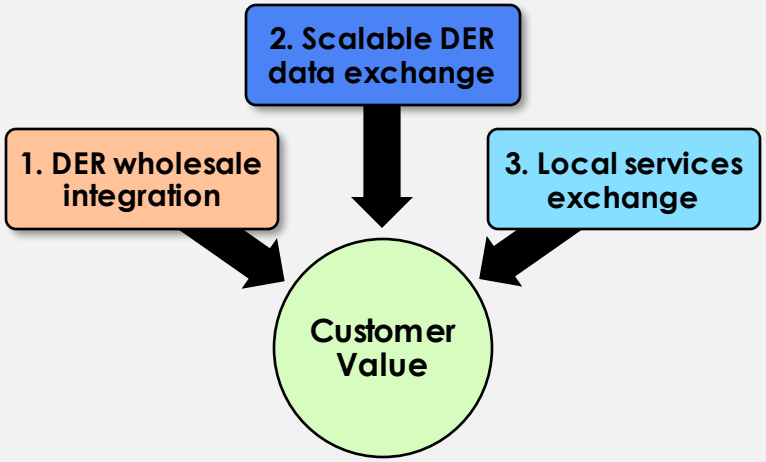
- Within the secure limits of the network
- Visible to the market operator so that it can efficiently coordinate the supply demand balance.

This could be enabled through:

- DNSPs sharing dynamic operating envelopes to ensure DER operate within local network limits
- DER portfolios first providing visibility to the market operator, then participating in the NEM dispatch process.

2. Scalable DER data exchange function

Project EDGE will test how to best harness digital technologies to enable secure, efficient, and scalable ways to exchange vast amounts of data between industry participants to facilitate DER service delivery.



3. Local services exchange function

Project EDGE is testing how a Local Services Exchange (LSE) digital dashboard could enable efficient and scalable trade of local network services that DNSPs procure from aggregators bilaterally.

DNSPs could develop and use an LSE interface to procure services from DER aggregators as a non-network alternative to augmenting the network. This also enables aggregators to stack value streams efficiently and provide better offers to customers.

To promote the NEO it is critical that Project EDGE identifies how these key functions provide long-term value to customers.

Simplifying aggregator user experiences enables them to offer a more simple and compelling value proposition to customers. If wholesale/local services are defined consistently and are easy to deliver across DNSP jurisdictions, then aggregators will be able to develop customer incentives that promote greater DER activation.

The role of the Research Plan

The Research Plan will guide the delivery of Project EDGE

Project EDGE is taking a scientific approach to developing robust evidence that can be trusted to inform regulatory reforms, business capabilities, investment decisions and innovation for the efficient market integration of DER. It seeks to achieve this through a clearly defined Research Plan (this report), an evidence-based cost-benefit analysis, and regular knowledge sharing and stakeholder engagement activities. UoM applied its world-class research design capability and expertise to develop a Research Plan that applies the design thinking approach adopted by EDGE, which begins with the NEO and cascades through multiple steps to ultimately define the Project EDGE design. This framework is outlined in the next section.

The NEO has underpinned each step of the design process so that policymakers and regulators can have confidence in the evidence-based recommendations. Ultimately, the design of Project EDGE (and any future iteration of the DER Marketplace concept) must promote the long-term interests of consumers through lower system cost, maximum market efficiency, and appropriately allocated risk to the actors best suited to manage them without compromising the quality, reliability, safety, and security of the national electricity system.

The Research Plan is important because it prioritises and identifies the activities that are essential and achievable to test research questions and hypotheses. The Research Plan clearly defines these activities and sets out the roadmap to systematically progress toward demonstrating the trial's purpose with clear actions, inputs, and outputs at each step. As a first step, key assumptions (outlined below) needed to be made, guided by the project's scope and primary purpose.

1. The Open Energy Networks Hybrid model will be tested. EDGE will practically test the associated layers of complexity and propose pragmatic ways that AEMO and DNSPs can collaborate.
2. The primary aim is to build industry knowledge of how a DER Marketplace concept could operate in the NEM. EDGE will implement an off-market proof-of-concept digital ecosystem that integrates systems and capabilities developed by the Project Partners into a working DER Marketplace to enable field trials.
3. The DER Marketplace will have integration with AEMO's Enterprise Data Platform to share and access relevant data but will not be integrated with the wholesale energy market operational systems.
4. The local network services between DNSPs and aggregators will be traded as bilateral contracts and there is no market for local services. Rather, Project EDGE will act as a marketplace that facilitates trade between the buyer (AusNet) and sellers (aggregators).
5. The trials will take place in Victoria with a focus on the north-east where near 100% penetration of smart meters gives AusNet access to high resolution customer data.
6. The technical solution implemented will be designed to test the Hybrid model.

The framework used to develop the Research Plan traces back to the NEO

The Research Plan provides traceability to the NEO and Project EDGE objectives and it will inform the Project Partners on the various elements of the design thinking, including the research questions, hypotheses, theoretical and practical exercises, and the data collection and analysis plan required to address Project EDGE's objectives and industry problem statements.

The Research Plan was developed using an iterative approach to refine and prioritise questions, hypotheses, and define test cases that will generate empirical evidence to feed into regulatory and industry decision making. It has been developed based on literature review, subject matter expertise from the Project Partners, and feedback from broad stakeholder engagement, with the ultimate aim to tie every aspect of Project EDGE back to the NEO.

Design thinking cascade

NEO	To promote efficient investment in, and **efficient operation and use of electricity services for the long-term interests of consumers** of electricity.
Problem statements	Engaging stakeholders to understand their perspectives on what is required to enable DER to efficiently deliver wholesale and local network services at scale and develop clear problem statements.
EDGE objectives	Stakeholder perspectives and problems statements were used to define Project EDGE objectives that could demonstrate technical requirements but also enable evidence produced to inform regulatory reforms and industry development.
EDGE research questions	Various high level research questions were drafted in the early stages of Project EDGE, which were refined through stakeholder engagement down to 7 prioritised research questions and associated hypotheses.
EDGE design principles	For each of the three core function sets of the DER Marketplace concept, the EDGE Project Partners agreed some design principles that should guide the detailed design process.
EDGE design	The Project EDGE partners collaboratively designed each element of the DER Marketplace over a series of workshops, which then enabled them to develop detailed requirements for their own systems/capabilities.
Requirements	Detailed requirements developed by each Project Partner for the systems and capabilities that collectively make up the DER Marketplace were informed by the design thinking cascade, starting with the NEO.

Understanding stakeholder expectations: Customer problem statements

A key element of the design thinking framework included engaging with stakeholders to understand their expectations and key challenges in efficiently delivering wholesale and local network services at scale. These stakeholder expectations informed the development of problem statements, which in turn guided the EDGE objectives and research questions.

Customer perspectives were explored to understand key issues that might impact participation and social licence and identify what is required to optimise customer value.

Customers need a simple and secure experience that gives them value, choice and control

"Curtailment seems unfair – what does it mean for me?"[5]

Customer perspectives towards coordination of their DER exports to remain within network limits and their impacts on incentivising behaviour are unclear
Further work is needed to explore customer attitudes towards the benefits of dynamic connection agreements rather than the drawbacks of DER curtailment.

Customer perspectives towards allowing third parties to operate their DER systems are unclear
An efficient DER Marketplace will require customers to grant – formally or informally – permission to allow third parties to operate their DER systems according to their preferences. This means a DER Marketplace requires social licence and customer preferences, motivations, abilities, and preferred incentives in the DER Marketplace design need to be understood (including customers without DER).

"Why should I grant a company permission to use my devices?"

"I don't have solar, why should I care?"

"What are my customer protections with non-retail service providers?"

The national energy customer framework is not fit-for-purpose for the two-side market
The current customer protection framework was designed for a traditional, one-side market where consumers passively participate through purchasing energy they consume from a single retailer. The regulatory framework therefore needs to evolve to ensure adequate customer protections are in place for their engagement with DER aggregators. The assessment of adequate customer protections is not in scope for Project EDGE but is being addressed in Australian Energy Market Commission (AEMC) and ESB reforms.

5 These stakeholder statements are not direct quotes, rather representative perspectives from stakeholder feedback gathered through various engagement activities.

Understanding stakeholder expectations: Aggregator problem statements

Aggregator perspectives were explored to understand key issues and what is required to promote participation and develop the aggregator market to enable DER to efficiently deliver wholesale and local network services at scale and unlock value for customers and businesses.

"Participation in services needs to be simple and not too onerous while I am growing my business."

The existing wholesale market systems and processes do not facilitate the efficient integration of DER at scale that promotes the NEO
Market structures need to provide a simple user experience for aggregators to integrate with the wholesale market and offer local network services at scale. The processes need to be standard across networks to optimise the value to their customers and their business.

A nationally consistent approach to the calculation, communication, and enforcement of operating envelopes has not yet been established
The allocation principles for operating envelopes need to be consistent to make it easier for aggregators to participate and comply. The envelopes need to provide business and customer value to unlock participation in markets and services.

"A nationally consistent approach to the calculation and communication of dynamic operating envelopes is needed."

"Data exchange needs to be efficient and supported by adequate protocols and integrated interfaces."

Current systems and processes to exchange data between industry actors are inefficient and will add unnecessary costs to consumers if continued in a high DER future
Aggregators need to collect, communicate, and access real-time data based on industry agreed protocols that promote customer flexibility and are secure and reliable. This requires loss and interruption resilience and defined governance arrangements.

Customer perspectives towards allowing third parties to operate their DER systems are unclear The DER Marketplace requires social licence to incentivise customers to grant permission– formally or informally– to operate their systems.

"I need clarity on what customers need and expect from my business."

Understanding stakeholder expectations: DNSP problem statements

Key issues from a DNSP perspective were considered to understand what is required to enable DER to efficiently deliver wholesale and local network services at scale, provide network efficiencies and facilitate system security.

"I need confidence that DER are going to operate within my network limits."

The existing wholesale market systems and processes do not facilitate the efficient integration of DER at scale that promotes the NEO
Market structures need to enable DER participation that is visible and forecastable to provide DNSPs confidence they operate within network limits. Systems and processes to facilitate these functions do not exist on an operational scale yet and it is not clear when they will be required.

Current systems and processes to exchange data between industry actors are inefficient and will add unnecessary costs to consumers if continued in a high DER future
DNSPs need to collect, communicate, and access real-time data based on industry agreed protocols that promote customer flexibility and are secure and reliable. This requires loss and interruption resilience and defined governance arrangements.

"Data exchange needs to be efficient and supported by adequate protocols and integrated interfaces."

"The role and functions of DNSPs in a high DER future need to be clear."

The roles and responsibilities of DNSPs and AEMO are insufficiently defined in the consideration of distribution network limits in wholesale dispatch and the structured procurement of local network services
There is a need to clearly define the functions of DNSPs in the DER Marketplace. This includes identifying the functions which it is best placed to manage efficiently, including risk management.

"What are the regulatory incentives for me to procure local network services?"

There are insufficient regulatory incentives for DNSPs to procure local network services from DER at scale

A nationally consistent approach to the calculation, communication, and enforcement of operating envelopes has not yet been established
Static limits often used by DNSPs to restrict DER operation are overly conservative and ineffective at unlocking latent value from DER via participation in markets and services. Many questions around operational envelopes do not yet have a definitive answer, including the duration of each envelope, how frequently envelopes should be updated, and at what physical layer (e.g. device, NMI, node) the envelope should be implemented.

"I need clarity on an approach to implement operating envelopes."

"I need to understand the value that local network services from DER can provide."

Local network services and the value DER can provide to DNSPs are undefined and inconsistent among regions
Currently, local support services are rarely delivered, especially from aggregations of smaller consumer owned DER. DER are engaged through bespoke negotiations for each contract that vary among regions. This does not optimise efficiencies and an easier and standardised procurement process is needed.

Understanding stakeholder expectations: AEMO problem statements

Key issues from AEMO's perspective were considered to understand what is required to enable DER to efficiently deliver wholesale and local network services at scale and maintain power system security.

"DER needs to be visible and forecastable so that I can manage the supply demand balance."

The existing wholesale market systems and processes do not facilitate the efficient integration of DER at scale that promotes the NEO

Market structures need to enable DER participation that is visible and forecastable to enable AEMO to coordinate DER within the technical limits of the grid. Systems and processes to facilitate these functions do not exist on an operational scale yet and it is not clear when they will be required.

AEMO currently has limited visibility of aggregated DER, which impacts the accuracy of their operational forecasts and their ability to efficiently manage the supply demand balance

AEMO must be able to observe or forecast DER in aggregate. The scheduled lite ESB reforms will determine what level of visibility is required and how it is delivered, but the detailed design for schedule lite visibility and dispatchability models should be informed by evidence.

"I need to observe and accurately forecast DER in aggregate."

"Data exchange needs to be efficient and supported by adequate protocols and integrated interfaces."

Current systems and processes to exchange data between industry actors are inefficient and will add unnecessary costs to consumers if continued in a high DER future

AEMO needs to collect, communicate, and access real-time data based on industry agreed protocols that promote customer flexibility and are secure and reliable. This requires loss and interruption resilience and defined governance arrangements.

The roles and responsibilities of DNSPs and AEMO are insufficiently defined in the consideration of distribution network limits in wholesale dispatch and the structured procurement of local network services

There is a need to clearly define the functions of AEMO in the DER Marketplace. This includes identifying the functions which it is best placed to manage efficiently, including risk management.

"The role and functions of the market operator in a high DER future need to be clear."

The Project EDGE objectives guided the development of the research questions

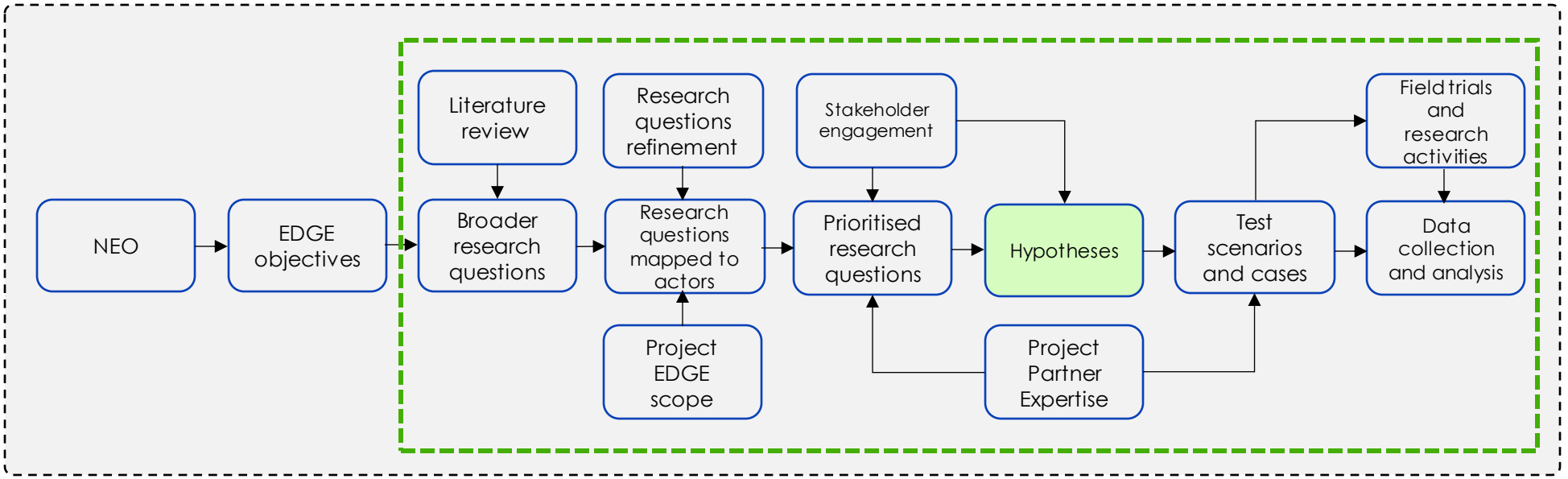
Project EDGE has 10 objectives seeking to test and demonstrate the concepts to enable an efficient DER Marketplace. The objectives are split between demonstrating technical requirements and enabling the outputs of Project EDGE to feed into implementable reforms, such as the ESB Post 2025 market reforms. These objectives were developed to address stakeholder expectations and align to the NEO.

1.	**WHOLESALE MARKET PARTICIPATION ENABLED AT SCALE** | Demonstrate how DER fleets could participate in existing and future wholesale energy markets at scale	**Marketplace technical requirements**
2.	**DISTRIBUTION NETWORK LIMITS IN WHOLESALE DISPATCH CONSIDERED** | Demonstrate different ways to consider distribution network limits in the wholesale dispatch process	
3.	**EFFICIENT AND SCALABLE TRADE OF LOCAL NETWORK SERVICES ENABLED** | Demonstrate how to facilitate standardised, scalable and competitive trade of local network services	
4.	**EFFICIENT, SCALABLE AND SECURE DATA EXCHANGE ENABLED** | Demonstrate how data should be exchanged efficiently and securely between interested parties to support distributed energy services	
5.	**INTEGRATED TECHNOLOGY** | Develop a proof of concept, integrated software solution to facilitate delivery of objectives 1-4 in an efficient and scalable way	
6.	**DEFINED ROLES AND RESPONSIBILITIES** | Develop a detailed understanding of roles and specific responsibilities that each industry actor should play	**Enablers for implementable reform**
7.	**COST-BENEFIT ANALYSIS** | Conduct comprehensive cost-benefit analysis to provide an evidence base for future regulatory decision making	
8.	**CUSTOMER PERSPECTIVE ENGAGED** | Conduct a customer focused social science study to understand customer opinions on the complexities of DER integration	
9.	**STAKEHOLDERS ENGAGED ACCORDING TO BEST PRACTICE PRINCIPLES** | Deliver best practice stakeholder engagement throughout the project with a commitment to knowledge sharing	
10.	**EVIDENCE-BASED IMPLEMENTATION RECOMMENDATIONS** | Deliver recommendations, supported with evidence, on how and when the concepts demonstrated should be implemented operationally	

EDGE research questions

UoM applied an iterative approach to test, refine and prioritise research questions and hypotheses

The Project Partners co-developed initial research questions that were used to progress early trial design and platform development. These initial research questions were also informed by an extensive literature review, including the related national and international activities summarised in Appendices 2 and 3. A comprehensive stakeholder consultation and collaboration process further refined the research questions and hypotheses. Engagement was conducted through direct one-to-one discussions with key stakeholders, while forums facilitated engagement with a broader audience. Collaboration with Project Partners facilitated the design of test cases and scenarios, and the data that would need to be collected from those research activities. The approach adopted by UoM is illustrated in the process diagram below. The full list of stakeholders engaged is included in Appendix 4.



Key stakeholders engaged in one-to-one discussions

- Australian Energy Council
- Australian Energy Market Commission
- Australian Energy Regulator
- Australian Renewable Energy Agency
- Clean Energy Council
- Energy Consumers Australia
- Energy Networks Australia
- Energy Security Board
- SA Power Networks

Forums for engaging with a broader audience

- DER Demonstrations Insights Forum
- Market Integration Consultative Forum
- Networks Advisory Group

The research questions will test fundamental elements and trace to the NEO

The seven research questions test key elements of the core functions and mechanisms and capabilities needed to facilitate an efficient DER Marketplace.

Customer

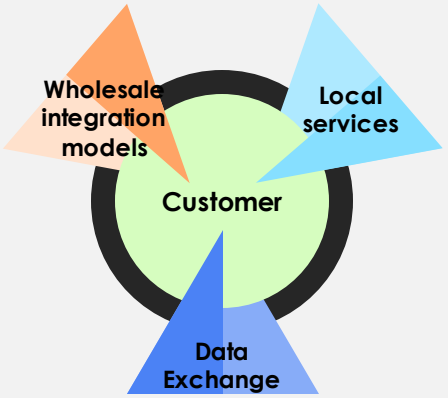
RQ.1 How can the DER Marketplace be designed to enable simple customer experiences, deliver the needs of customers and improve social license for active DER participation?

CBA/ NEO

RQ.2 Does the DER Marketplace promote efficient investment in, and efficient operation and use of, electricity services for the long-term interests of consumers?

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?



Operating envelope design

RQ.3 How does operating envelope design impact on the efficient allocation of network capacity while enabling the provision of wholesale energy and local network services?

Local network services

RQ.5 How can the DER Marketplace facilitate efficient and scalable provision of local network support services from DER so that network efficiency benefits are realised for all customers?

DNSP investment and capability

RQ.7 How could DNSP investment to develop DSO capabilities improve the economic efficiency of the DER Marketplace?

Efficient data exchange

RQ.6 What is the most efficient and scalable way to exchange data between industry actors, considering data privacy and cyber security, to benefit all consumers?

The hypotheses for each research question have traceability to EDGE objectives

Research questions			Hypotheses		Related Project Objectives
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?	Hp.A	Customer 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.	8
			Hp.B	Customers are willing to let aggregators utilise their assets if offers are presented to them simply and provide sufficient value over time.	8
			Hp.C	Enabling aggregators to deliver multiple services whilst minimising market participation complexity.	1, 3
CBA/NEO	RQ.2	Does the DER Marketplace promote efficient investment in, and efficient operation and use of, electricity services for the long-term interests of consumers?	Hp.A	A DER Marketplace can deliver net positive economic impacts for all consumers, particularly if started simply and developed progressively as DER penetration increases.	1, 7
			Hp.B	DER delivery of local services enable DNSPs to defer investments and efficiently manage network reliability and ensure best long-term outcomes for all consumers.	3, 7
			Hp.C	A data hub model reduces cost and complexity of data exchange and provides an economically efficient and scalable approach for the DER Marketplace.	4, 7
			Hp.D	The roles and responsibilities of industry actors that best deliver on the NEO under the hybrid model are largely aligned to their current roles under the existing regulatory frameworks.	6
Operating envelope design	RQ.3	How does operating envelope design impact on the efficient allocation of network capacity while enabling the provision of wholesale energy and local network services?	Hp.A	The design of the operating envelopes has a material impact on the network operation and efficient provision of wholesale energy and local network services.	1, 2, 3
			Hp.B	Accounting for uncertainty in the calculation of operating envelopes improves the technical and economic outcomes of the DER Marketplace.	3, 7
			Hp.C	It is possible to increase efficiency of operating envelope design and implementation as DER penetration increases	2, 3, 7
			Hp.D	Network capacity allocation should focus on maximising network utilisation and yielding the highest net economic benefit for all consumers. Meanwhile, fairness is best achieved ex-post, through a wealth redistribution model and not through the operating envelope.	2, 3, 7
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?	Hp.A	DER participation in wholesale energy markets can be achieved progressively as DER fleets reach materiality thresholds, aligning with ESB visibility and dispatchability models.	1, 2
			Hp.B	System Operator and Distribution Network Service Provider interactions can be defined and implemented efficiently so that DER operation remains within local and system-wide limits at all times.	2
			Hp.C	The aggregator should be responsible for ensuring DER can effectively provide stacked delivery of wholesale energy and local network services simultaneously instead of the market operator co-optimising these services.	1, 3, 6

The hypotheses for each research question have traceability to EDGE objectives

Research questions			Hypotheses		Related Project Objectives
Local network services	RQ.5	How can the DER Marketplace facilitate efficient and scalable provision of local network support services from DER so that network efficiency benefits are realised for all customers?	Hp.A	Network reliability can be managed through the provision of local network services from customer-owned assets.	3
			Hp.B	The barriers to DNSPs relying on local network services from DER can be overcome through proper design of procurement mechanisms.	3
			Hp.C	It is possible to standardise the characteristics and procurement of local network services so that aggregator-DNSP trade of these services can be consistent between regions.	3
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?	Hp.A	A data hub model provides a scalable and long-term approach for DER Marketplace data exchange compared with a web of many point to point interactions between industry actors.	4 5
			Hp.B	Decentralised digital infrastructure, with digital identities and appropriate governance arrangements, enables opportunities for broader benefits to efficient operation of, and participation in electricity markets, and address cyber security risks and consumer data privacy.	4 5
			Hp.C	AEMO and DNSPs need to develop capabilities that maintain the secure operation of the power system and distribution network (respectively) that is resilient to data outages associated with public internet failure in a high DER future.	4 6
DNSP investment and capability	RQ.7	How could DNSP investment to develop DSO capabilities improve the economic efficiency of the DER Marketplace?	Hp.A	There is an optimal combination of DNSP investment in network and DER based non-network solutions which results in higher economic efficiency and improved operation of the DER Marketplace as DER penetrations and density increases.	1 6 7

EDGE research question 1

How can the DER Marketplace be designed to enable simple aggregator and customer experiences, deliver the needs of customers, and improve social licence for active DER participation?

How can the DER Marketplace be designed to enable simple aggregator and customer experiences, deliver the needs of customers, and improve social licence for active DER participation?

Customer

EDGE Objectives

1. Demonstrate how DER fleets could participate in existing and future wholesale energy markets at scale

3. Demonstrate how to facilitate standardised, scalable and competitive trade of local network services

8. Conduct a customer focused social science study to understand customer opinions on the complexities of DER integration

Hypothesis

A. Customer decisions to invest in DER and sign up with an aggregator (to participate in the DER market place) are influenced by financial, social, cultural, environmental, and behavioural factors. (Project Objective 8)

B. Customers are willing to let aggregators utilise their assets if offers are presented to them simply and provide sufficient value over time (Project Objective 8)

C. Enabling aggregators to deliver multiple services through minimising complexity of market participation for both parties (customers and aggregators) will enable them to provide valuable and simple offers to customers. (Project Objective 1 and 3).

Research activities

Literature review and stakeholder engagement to identify factors influencing customer behaviour and aggregator participation.

Customer insight survey to measure customer preferences and decision-making drivers.

Technical and economic modelling and analysis of business models' and incentives' impacts on customer expectations and participation.

Cost-benefit analysis of aggregator participation in simple and sophisticated markets.

Field test to quantify the technical and economic impact of aggregators controlling customer assets. This aims to validate whether the design of how aggregators could participate in the wholesale market and deliver local network services succeeds in creating a more simple user experience for aggregators, enabling them to create more simple offers to consumers.

EDGE research question 2

Does the DER Marketplace promote efficient investment in, and efficient operation and use of, electricity services for the long-term interests of consumers?

Does the DER Marketplace promote efficient investment in, and efficient operation and use of, electricity services for the long-term interests of consumers?

Wholesale market integration | Local services | Efficient data exchange

EDGE Objectives

1. Demonstrate how DER fleets could participate in existing and future wholesale energy markets at scale
3. Demonstrate how to facilitate standardised, scalable and competitive trade of local network services
4. Demonstrate how data should be exchanged efficiently and securely between interested parties to support delivery of distributed energy services
6. Develop a detailed understanding of roles and specific responsibilities that each industry actor should play
7. Conduct comprehensive cost-benefit analysis to provide an evidence base for future regulatory decision making

Hypothesis

A. A DER Marketplace can deliver net positive economic benefits for all consumers, particularly if started simply and developed progressively under different arrangements over time as DER penetration increases. (Project Objectives 1 and 7)

B. DER delivery of local services enable DNSPs to defer investments and efficiently manage network reliability and ensure best long-term outcomes for all consumers. (Project Objectives 3 and 7)

C. A data hub model reduces cost and complexity of data exchange and provides an economically efficient and scalable approach for DER Marketplace. (Project Objective 4 and 7)

D. The roles and responsibilities of industry actors that best deliver on the NEO under the hybrid model are largely aligned to their current roles under the existing regulatory frameworks. (Project Objective 6)

Research activities

Literature review to identify range of commercial arrangements and solutions are various levels of penetration sophistication, local network support services that support deferral of network investment, and suitable data communications methods, platforms and architectures

Cost-benefit analysis of different data exchange models and required expenditures for different industry actors to facilitate or integrate with them

Techno-economic modelling and analysis of the most efficient DER management solutions using various metrics

Cost-benefit analysis of wholesale energy markets impact from increasing penetration, and commercial procurement arrangements for different services, aggregator participation, and market benefits for both active and passive customers. Analysis of new capabilities and regulatory requirements

Framework for different commercial procurement arrangements and comparative analysis of data exchange models

Field tests to identify the impacts and benefits for customers, wholesale energy market, aggregators, customers, and test the feasibility and efficacy of different solutions

Sensitivity analysis of impacts on the wholesale energy market and local network services from different penetration levels

Stakeholder engagement on roles and responsibilities, including SWOT and required regulatory changes and capabilities

EDGE research question 3

How does operating envelope design impact on the efficient allocation of network capacity while enabling the provision of wholesale energy and local network services?

How does operating envelope design impact on the efficient allocation of network capacity while enabling the provision of wholesale energy and local network services?

Wholesale market integration | Local services

EDGE Objectives

1. Demonstrate how DER fleets could participate in existing and future wholesale energy markets at scale
2. Demonstrate different ways to consider distribution network limits in the wholesale dispatch process
3. Demonstrate how to facilitate standardised, scalable, and competitive trade of local network services
7. Conduct comprehensive cost-benefit analysis to provide an evidence base for future regulatory decision making

Hypothesis

- **A** The design of the operating envelopes has a material impact on the network operation and efficient provision of wholesale energy and local network services. (Project Objectives 1, 2 and 3)
- **B** Accounting for uncertainty in the calculation of operating envelopes improves the technical and economic outcomes of the marketplace. [Project Objective 3 & 7]
- **C** It is possible to increase efficiency of operating envelope design and implementation as DER penetration increases. (Project Objectives 2, 3 and 7)
- **D** Network capacity allocation can achieve a scale of objectives ranging from 'equal capacity for all' to 'maximising network utilisation' which yields the highest net economic benefit for all consumers. (Project Objectives 2, 3 and 7)

Research activities

Literature review and stakeholder engagement on different operating envelope calculation methods, sources of operating uncertainty for actors, network management solutions at different penetration levels, and ex-post wealth distribution models

Technical and economic analysis of individual and collective uncertainty impacts, and unlocked economic value from different dynamic operation envelope approaches, and comparison of different objective functions on operating envelopes

Technical analysis of different operating envelope calculation and application approaches and across varying penetration levels and uncertain environments

Survey of different technologies being installed in the network and their relevant characteristics and capabilities

Field tests to determine the technical and economic impacts, utilisation and operation of different operating envelope approaches, and operational characteristics of participating DER under different conditions

Cost-benefit analysis of various approaches to calculation and communication of dynamic operating envelopes, and lost opportunity cost for customers from static limits

EDGE 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?

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?

Wholesale market integration

EDGE Objectives

1. Demonstrate how DER fleets could participate in existing and future wholesale energy markets at scale
2. Demonstrate different ways to consider distribution network limits in the wholesale dispatch process
3. Demonstrate how to facilitate standardised, scalable, and competitive trade of local network services
6. Develop a detailed understanding of roles and specific responsibilities that each industry actor should play

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. (Project Objective 1 and 2)
- **B** System Operator and Distribution Network Service Provider interactions can be defined and implemented efficiently so that DER operation remains within local and system-wide limits at all times. (Project Objective 2)
- **C** The aggregator should be responsible for ensuring DER can effectively provide stacked delivery of wholesale energy and local network services simultaneously instead of the market operator co-optimising these services. (Project Objective 1, 3 and 6)

Research activities

Literature review of current Australian ESB visibility and dispatchability requirements, required operational visibility and information flow requirements

Stakeholder engagement on key preferences, and feasibility of expanded roles for aggregators and the market operator

Cost-benefit analysis examining the costs to aggregators participating progressively in the central dispatch process compared to the benefits from avoided costs and inefficiencies associated with AEMO more effectively managing the supply demand balance through improved operational forecasting capabilities.

Technical and economic analysis of effective and efficient penetration, visibility and dispatchability thresholds, and visibility and information flow impacts on local and system-wide limits

Field tests of spectrum of approaches to DER visibility and dispatchability, aligned to the ESB Scheduled Lite models – including compliance with bids, verification and settlement mechanisms in the existing wholesale energy market, DNSP and market operator interactions, simultaneous provision of local network services, and different approaches to value stacking

EDGE research question 5

How can the DER Marketplace facilitate efficient and scalable provision of local network support services from DER so that network efficiency benefits are realised for all customers?

How can the DER Marketplace facilitate efficient and scalable provision of local network support services from DER so that network efficiency benefits are realised for all customers?

Local services

EDGE Objectives

3 Demonstrate how to facilitate standardised, scalable and competitive trade of local network services

Hypothesis

A Network reliability can be managed through the provision of local network services from customer-owned assets. (Project Objective 3)

B The barriers to DNSPs relying on local network services from DER can be overcome through proper design of procurement mechanisms. (Project Objective 3)

C It is possible to standardise the characteristics and procurement of local network services so that aggregator-DNSP trade of these services can be consistent between regions. (Project Objective 3)

Research activities

Mathematical model, desktop simulation and analysis of the risk of failure and reliability of customer assets, efficacy of reliability management from local services, and necessary volumes.

Literature review, stakeholder engagement and workshops on a delivery risk matrix of procurement mechanisms, and proposed local network services and operating envelopes for different areas and networks with varying levels of visibility

Field tests of the local service provision, DNSP procurement mechanisms, complexity and scalability of different approaches to operating envelope implementation, and effectiveness of financial penalties

Technical and economic analysis of aggregator preferences and sensitivities to different price signals, the complexity and scalability of different approaches to operating envelope implementation, modelling various penetration levels across different areas.

Modelling of non-delivery costs and cost reflective penalties, and likelihood of network protection triggers. Modelling and analysis of reliability and risk-profile comparison between reliance on local services and traditional assets

EDGE 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?

What is the most efficient and scalable way to exchange data between industry actors, considering privacy and cyber security, to benefit all consumers?

Efficient data exchange

EDGE Objectives

4 Demonstrate how data should be exchanged efficiently and securely between interested parties to support delivery of distributed energy services

5 Develop a proof of concept, integrated software platform to facilitate delivery of objectives 1-4 in an efficient and scalable way

Hypothesis

A A data hub model provides a scalable and long-term approach for DER Marketplace data exchange compared with a web of many point to point interactions between industry actors. (Project Objectives 4 and 5)

B Decentralised digital infrastructure, with digital identities and appropriate governance arrangements, enables opportunities for broader benefits to efficiency operation of, and participation in electricity markets, address cyber security risks, consumer data privacy/ control

C AEMO and DNSPs need to develop capabilities that maintain the secure operation of power system and distribution network that is resilient to data outages associated with public internet failure in a high DER future. (Project Objectives 4 and 6)

Research activities

Framework for comparative analysis the different data exchange models

Customer insight study of customer expectations around data privacy

Technical and economic analysis impacts of data outages on power system and distribution network operation

Literature review, workshops and stakeholder engagement on data transfer methods, platforms and architectures, including communication protocol security risks and mitigation, and privacy methods, and governance, data requirements and access for different roles.

Engagement to refine AESCSF

Desktop study and simulations of data anonymisation, attributes of different communication protocols, data reliability under different data exchange approaches,

Field test of operational functionality and reliability of selected protocols, including testing against cyber-attacks, data outage and mitigation methods. Tests of data responsibilities and access for different actors, and viability of governance arrangements

Field tests of different operating envelope implementation approaches across varying complexity and scalability,

EDGE research question 7

How could DNSP investment to develop DSO capabilities improve the economic efficiency of the DER Marketplace?

How could DNSP investment to develop DSO capabilities improve the economic efficiency of the DER Marketplace?

Local services

EDGE Objectives

3 Demonstrate how to facilitate standardised, scalable, and competitive trade of local network services

6 Develop a detailed understanding of roles and specific responsibilities that each industry actor should play

7 Conduct comprehensive cost-benefit analysis to provide an evidence base for future regulatory decision making

Hypothesis

A There is an optimal combination of DNSP investment in network and DER based non-network solutions which results in higher economic efficiency and improved operation of the DER Marketplace as DER penetrations and density increases. (Project Objectives 3, 6 and 7)

Research activities

Literature review and stakeholder engagement on different investment options of DNSP-owned network and non-network solutions and relevant regulatory framework considerations and barriers

Cost-benefit analysis of possible incentives for DNSP investment, including financial benefits from increased hosting capacity and more DER available for local service provision, and DNSP expenditure

Technical economic framework that compares different DNSP network and non-network solution investments and operational options, and impacts on economic efficiency from higher network hosting capacity

Field tests of increased economic hosting capacity and efficiency compared to existing network solutions

Data collection

Data that will be collected as part of the trials

Categories of data collected in Project EDGE

The Project EDGE partners will utilise and exchange a broad range of data sets to facilitate the DER Marketplace and to assess the costs and benefits of scaling the concepts being tested as DER penetration grows. Data flows in Project EDGE will provide a robust evidence base to indicate the volumes and costs of distribution level data flows in a high DER future. Data will be collected and shared in alignment with obligations relating to private and protected data.

Enrolment and standing data

DER asset and portfolio level data required to enrol in the wholesale market and for each local service. This includes pre-qualification testing data if required for local services

Near real time monitoring / visibility

Near real time visibility of aggregated DER operation, aligned to the Scheduled Lite Visibility Model. It will be provided at slower sampling rates than the 4 second visibility that Scheduled resources provide currently in the NEM.

Wholesale bid / offer data

To simulate participation in the NEM dispatch process, aggregators will submit wholesale bids/offers into the DER Marketplace. The bid file is amended to test bi-directional bidding aligned to the Integrating Energy Storage Systems rule change[6].

Distribution level load forecasts

In order to calculate the operating envelopes, AusNet will forecast distribution level load and customer site behaviour to understand projected constraints on their network.

Dynamic Operating Envelopes

AusNet will allocate distribution network capacity limits to connection point level dynamic operating envelopes and communicate them to aggregators via the DER Marketplace.

Smart meter data

Smart meter data will be used as inputs into the distribution level load forecasts, but also to verify compliance to the connection point level dynamic operating envelopes.

Local Services engagement data

AusNet and aggregators will exchange data to test how the structured procurement of local network or 'flexibility' services could be achieved through a DER Marketplace, including specific service details and offers to provide the services.

Local Services verification data

As aggregators deliver local services they will also need to submit verification data to AusNet via the DER Marketplace, which could include energy, power or voltage data depending on the service.

Cost-benefit analysis data

Cost data relating to the costs of facilitating and scaling the DER Marketplace will be collected and shared with the independent cost-benefit analysis consultant.

6 Australian Energy Market Commission (AEMC), Integration energy storage systems into the NEM, https://www.aemc.gov.au/rule-changes/integrating-energy-storage-systems-nem, accessed on 10 December 2021.

Categories of data collected in Project EDGE

Research questions			Data Collection			
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?	Consumer Survey	Market operational data	Network operational data	
			DER historical data	Market historical data	DER parameters	
			DER operational data	Customer economic incentives and contracts		
CBA/NEO	RQ.2	Does the DER Marketplace promote efficient investment in, and efficient operation and use of, electricity services for the long-term interests of consumers?	DER historical data	Customer economic incentives and contracts	Market parameters	Customer Survey
			DER technical parameters	Historical customer demand data	Market operational data	Network operational data
			Definitions of services	Distribution network technical parameters	Market historical data	Network cost
			DER operational data	Details of communication protocols, historical market data	Market participants registration data	
Operating envelope design	RQ.3	How does operating envelope design impact on the efficient allocation of network capacity while enabling the provision of wholesale energy and local network services?	Network technical parameters	Historical data for sources of uncertainty	DER operational data	Operational network telemetry
			Network operational data	Historical customer demand data	DER historical data	Customer economic incentives and contracts
			Network historical data	Market operational data	DER cost data	
			DER technical parameters	Market historical data	Market parameters	
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?	Network parameters	Operational network telemetry	Market parameters	DER parameters	Market settlement data
			Network operational data	Definitions of services	Market operational data	Customer economic incentives, contracts	DER cost data
			Network historical data	DER operational data	Market historical data	DER historical data	

Categories of data collected in Project EDGE

Research questions			Data Collection			
Local network services	RQ.5	How can the DER Marketplace facilitate efficient and scalable provision of local network support services from DER so that network efficiency benefits are realised for all customers?	Network parameters	Customer economic incentives and contracts	DER technical parameters	Operational network telemetry
			Network operational data	Operational DER data	DER operational data	Definitions of services
			Network historical data	Market settlement data	DER historical	
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?	Network costs	Details of communication protocols	Market operational data	
			Historical market prices	Data anonymisation and de-anonymisation techniques		
			Customer Survey	DER operational data		
			Definitions of services	Historical network data		
DNSP investment and capability	RQ.7	How could DNSP investment to develop DSO capabilities improve the economic efficiency of the DER Marketplace?	Distribution network technical parameters	Customer economic incentives and contracts	DER historical data	
			DER technical parameters	Network and non-network solutions capex and opex	Operational DER data	
			Definitions of services	Historical customer demand data		

EDGE design principles and high level design

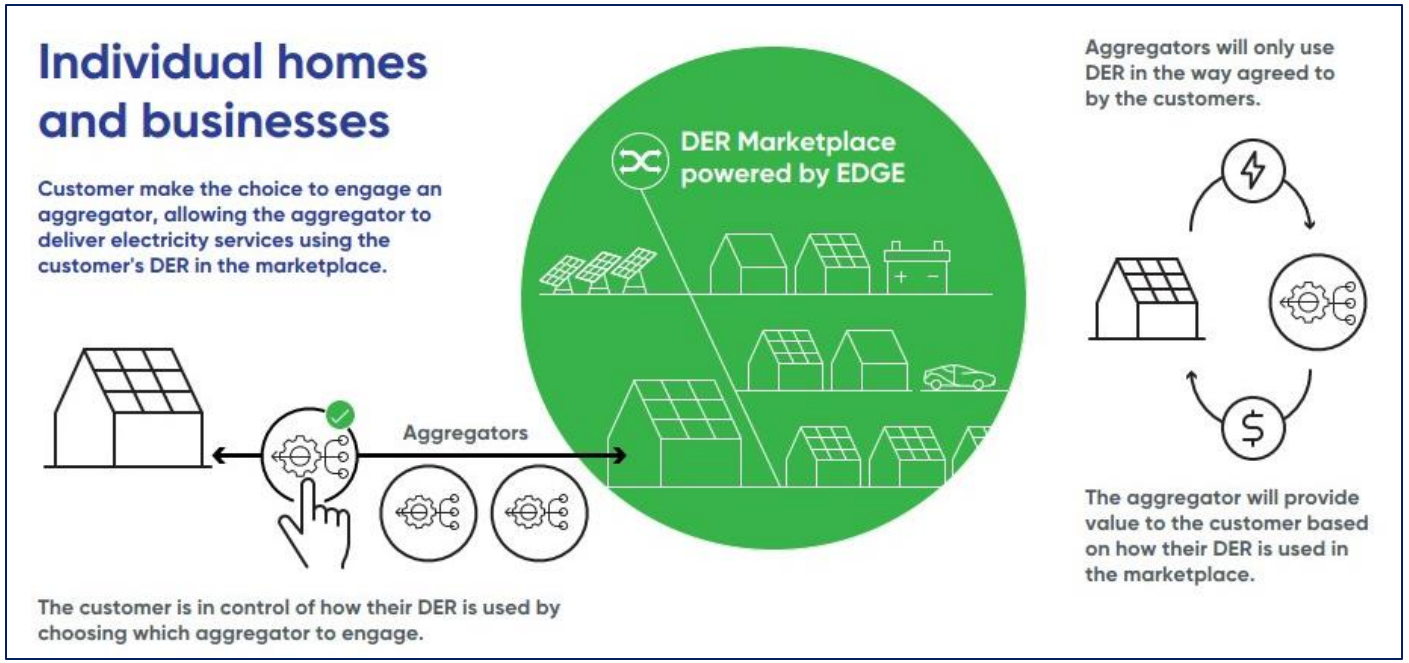
A DER Marketplace enables aggregators to access and deliver electricity services using customers' DER

RQ.1

Objectives: 1 3 8

The design thinking framework facilitated the identification of key stakeholder expectations, development of the objectives, research questions and design principles, which in turn informed the Project EDGE detailed design process. Guided by the preceding cascade elements, the Project Partners worked collaboratively to design each aspect of the DER Marketplace. The research questions and associated hypotheses set out in the Research Plan will test these detailed design aspects to identify whether the Project EDGE design provides the most efficient framework for a DER Marketplace that promotes the NEO. The following sections summarise the key elements of the detailed Project EDGE design. The legend on the top-right corner traces the design elements to the relevant research question that will test the design, and the related Project EDGE Objectives the design is intended to facilitate.

Aggregators have a key role in representing consumers in a DER Marketplace and managing the risk and complexity of delivering multiple services on their behalf through the DER Marketplace. Importantly, consumers are ultimately in control and grant aggregators permission to use their DER and data to deliver services according to the consumers' preferences – not the preference of the market operator or DNSPs. Aggregators provide value to consumers, through up-front discounts, regular payments or revenue sharing arrangements, in exchange for using customers' DER. Project EDGE will test how the DER Marketplace design enables simple customer experiences, delivers customer needs and improves social licence for active DER participation.



Project EDGE roles and responsibilities

RQ.2

Objectives: 1, 3, 4, 6, 7

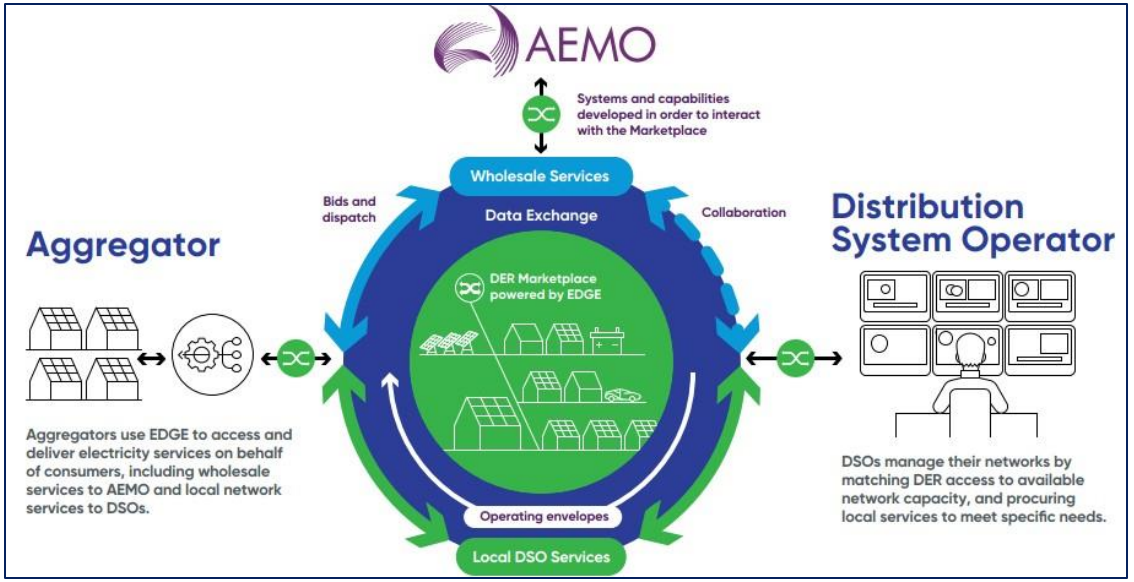
There are three primary roles that enable the DER Marketplace – the Power System and Market Operator, the Distribution System Operator (the DNSP in the Australian context), and aggregators/retailers who facilitate DER responding to wholesale price signals or delivering local network 'flexibility' services. In Project EDGE, these roles and their respective responsibilities are being undertaken by the Project Partners.

AEMO's role primarily relates to its statutory responsibilities in the National Electricity Rules (NER) to establish the spot market (NER 3.4), operate a central dispatch process (NER 3.8.1) and to determine and represent network constraints in dispatch (NER 3.8.10). As DNSPs are the experts of their distribution networks, AEMO must collaborate with DNSPs to gain confidence that wholesale dispatch will not lead to distribution network limits being breached.

Ausnet, in transitioning to a Distribution System Operator role, will dynamically optimise their network, calculate the network limits and communicate them as 'dynamic operating envelopes' to aggregators via the DER Marketplace (see white arrow below). AusNet will also define local network services and engage aggregators to deliver them using the Local Service Exchange function.

Mondo is acting as the sole aggregator for the first two trial phases of the project and is the key driver of EDGE's Customer Insights Study. Project EDGE ultimately anticipates testing the operation of the DER Marketplace with multiple aggregators.

The Research Plan sets out how Project EDGE will test the design of the DER Marketplace to identify the optimal framework to promote the NEO, including the roles and responsibilities of the industry actors who are best place to deliver on the NEO efficiently and manage risk.



Wholesale Integration Design Principles

RQ.4

Objectives: 1, 2, 3, 6

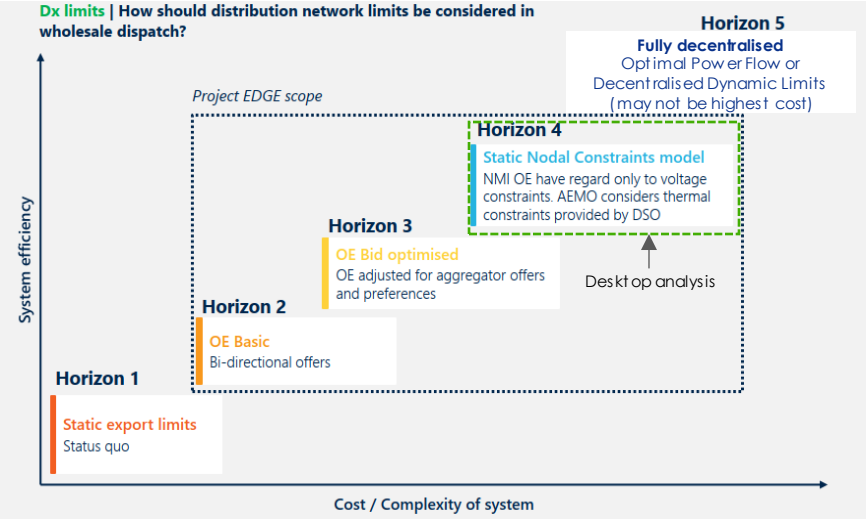
The wholesale integration function will test how to optimally integrate DER via aggregators as new market participants into wholesale markets. AEMO, Ausnet and Mondo developed a progression of draft target operating models for the wholesale energy spot market to test this function. Design principles were defined to maintain alignment to project goals in recognition the draft models may evolve.

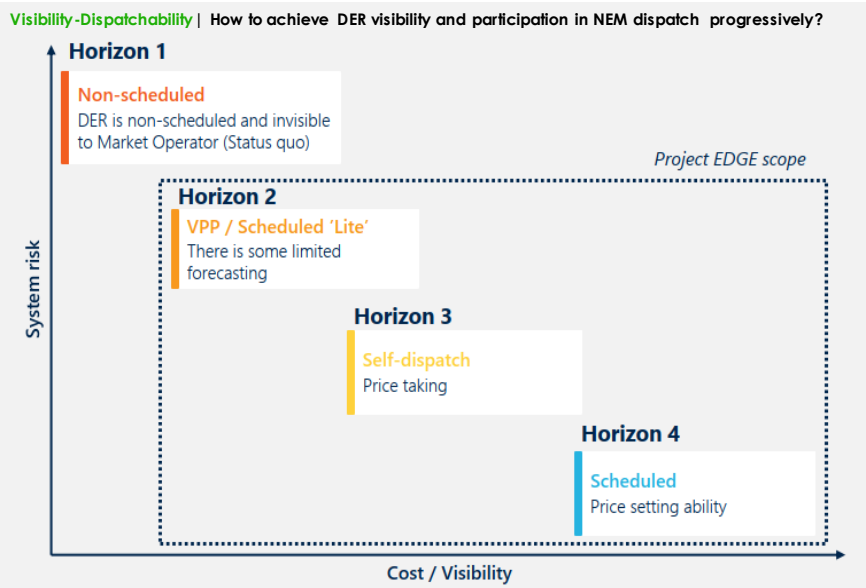
The principles guide the assessment and comparison of design approaches regarding (but not limited to) system implementation, customer focus, maximising utilisation of DER assets and distribution network capacity, and flexibility and responsiveness to changing market and DER's dynamic nature.

Principle	Considerations
1	• Minimise complexity of design to achieve desired outcomes • Minimise complexity of integration to achieve desired outcomes • Design in appropriate level of resilience
2	• Minimise complexity of design to achieve desired outcomes • Minimise complexity of integration to achieve desired outcomes • Ability to handle exceptions and contingent events
3	• Maximises economically efficient DER participation and utilisation of distribution network capacity through a security constrained economic dispatch process • Reduced reliability risk • Improves customer outcomes or meets expectations and reduce overall market dispatch costs
4	• Maximises competitive behaviour • Minimises poor participant behaviour and risk of gaming • Reduced interventions in operations
5	• Market functions performed by AEMO • Network functions performed by DNSPs • Allows business risks to be controlled or managed by accountable parties
6	• Different jurisdictions and networks • Different DER transition approaches • Different future markets and aggregation models
7	• Minimise complexity of design to achieve desired outcomes • Minimise complexity of integration to achieve desired outcomes • Lowest reliance on designs not previously operationalised at scale
8	• Access to information that enables assessment of risk and value • Access to latest signals and on timely basis • Maximises flexibility in procurement approaches

Project EDGE is testing a spectrum of approaches to operating envelope design and key wholesale integration functions

RQ.3 RQ.4 Objectives 1 2 3 6 7





Integration of DER at scale into wholesale markets is focused on maintaining wholesale market operability with a very high penetration of price responsive DER and within distribution network constraints. Power system operability is outlined in detail in AEMO's Power System Requirements[7], with a focus on the dispatchability and predictability of the power system. These capabilities are fundamental to how AEMO keeps the power system in balance using security constrained economic dispatch. In the context of this project, these capabilities relate to:

Operating envelope design, allocation and DER operation within distribution network limits

How to ensure distribution network limits is considered in the coordination of resources for wholesale dispatch. DNSPs are the experts of the distribution network and will be responsible for calculating distribution network limits and communicating them to aggregators. However, there is spectrum of approaches to calculation affecting cost efficiency through network utilisation and fairness amongst DER owners, and to incorporating these network limits into the wholesale dispatch process, starting with the basic operating envelopes that sends connection point level dynamic operating envelopes to aggregators on a day-ahead basis.

DER visibility to enable efficient management of the supply demand balance

AEMO manages the supply demand balance by coordinating large-scale resources in NEM wholesale dispatch through the scheduling process. Project EDGE aims to assess the feasibility of aggregated DER operating as a scheduled resource, or whether a yet-to-be-defined form of scheduling 'lite' is more appropriate.

The spectrum of approaches spans a simplicity-efficiency trade-off, from relatively simple and lower cost to implement, but relatively inefficient, to more complex, higher cost to implement and enables more efficient system operation. Efficiency refers to both the level of market efficiency and efficacy (outlined in the principles above) and the level of network utilisation (that is, how close to the true network limits can the market securely operate).

Project EDGE test cases will explore the advantages, disadvantages, costs and benefits of each horizon on the spectrum of approaches for both functions. The results will feed into the evidence based cost-benefit analysis, which can inform the level of DER penetration that should warrant more sophisticated approaches to these functions.

7 Australian Energy Market Operator (AEMO), Power System Requirements: Reference Paper, July 2020, https://www.aemo.com.au/-/media/files/electricity/nem/security_and_reliability/power-system-requirements.pdf?la=en&hash=04F4669E6663B1763086B291B463C0A5, accessed on 10 December 2021.

Wholesale integration | A day in the life for two Wholesale Operating Models (indicative design)

RQ.4

Objectives: 1, 2, 3, 6

Basic operating envelopes approach

Assumptions:

- DNSP and Aggregator successfully enrolled
- DNSP able to calculate Operating Envelopes
- Aggregator able to submit Bi-directional Offers
- Wholesale market gate closure rules for bidding and re-bidding are not considered

Day Before Trading Day

- DNSP calculates the operating envelope and sends to AEMO and Aggregator
- Aggregator reviews available capacity for wholesale Bi-directional offer, taking into account:
  - Import / export limits communicated through operating envelope (where applicable, i.e. there is an updated limit to comply with at a given NMI)
  - Capacity required for other services (e.g. FCAS)
- Aggregator creates / updates and submits regional Bi-directional offer for the wholesale energy spot market
- AEMO validates the NMIs attached to the submitted offer and maps them to TNIs

Trading Day (Leading up to Dispatch Interval)

- Aggregator reviews available capacity for wholesale Bi-directional offer, taking into account:
  - Import / export limits communicated through operating envelope (where applicable, i.e. there is an updated limit to comply with at a given NMI)
  - Capacity required for other services (e.g. FCAS)
- Aggregator creates / updates and submits regional Bi-directional offer for the wholesale energy spot market

Trading Day (Dispatch)

- AEMO 'pre-solves' the TNI level bi-directional offer at time of Dispatch Interval gate closure as follows:
  - Aggregates the operating envelope limits for the NMIs attached to each price band
  - Where the NMI limit aggregate < the price band offer, the price band is constrained to the NMI aggregate
- AEMO submits the TNI level Bi-directional offer to Central Dispatch so that the offer can be compared to the Wholesale Clearing Price for the relevant Dispatch Interval
- AEMO generates a merit order from those Bi-directional offers that are below the wholesale clearing price
- AEMO generates Dispatch Instructions, including the 'pre-solve' constraint information where required and send to Aggregator
- AEMO generates Dispatch Instructions and send to merit order Aggregators
- Aggregator performs local dispatch according to the received Dispatch Instructions
- Aggregator provides operational data to AEMO for Dispatch Verification

Post-Dispatch

- AEMO verifies the dispatch against operating envelope and dispatch target to assess DER compliance
- AEMO records Aggregator compliance and takes appropriate action in case of non-compliance.

Bid optimised operating envelopes approach

Assumptions:

- DNSP and Aggregator successfully enrolled
- DNSP able to calculate Operating Envelopes
- Aggregator able to submit Bi-directional Offers
- Wholesale market gate closure rules for bidding and re-bidding are not considered
- *The below activities are presented as a linear progression, however there are feedback loops such as the operating envelope update activities (operating envelope update frequency is to be determined, however it is to be noted that update frequency may be as high as 5 minutes)*

Day Before Trading Day

- DNSP calculates the operating envelope *using additional economic and physical inputs as follows* and sends to AEMO and Aggregator
  - *Wholesale bi-directional offers*
  - *Network setting configuration*
- Aggregator reviews available capacity for wholesale Bi-directional offer, taking into account:
  - *Updated* Import / export limits communicated through operating envelope (where applicable, i.e. there is an updated limit to comply with at a given NMI)
  - Capacity required for other services (e.g. FCAS or Local DER Service)
- Aggregator creates / updates and submits regional bi-directional offer for the wholesale energy spot market
- AEMO validate the NMIs attached to the submitted offer and maps them to TNIs
- *AEMO sends the wholesale bi-directional offers to the DNSP (at frequency TBD) for operating envelope update*

Trading Day (Leading up to Dispatch Interval)

- Aggregator reviews available capacity for wholesale Bi-directional offer, taking into account:
  - *Updated* Import / export limits communicated through operating envelope
  - Capacity required for other services (e.g. FCAS or Local DER Service)
- Aggregator creates / updates and submits regional Bi-directional offer for the wholesale energy spot market
- AEMO validate the NMIs attached to the submitted offer and maps them to TNIs
- *AEMO sends the wholesale bi-directional offers to the DNSP (at frequency TBD) for operating envelope update*
- *DNSP re-calculates operating envelope, using TNI-level Bi-directional offer as an Active DER Forecast (at frequency TBD) and re-sends to AEMO and Aggregator*
- *DNSP re-calculates operating envelope using re-configured network volt / var settings (at frequency TBD) and re-sends to AEMO and Aggregator*

Blue it alicised t ext highlights differences betw een the basic and bid optimised operating env elopes approaches

Data Exchange Design Principles

RQ.6

Objectives: 4 5 6

The data exchange capability provided by a platform is critical to enabling a fully functional DER Marketplace and participants will need to integrate and facilitate data exchange via this platform. EDGE aims to test an efficient and scalable approach to data exchange among industry actors, with consideration for privacy and cyber security, and that benefits all consumers. The Research Plan also seeks to identify whether AEMO and DNSPs need to develop resilient capabilities to maintain secure operation of the power system and distribution network respectively.

Data Exchange design principles

Principle	Considerations
1	• How can the industry wide costs and complexity of exchanging data between many parties be reduced through standards or common digital infrastructure?
2	• Agree between project partners what data standards should be used.
3	• Aim to avoid point-to-point connections between actors (tight coupling), or market operator and DSO sending simultaneous but conflicting signals to the aggregator (hidden coupling).
4	• Make it as easy as possible for aggregators to connect with the market operator and multiple DNSPs to exchange data. Find alternatives to the expense of connecting to Supervisory Control and Data Acquisition system (SCADA) for sending operational data.
5	• Enable aggregators to have consistent user experiences when sending data to multiple DNSPs or the market operator.
6	• Ensure appropriate standards are upheld regarding data privacy, cyber security and data quality.

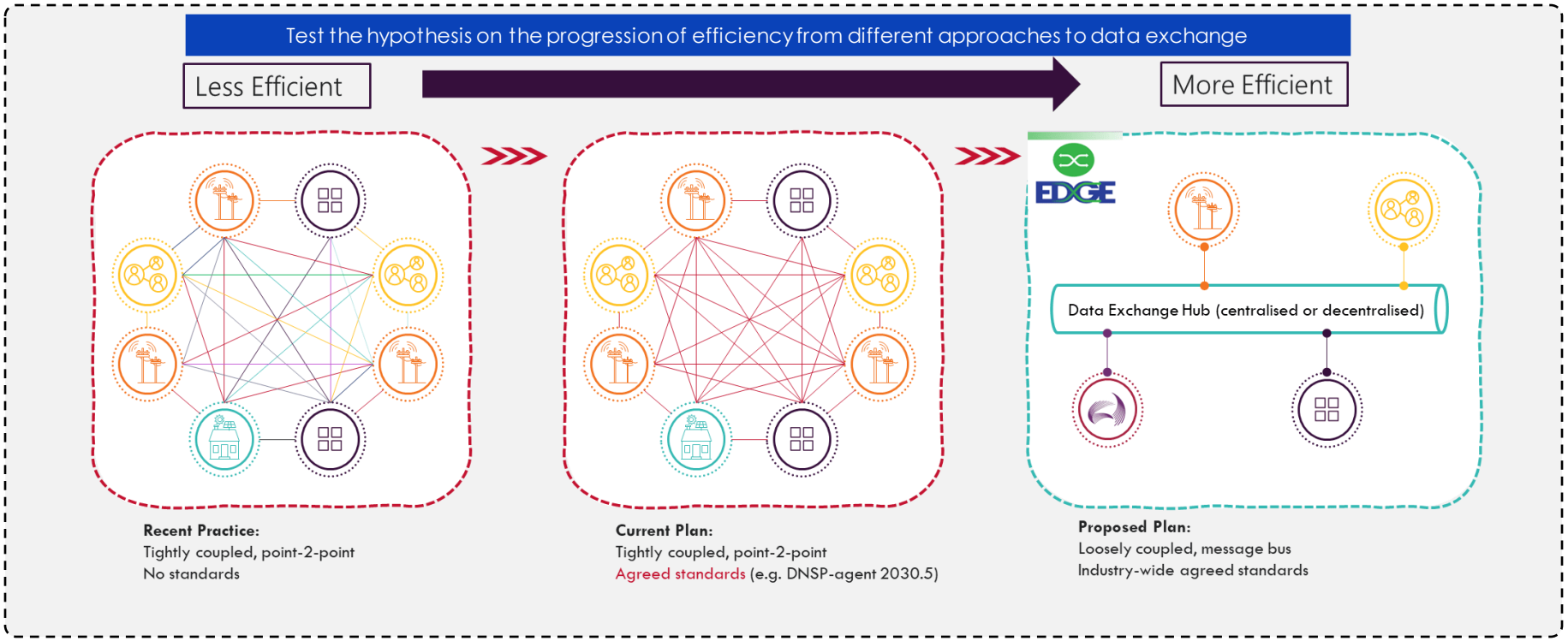
Data Exchange | EDGE is testing how a DER Marketplace could act as a data exchange hub

RQ.6

Objectives: 4 5 6

One of Project EDGE's objectives is to test efficient and scalable approaches to data exchange. The hypothesis that will be tested is that many 'tightly coupled' point to point integrations are inefficient and costly if scaled in a high DER future. A potentially more efficient solution would be to enable any party connected to the DER Marketplace to share data and communicate with anyone else connected to it. This aligns with the key design principles of simplicity and standardisation.

The digital infrastructure that underpins an integration framework for digital identities and efficient data exchange could be centralised (hosted by AEMO) or decentralised as shared industry infrastructure. EDGE is examining both options, but in either case a governance role will be required to establish and maintain the procedures and standards to facilitate the framework. This will test the hypothesis that decentralised digital infrastructure with appropriate governance arrangements enables opportunities for broader benefits to operational efficiency and participation while addressing privacy and cyber security risks.

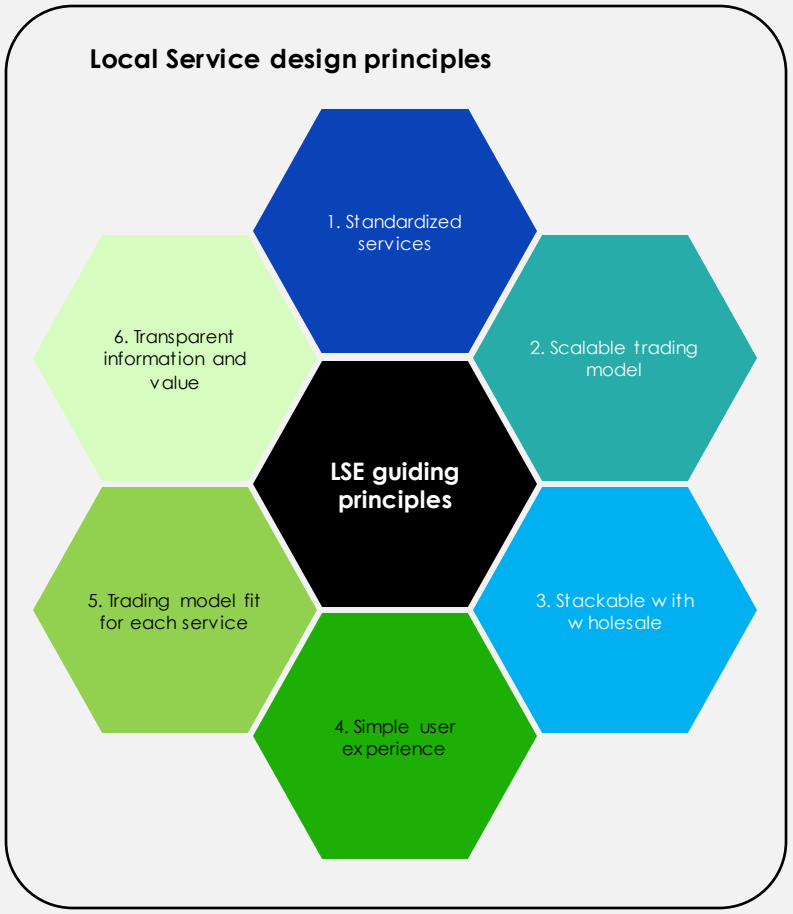


Local Services Design Principles

RQ.5

Objectives 3

The Local Services Exchange (LSE) function aims to facilitate visible, scalable and competitive trade of local DER services that enable DNSPs to manage local power security and reliability, and enable aggregators to stack local and wholesale value streams efficiently (deliver them simultaneously). The LSE aims to make it easier for DNSPs/DSOs and aggregators to trade local services and enable the $2.5 billion trade of such services that the ENA and CSIRO projected could occur by 2050[8]. Design principles were developed by the Project Partners to maintain key areas of focus as the LSE design was developed. These design principles led to the development of the Project EDGE design for the LSE function that will be tested by the Research Plan to identify whether it is the most efficient and scalable way to provide LSE services.



Principle	Considerations
1	• Local services should be defined using a common set of attributes, such as a unit of measurement, activation/lead time, response speed and duration.
2	• In order to facilitate billion dollar trade of local services the LSE concept must be standardised and able to be scalable in throughput and across regions.
3	• Wholesale alignment across market participants and processes, especially relating to timing/dispatch so that services can be value stacked.
4	• Simplicity and efficiency of processes to enable service transactions, delivery and settlement activities.
5	• The breadth and type of DER required to provide the service, taking a technology neutral approach. • Balance between market size, service and performance requirements, especially in a thin market with fewer buyers and sellers.
6	• Value and impact should be visible to the market to provide an efficient investment signal. • Local services need to present a positive net value in economic terms to LSE participants and end customers.

8 Energy Networks Australia and CSIRO, Electricity Network Transformation Roadmap, https://www.energynetworks.com.au/resources/reports/entr-final-report-summary/, accessed on 10 December 2021.

Local Services – proposed services and lifecycle through the Local Services Exchange

RQ.5

Objectives 3

AusNet has taken the lead to define a number of local services that could be tested in Project EDGE, and prioritised three specific services to develop further.

The Local Services Lifecyle provides an indication of the user experience on both the aggregator and the DSO sides of the LSE that can enable bilateral structured procurement of local services between them.

EDGE is testing whether definition of these services and the how they are traded can be more standardised to enable scalable and competitive trade to deliver most value to all consumers from DER investments.

Potential Local Services To Test in EDGE

Primary Focus

Capex Deferral

- Service as alternative to investing in new network capacity
- Increase generation or reduce controlled load at particular location

Peak Demand / Generation

- Response during forecast peak demand / generation windows (=~ 5 p.a.) to reduce the risk of asset failure
- Note that this service is less firm and is likely to have an aligned cost profile

Voltage management

- Reactive Power service to manage over / under voltage excursions
- To alleviate binding voltage constraints and unlock further export / import capacity

Planned Outage

- Service to provide capacity for 1 – 6 week timeframe, to address planned outages

Unplanned Outage

- Used reactively with little or no notice to provide capacity to enable the network to be reconfigured

Aggregator	Local Services Lifecyle	Distribution System Operator
View service and assess whether to enrol	Define	Define service characteristics and contractual terms
Submit enrolment information and performance test data	Enrol	Assess performance test data and pre-approve to participate
Submit offer - if accepted, exchange contracts per pre-agreed terms	Engage	Post service opportunity, assess offers from pre-approved participants, exchange contracts
Respond to dispatch signal to deliver service	Deliver	Schedule service delivery or trigger dispatch via EDGE
Submit service verification data	Verify	Download/view data on EDGE Assess data to verify performance
Set up standard queries for reporting	Report	Set up standard queries for reporting

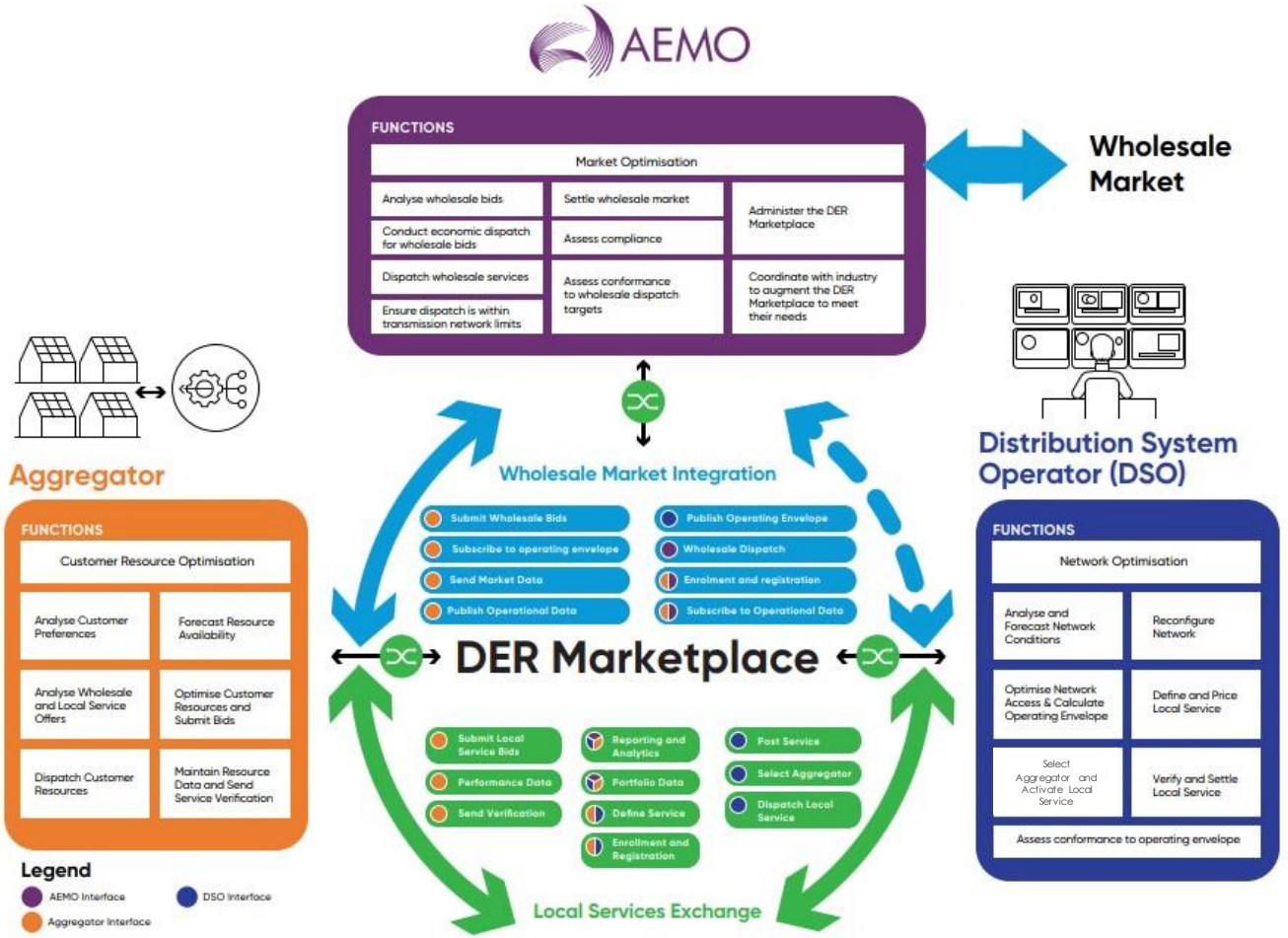
The DER Marketplace will require interactions between many systems and capabilities

RQ.2 and 4 | RQ.5 | RQ.6

Objectives: 1 2 3 4 5 6 7

Project EDGE is testing the three key function sets associated with the DER Marketplace concept, spread across three key roles.

The functional view illustrated in this diagram summarises, at a high-level, the key functions for each actor in the DER Marketplace as they relate to wholesale market integration, data exchange and the local services exchange.



Each party needs to develop systems and capabilities in order to deliver each function.

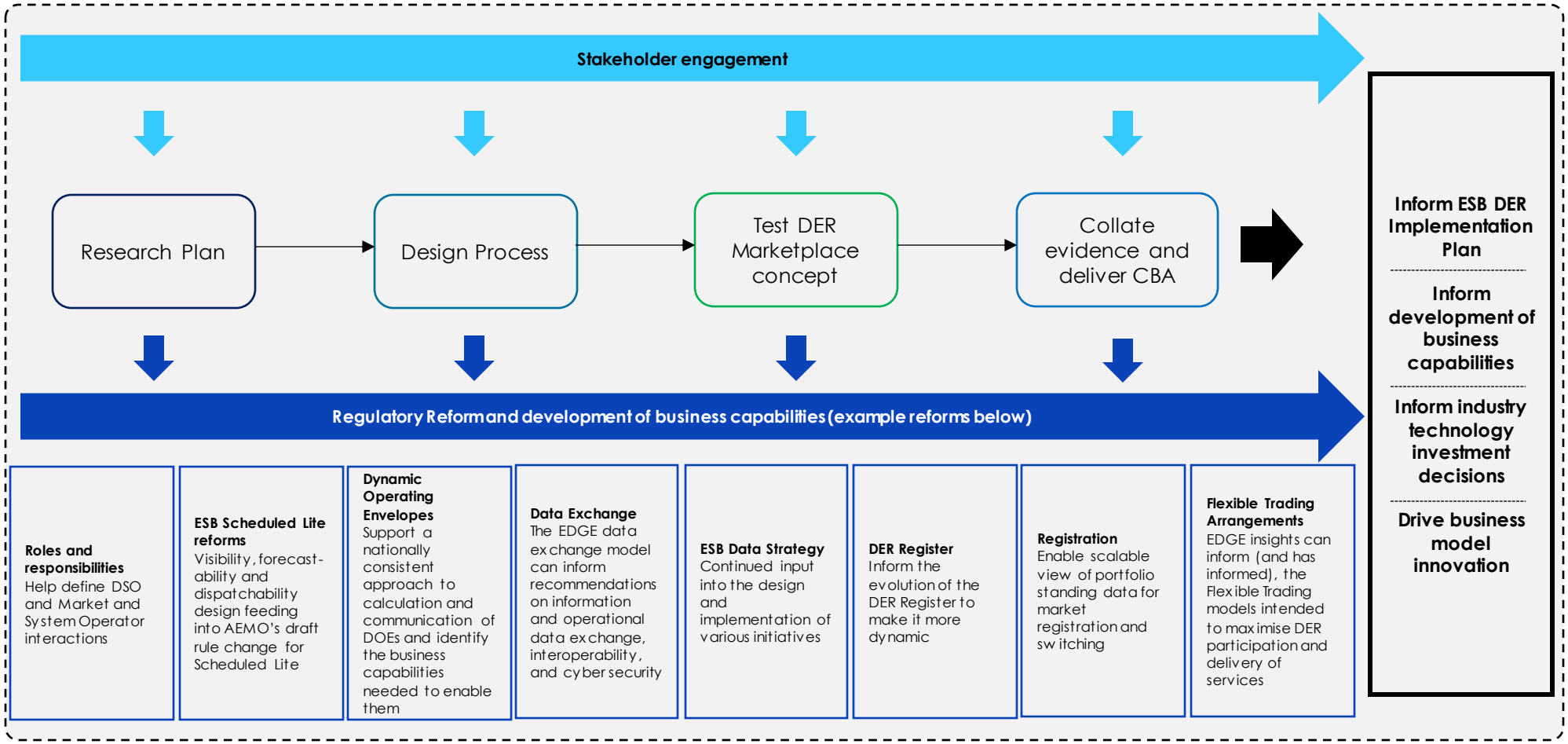
Collectively, these capabilities constitute the DER Marketplace. For instance there may not be one LSE, rather each DNSP could procure or develop their own LSE that utilises the same underlying digital infrastructure to facilitate data exchange and digital identities used by participants.

Project EDGE will test how this digital ecosystem could facilitate the interactions between industry participants in an efficient and scalable way for the long-term interests of consumers.

Research outputs

Research outputs will provide an evidence base to inform stakeholder decision-making

The research outputs will help inform stakeholder decisions (including regulatory reforms and the development of business capabilities) throughout Project EDGE. For instance, the design process is already feeding into the design thinking for the ESB Schedule Lite reforms and the DEIP Dynamic Operating Envelopes working group. The field testing and final research outputs (including the CBA) will inform further stakeholder decisions.



Appendix 1

Research Plan implementation approach

The Research Plan implementation timeline adopts a phased approach

Project EDGE is divided into five phases. The first two phases are project inception and development. The last three phases are committed to field trails. Only the Phases 2 to 4 directly relate to this Research Plan and these are summarised below.

Phase 2

Core Platform development

- Detailed design of the DER Marketplace, testing the platform and interface for all Project Partners and customer recruitment.
- This phase includes the development and finalisation of the Research Plan.

Phase 3

Implementation and testing of offline marketplace

- This is expected to commence from November 2021 and last until April 2022.
- EDGE will demonstrate and test marketplace operation off-line, including data exchange between participants, local network services and the wholesale energy service.
- The testing in this phase will be undertaken with less than 100 customers and less than 1 MW of flexible capacity.

Phase 4

Marketplace operational trial with a single aggregator

- This is expected to span from May 2022 to August 2022 and will move from off-line to online testing of different functions and scenarios, with real-world DER fleet dispatch using live market price data from AEMO's enterprise database.

Phase 5

Marketplace operational trial with multiple aggregators

- Introduce additional aggregators and test DER Marketplace functionality using near real-time price signals from the wholesale market.
- By Phase 5 EDGE aims to recruit at least two additional aggregators and scale to a maximum capacity of 10 MW or a mix of 1,000 residential, commercial and industrial customers.
- Phase 5 is expected to conclude by 31 March of 2023.

Appendix 2

Literature review – national activities

Various national activities were reviewed to inform EDGE

Past and ongoing Australian projects related to the concept of a DER Marketplace were reviewed to understand their objectives and outcomes and to identify how learnings from these projects could be applied to EDGE.

Activity	Description and objectives	Learnings that could feed into EDGE (linked to objectives)
Evolve	Development and demonstration of a DER coordinating system ensuring the secure technical limits of the distribution network are not breached. https://arena.gov.au/assets/2021/04/evolve-on-the-implementation-and-publishing-of-operating-envelopes.pdf	**Objective 2** Work related to operating envelope calculation, including the data for formulation, communication, and scalability, can be used as a reference to inform the strategies used by Project EDGE.
VPP Demonstration	Tests a range of objectives to understand the interaction between VPPs, AEMO and the NEM. https://aemo.com.au/-/media/files/initiatives/der/2021/csba-vpp-customer-insights-study-report-feb-2021.pdf?la=en	**Objectives 1, 2, 3, 4, 8** This work will inform several considerations and capabilities relevant to Project EDGE including operational visibility, forecasting and dispatching, value stacking abilities, technical specifications for participation in multiple services, regulatory arrangements, customer experience, data exchange over API, and cyber security.
Simply Energy VPPx	The first VPP that will integrate with a distributed energy market platform that is being developed for the project. The platform will support the transaction of value from flexible capacity to the provision of wholesale energy, FCAS, and potentially network support, services while maintaining distribution network security and stability. https://arena.gov.au/assets/2019/06/simply-energy-vppx.pdf	**Objectives 1, 2, 3, 4, 5, 8** The technical validation could assist Project EDGE understand the feasibility of relying on DER to provide local network services, while customer insights could support the design of the EDGE Marketplace considering customers' financial preferences.

Project EDGE Objectives

1. Wholesale market participation enabled at scale
2. Distribution network limits in wholesale dispatch considered
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4. Efficient, scalable and secure data exchange enabled
5. Integrated technology
6. Defined roles and responsibilities
7. Cost-benefit analysis
8. Customer perspective engaged
9. Stakeholder engaged according to best practice principles
10. Evidence-based implementation recommendations

Various national activities were reviewed to inform EDGE (continued)

Past and ongoing Australian projects related to the concept of a DER Marketplace were reviewed to understand their objectives and outcomes and to identify how learnings from these projects could be applied to EDGE.

Activity	Description and objectives	Learnings that could feed into EDGE (linked to objectives)
Advanced VPP Grid Integration	Developed a web interface (API) to exchange data on available distribution network export capacity (dynamic operating envelopes). This enable the VPP to dispatch at higher levels of export power while participating in the wholesale energy and FCAS markets and remain within safe operating capacity of the local distribution network. https://arena.gov.au/assets/2021/05/advanced-vpp-grid-integration-final-report.pdf	**Objectives 1, 2, 4** The methods use to formulate and communicate operating envelopes and the interactions with AEMO and wholesale markets could provide insights for Project EDGE.
Project CONSORT	A platform to non-intrusively coordinate the energy systems owned by consumers that meets network capacity and voltage constraints to achieve required network benefits at minimal cost. It also explores way to financially compensate consumers for network support. https://arena.gov.au/assets/2019/06/consort-network-aware-coordination-report.pdf	**Objectives 1, 2, 3, 4, 5** The findings related to providing appropriate price signals to the aggregator's energy management system located within consumers' homes to incentivise network support, and the methods used to maintain the scalability of the project and customer insights could inform Project EDGE.
University of Queensland's Solar Enablement Initiative	Demonstrates the technical feasibility of distribution system state estimation and aims to develop technology readiness that can be used by DNSPs to support full network visibility and assess operational network conditions more accurately. https://arena.gov.au/assets/2018/02/uq-solar-enablement-initiative-final-report.pdf	**Objective 2** A real-time state estimation tool could be a starting point for how the DNSP in Project EDGE could determine capacity allocation and inform the data required for sufficient network visibility. Real-time dynamic export limits provided by the estimation tool could inform assessment of the benefits of dynamic export limits and the required time resolution for Project EDGE.

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Past and ongoing Australian projects related to the concept of a DER Marketplace were reviewed to understand their objectives and outcomes and to identify how learnings from these projects could be applied to EDGE.

Activity	Description and objectives	Learnings that could feed into EDGE (linked to objectives)
Optimal DER Scheduling for Frequency Stability (University of Tasmania)	Develop and test software coordinating DER fleets and enable them to provide FCAS and system stability functions. https://arena.gov.au/projects/optimal-der-scheduling-for-frequency-stability-study/	**Objective 2** While FCAS is not in Project EDGE's scope, the methods used to maintain DER operation within network limitations could inform the operating envelope design methodology for Project EDGE.
Dynamic Operating Envelopes Workstream	The program explores the value that dynamic operating envelopes could offer and provide a working definition of operating envelopes and dynamic operating envelopes. https://arena.gov.au/knowledge-innovation/distributed-energy-integration-program/dynamic-operating-envelopes-workstream/	**Objective 2** The results and stakeholder insights could inform the design, operation, and governance of the operating envelopes used in Project EDGE.
Networks Renewed	Demonstrated how customer-owned smart inverters can be controlled by a third party and integrated with DNSP distribution management systems. It demonstrated local network services can be commercially obtained from consumer-owned DER and enable capital expenditure deferral for DNSPs. https://arena.gov.au/projects/networks-renewed/	**Objectives 3, 8** Insights inform Project EDGE on the need for standardisation of communication and control protocols among different stakeholders to achieve scalability. Insights on business models inform Project EDGE regarding simple financial incentives for customers while insights on customer engagement inform process and the need to capture regional and socio-economic variability when planning surveys.

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Various national activities were reviewed to inform EDGE (continued)

Past and ongoing Australian projects related to the concept of a DER Marketplace were reviewed to understand their objectives and outcomes and to identify how learnings from these projects could be applied to EDGE.

Activity	Description and objectives	Learnings that could feed into EDGE (linked to objectives)
Dynamic Limits	Investigation of the decentralised control of DER for the management of local network constraints to increase hosting capacity. The main objective is the implementation of dynamic export limits to ensure adequate voltages and power flows and allow DER participation on system-level services contingent to the local network constraints. https://arena.gov.au/assets/2020/09/dynamic-limits-der-report.pdf	**Objectives 2, 4** This report outlines how Decentralised Dynamic Limits Control Schemes could be an alternative approach for communicating network limits to DER – this is considered in Horizon 5 on the spectrum of approaches to considering distribution limits in the wholesale integration section of the high level design. Although Horizon 5 is out of scope for Project EDGE the dynamic limits approach is important to consider in the reform agenda.
State of Distributed Resources Technology Integration Report	Exploration of the functional areas key to enabling DER integration and highlights the significance of visibility and information exchange, and standardisation of protocols. https://arena.gov.au/assets/2021/02/state-of-distributed-energy-resources-technology-integration-report.pdf	**Objectives 1, 4, 5** The findings on the functional areas that are key to enabling DER integration is one of the main objectives of Project EDGE. The learnings relating to the significance of scalable and standardised communication and information exchange provide valuable insights for Project EDGE to ensure review of current protocols and ongoing developments it could adopt in the DER Marketplace.
Insight into Distributed Energy Resource Customers	Investigation of the customer experience in ARENA-funded DER projects. It identified the key elements that support the acceleration of DER deployment and maximise potential benefits to customers and the energy system. The review also explored the values and motivations of DER customers. https://arena.gov.au/assets/2020/08/der-customer-insights-the-customer-journey.pdf	**Objectives 1, 8** The findings on elements that support deployment and benefits to customers and the energy systems will provide valuable insights that can inform the design of Project EDGE and the functions of the DER Marketplace. The insights relating to values and motivations of DER customers could inform Project EDGE's customer surveys to understand the value propositions that can be more appealing for costumers.

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Appendix 3

Literature review – international activities

Various international activities were reviewed to inform EDGE

The concept of the DER Marketplace is also being researched around the world. Relevant past and ongoing international projects were reviewed to understand their objectives and outcomes and to identify how learnings from these projects could be applied to EDGE.

Activity	Description and objectives	Learnings that could feed into EDGE (linked to objectives)
EUniversal	Development of an universal approach for DSOs to procure flexibility through an agnostic and scalable approach to develop new services and market solutions for active customers to participate in the electricity market. It seeks to identify technologies and systems suitable to provide flexible services to the distribution network. The project also explores the reliability of services and additional security needs for systems, and TSO/DSO coordination. https://euniversal.eu/download-center/	**Objectives 1, 3, 4, 5** Insights relating scalable approaches, technologies and systems to procuring and providing network services, and the development of new services and market solutions to incentivise customer participation could inform Project EDGE, particularly because the project scope is similar. Research on security needs for systems includes relevant issues for Project EDGE such as communication requirements for DER to participate in different markets, prioritisation of flexibility services, and coordination between different markets.
Open Networks Project	This is a major ongoing industry initiative to standardise customer experiences and align processes to make connection to the networks as easy as possible and enable integration of DER to the local grid. It aims to deliver a smart grid by opening up new markets and building an all-inclusive energy system that will enable customers to access multiple markets to provide services and reduce cost for customers through more cost-effective planning. https://www.energynetworks.org/creating-tomorrows-networks/open-networks/	**Objectives 1, 2, 3** This project is the most aligned international activity with Project EDGE and multiple insights can inform the design of Project EDGE, particularly the similarity in the description of local network services.

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The concept of the DER Marketplace is also being researched around the world. Relevant past and ongoing international projects were reviewed to understand their objectives and outcomes and to identify how learnings from these projects could be applied to EDGE.

Activity	Description and objectives	Learnings that could feed into EDGE (linked to objectives)
Power Potential	Creation of a new reactive market for DER to generate additional capacity in the network and provide capital expenditure deferral services. It aims to increase system flexibility by using more DER capabilities and provide network support at distribution and transmission level. https://www.nationalgrideso.com/document/205371/download	**Objectives 2, 3** Key learnings relating to the different stages within field tests can inform Project EDGE along with insights relating to visibility, controllability, procurement mechanisms and development of new markets, and coordination among different actors.
ADDRESS	The project aimed to enable market participation and flexibility provision of small residential and commercial customers. It developed a commercial and technical framework including flexibility provision from demand response and DER. http://www.addressfp7.org/	**Objectives 1, 3** Key insights and recommendations from the project can inform EDGE's aims and field tests relating to wholesale participation and local network services.
FEVER	The project aims to orchestrate flexibilities in generation, storage and consumption to ensure secure and reliable power systems and proposes solutions and services that leverage flexibility and address distribution network needs by incorporating different technologies and solutions. The project also seeks to demonstrate tools for advanced monitoring and control of the distribution network, and the analysis of novel market mechanisms and tools to support flexibility services. https://fever-h2020.eu/	**Objectives 1, 2, 3, 4** Insights relating to regional differences will provide valuable insights to Project EDGE on suitable and robust standards and solutions in regions with technical, regulatory and socio-economic differences and how these can be applied in the Australian context.

Project EDGE Objectives

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The concept of the DER Marketplace is also being researched around the world. Relevant past and ongoing international projects were reviewed to understand their objectives and outcomes and to identify how learnings from these projects could be applied to EDGE.

Activity	Description and objectives	Learnings that could feed into EDGE (linked to objectives)
ENGAGE	Development and testing of an end-to-end aggregation and control architecture for DER. The architecture designed will enable behind-the-meter DER to provide both wholesale energy and distribution network services. The project seeks to address several barriers that prevent behind-the-meter DER from being used to provide network services including technological and economic barriers. https://www.epri.com/research/programs/067418/results/3002022480, https://www.epri.com/research/programs/067418/results/3002022405, https://www.epri.com/research/programs/067418/results/3002022403	**Objectives 1, 3, 4, 5** The project has published several technical reports that could inform Project EDGE, including DER management system control architecture, grid services from DER, and DER cyber-security interoperability specifications.
The Integrated Grid Initiative	This project explores the transformation to the 'Integrated Grid' and identifies key areas of global collaboration needed to develop an optimal Integrated Grid. The project has developed a benefit-cost framework that defines the tools, protocols, and methods necessary to conduct consistent, repeatable, and transparent studies to anticipate and accommodate DER. https://www.epri.com/research/products/000000003002004878	**Objectives 1, 3** The framework developed by the project is rooted in the fundamentals of power system engineering and economics, making the methods applicable to all regions, systems, markets, technologies, and research questions. Therefore, it can inform Project EDGE's design of the DER Marketplace functions to integrate DER into the grid.

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2. Distribution network limits in wholesale dispatch considered
3. Efficient and scalable trade of local network services
4. Efficient, scalable and secure data exchange enabled
5. Integrated technology
6. Defined roles and responsibilities
7. Cost-benefit analysis
8. Customer perspective engaged
9. Stakeholder engaged according to best practice principles
10. Evidence-based implementation recommendations

Various international activities were reviewed to inform EDGE (continued)

The concept of the DER Marketplace is also being researched around the world. Relevant past and ongoing international projects were reviewed to understand their objectives and outcomes and to identify how learnings from these projects could be applied to EDGE.

Activity	Description and objectives	Learnings that could feed into EDGE (linked to objectives)
NODES	The Network Optimized Distributed Energy Systems (NODES) Program aims to enable renewables penetration at levels of 50% or greater by developing transformational grid management and control methods to create a virtual energy storage system based on the use of flexible load and DER. The expected benefits include reduced periods of costly peak demand, reduced energy waste, and increased penetration of renewable energy production. The umbrella group funds a number of other innovative projects relating to the control strategies for coordinating DER to provide ancillary services, and real-time optimisation and control of next-generation distribution infrastructure. https://arpa-e.energy.gov/sites/default/files/Day-1-0945-NODES-kickoff-ARPAE-Glavaski.pdf	**Objectives 1, 3, 4** The findings on system and network management and control methods, and the flexible use of DER can inform Project EDGE's design of integration of DER into wholesale market, provision of local network services and data exchange to enable these functions.
NYISO DER Energy and Capacity Market	The New York Independent System Operator (NYISO) released its DER roadmap in 2017 as a first step to enhancing its market rules for DER participation in the energy, ancillary services and capacity markets. NYISO has since proposed designs for a DER energy market and a DER capacity market. These designs include consideration of DER aggregation, registration, bidding, dispatch, telemetry, settlements, and metering. https://www.nyiso.com/documents/20142/6006612/BIC%20DER%20Market%20Design%20Presentation.pdf/9cdc8700-ab90-d741-c28d-0c29b3468807	**Objectives 1, 3, 4** The market design and mechanisms that are planned to be utilised by the NYISO could help inform the market design in EDGE. Additionally, once these new markets and models have been approved and implemented there may be further learnings that are relevant for Project EDGE's objectives to test the functions of participation in wholesale energy market and provision of local network services.

Project EDGE Objectives

1. Wholesale market participation enabled at scale
2. Distribution network limits in wholesale dispatch considered
3. Efficient and scalable trade of local network services
4. Efficient, scalable and secure data exchange enabled
5. Integrated technology
6. Defined roles and responsibilities
7. Cost-benefit analysis
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Various international activities were reviewed to inform EDGE (continued)

The concept of the DER Marketplace is also being researched around the world. Relevant past and ongoing international projects were reviewed to understand their objectives and outcomes and to identify how learnings from these projects could be applied to EDGE.

Activity	Description and objectives	Learnings that could feed into EDGE (linked to objectives)
International Renewable Energy Agency (IRENA)	IRENA considered short and long-term as well as centralised and decentralised forecasting to identify the impacts and key enablers of advanced forecasting. Its report found that implementing these advanced forecast techniques could result in tens of millions of dollars of savings annually and identified one of the key requirements is the visibility of generation from DER. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2020/Jul/IRENA_Advanced_weather_forecasting_2020.pdf?la=en&hash=8384431B56569C0D8786C9A4FDD56864443D10AF	**Objective 1** The findings on the impacts and key enablers of advanced forecasting could inform Project EDGE's research activities on wholesale market participation.

Project EDGE Objectives

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Appendix 4

Stakeholders engaged in the development of the Research Plan

List of all stakeholders engaged through the Demonstrations Insight Forum

The DER Demonstrations Insights Forum consists of a panel of selected industry experts that provide feedback on all elements of the project, including the design, research questions, implementation and outputs, and provides a critical link between the evidence generated and the regulatory reform process.

Forum	Represented businesses	
Demonstrations Insights Forum	Australian Energy Council (ECA)	Energy Consumers Australia
	Australian Energy Market Commission (AEMC)	Energy Security Board (ESB)
	Australian Energy Market Operator (AEMO)	Mondo
	Australian Energy Regulator (AER) / Cadency Consulting	Nous
	AGL	Public Interest Advocacy Centre (PIAC)
	Australian National University (ANU)	South Australia Power Networks (SAPN)
	Australian Renewable Energy Agency (ARENA)	Simply Energy
	AusNet Services	Tesla
	Clean Energy Council (CEC)	University of Technology Sydney (UTS)
	Department of Environment, Land, Water and Planning (DELWP)	Engie
	Energy Networks Australia (ENA)	

List of all stakeholders engaged through the Network Advisory Group

The Network Advisory Group[9] provides feedback on the specific distribution network service design elements of the project and provides network businesses an opportunity to share information and uplift understanding of the Project EDGE objectives. The forum facilitates input and agreement by members on the scope of the project, which enhances the validity of the project for industry and its application for future market development.

Forum	Represented businesses	
Network Advisory Group	Ausgrid	Horizon Power
	AusNet Services	Jemena
	Australian Energy Market Operator (AEMO)	South Australia Power Networks (SAPN)
	Citipower/Powercor	TasNetworks
	Energy Networks Australia (ENA)	United Energy
	Energy Queensland	University of Melbourne (contracted by AusNet Services within the project)
	Essential Energy	Western Power
	evolve DER project (Australian National University (ANU)/ZepBen)	

9 Network Advisory Group – Terms of Reference: https://aemo.com.au/-/media/files/stakeholder_consultation/working_groups/der-program/der-micf/project-edge-networks-advisory-group-terms-of-reference.pdf?la=en

List of all stakeholders engaged through the Market Integration Consultative Forum

The Market Integration Consultative Forum[10] provides aggregator and retailer perspectives on the design options for market integration and participation and informs the development and prioritisation of design and research activities related to the market mechanisms supporting DER participation. The forum also provides an opportunity for aggregators to receive timely progress updates of relevant project trials and obtain better understanding of the operations and practicalities of participation to facilitate a smoother integration into the DER Marketplace frameworks.

Forum	Represented businesses				
Market Integration Consultative Forum	Actew AGL	Embertec	Healm	Planet Ark Power	Solar Service Group / Members Energy
	AGL	Enel X	Hydro Tasmania	Power Cor	sonnen
	Caris Brooke Consulting	EnergyAustralia	Independent consultant (Rheem)	Power Ledger	Starling Energy
	Centurion	Energy Locals	Intelligent Automation	Powershop	SwitchDin
	Citipower, Powercor and United Energy	Energy Queensland	Karit	Reposit Power	Tango Energy
	Clipsal Solar	Enphase	KIG Energy	Seed Advisory	Tesla
	Combined Energy Technology	EPWA	Light Source BP	Shell Energy	The Energy Project
	CSR Limited	ERM Power	Members Energy	Shinehub	Yates Electrical
	Central Victorian Greenhouse Alliance (CVGA)	Essential Services Commission Victoria	Mondo	Simply Energy	Yurika
	Deloitte	Evergen	My Green Power	Social Energy	
	Denovo Electra	Greensync	Natural Solar	Solar Analytics	
	Discover Energy	GTL Renewable	Origin Energy	Solar Service Group	

10 Market Integration Consultative Form – Terms of Reference: https://aemo.com.au/-/media/files/stakeholder_consultation/working_groups/der-program/der-micf/der-market-integration-consultative-forum-terms-of-reference.pdf?la=en

Appendix 5

References

List of sources referenced

Document	Source
Australian Energy Market Commission (AEMC), Integration energy storage systems into the NEM	https://www.aemc.gov.au/rule-changes/integrating-energy-storage-systems-nem
Australian Energy Market Operator (AEMO), AEMO's Reliability Outlook 2021	https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/nem_esoo/2021/2021-nem-esoo-summary.pdf?la=en&hash=33C0EE66FEF1A225C3BDB680D0C57AE0
Australian Energy Market Operator (AEMO), Power System Requirements: Reference Paper, July 2020	https://www.aemo.com.au/-/media/files/electricity/nem/security_and_reliability/power-system-requirements.pdf?la=en&hash=04F4669E6663B1763086B291B463C0A5
Energy Networks Australia and CSIRO, Electricity Network Transformation Roadmap	https://www.energynetworks.com.au/resources/reports/entr-final-report-summary/
Energy Security Board, Clean and Smart Power in the New Energy System: Unlocking benefits of change for consumers, July 2021	https://esb-post2025-market-design.aemc.gov.au/32572/1629954551-esb-final-report-explainer-clean-and-smart-power-der-pathway.pdf
Energy Security Board, Final advice July 2021	https://esb-post2025-market-design.aemc.gov.au/final-advice-july-2021
Network Advisory Group – Terms of Reference	https://aemo.com.au/-/media/files/stakeholder_consultation/working_groups/der-program/der-micf/project-edge-networks-advisory-group-terms-of-reference.pdf?la=en
Market Integration Consultative Form – Terms of Reference	https://aemo.com.au/-/media/files/stakeholder_consultation/working_groups/der-program/der-micf/der-market-integration-consultative-forum-terms-of-reference.pdf?la=en