Deloitte.

# Project EDGE CBA - Methodology

Australian Energy Market Operator

November 2022

Deloitte Access Economics

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# Glossary

| Key Terms | Description |
|---|---|
| Operating Envelopes (OEs) | The limits that an electricity customer can import or export to the grid. |
| Dynamic Operating Envelopes (DOEs) | Operating envelopes with limits that can vary according to the prevailing grid conditions, unlike static Operating Envelopes that have fixed limits. |
| Virtual Power Plant (VPP) | Distributed energy resources located in multiple places grouped together as an aggregated energy resource. |
| Distributed Energy Resources Management System (DERMS) | Software platform for coordination and management of Distributed Energy Resources. |
| Local Services Exchange (LSE) | The LSE function could enable the efficient and scalable trade of local network services that Distribution Network Service Providers (DNSPs) procure from aggregators representing customers and their DER devices. This presents DNSPs with an opportunity to procure an alternative and more cost-effective solution to augmenting their distribution network and increase the efficiency of the system by maximising the value delivered from customer devices. |
| Data Hub | Digital infrastructure allowing data exchange between parties. Project EDGE considers a centralised and decentralised data hub infrastructure. |
| Active DER | DER that can respond to external signals to apply power limits and dispatch active and reactive power. Can be turned on or turned off, ramped up or ramped down. |
| Passive DER | DER that cannot respond to external signals. |
| Distribution System Operator (DSO) | A change to the existing DNSP role with a more active network management role in the distribution network. |

| Acronym | Full name |
|---|---|
| **AEMC** | Australian Energy Market Commission |
| **AEMO** | Australian Energy Market Operator |
| **AER** | Australian Energy Regulator |

| | |
|---|---|
| **API** | Application Programming Interface |
| **ARENA** | Australian Renewable Energy Agency |
| **BAU** | Business As Usual |
| **BCR** | Benefit Cost Ratio |
| **Capex** | Capital expenditure |
| **CBA** | Cost Benefit Analysis |
| **CECV** | Customer Export Curtailment Value |
| **$CO_2$** | Carbon dioxide |
| **DER** | Distributed Energy Resource |
| **DERMS** | Distributed Energy Resources Management System |
| **DID** | Digital and Decentralised Identities |
| **DLT** | Distributed Ledger |
| **DNSP** | Distribution Network Service Provider |
| **DOE** | Dynamic Operating Envelope |
| **DSO** | Distribution System Operator |
| **ECA** | Energy Consumers Australia |
| **ENA** | Energy Networks Association |
| **ESB** | Energy Security Board |
| **EV** | Electric Vehicle |
| **EWF** | Energy Web Foundation |
| **FCAS** | Frequency Control Ancillary Services |
| **FRMP** | Financially Responsible Market Participant |
| **FTE** | Full Time Equivalent |
| **FTM** | Flexible Trader Model |

| | |
|---|---|
| **GSL** | Guaranteed Service Level |
| **Hp** | Hypothesis |
| **IESS** | Integrating Energy Storage Systems |
| **LRET** | Large-scale Renewable Energy Target |
| **LSE** | Local Services Exchange |
| **LV** | Low Voltage |
| **HV** | High Voltage |
| **ISP** | Integrated System Plan |
| **MCA** | Multi-criteria Analysis |
| **NEM** | National Electricity Market |
| **NEO** | National Electricity Objective |
| **NER** | National Electricity Rules |
| **O&M** | Operating and Maintenance |
| **OE** | Operating Envelope |
| **Opex** | Operating Expenditure |
| **PASA** | Projected Assessment of System Adequacy |
| **PV** | Photovoltaic |
| **RERT** | Reliability and Emergency Reserve Trader |
| **RET** | Renewable Energy Target |
| **RQ** | Research Question |
| **SCED** | Security Constrained Economic Dispatch |
| **TEM** | Techno-economic modelling |
| **TNSP** | Transmission Network Service Provider |
| **UoM** | University of Melbourne |

| | |
|---|---|
| **VPP** | Virtual Power Plant |
| **WDRM** | Wholesale Demand Response Mechanism |

# 1 Overview and Introduction


## 1.1 What is proposed?

Integrating Distributed Energy Resources (DER) at large scale into the National Electricity Market (NEM) is highly complicated as the power system and market frameworks are generally designed to facilitate the one-way trade and flows of electricity from large-scale generators to consumers.

DER are consumer-owned devices such as solar panels or batteries that, as individual units, can generate or shift electricity usage. When combined with on-board 'smart' technologies, DER can be orchestrated to limit the negative impacts of bi-directional flows on the network and respond to network and market signals.

Project EDGE (Energy Demand and Generation Exchange) is a multi-year project to demonstrate an off-market, proof-of-concept DER marketplace that efficiently operates DER to provide both wholesale and local network services within the constraints of the distribution network.

Project EDGE is a collaboration between the Australian Energy Market Operator (AEMO), AusNet Services and Mondo, with financial support from the Australian Renewable Energy Agency (ARENA) and is focussed within the AusNet distribution area of Victoria.

In the context of Project EDGE, a two-sided DER marketplace is one in which consumers with DER can actively participate in the market through an aggregator. This allows customers to play a part in both the supply and demand side, unlike a one-sided market where consumers only buy generation.

Project EDGE seeks to demonstrate how consumer participation in a DER marketplace could be facilitated at scale across the NEM. The Project EDGE marketplace enables the trade of wholesale market services with AEMO, and local network support services with the Distribution System Operator (DSO). A consumer engages an aggregator, a third-party service provider, who utilises the consumer owned DER to deliver electricity services within the DER marketplace, in exchange for monetary compensation.

Project EDGE incorporates many DER marketplace functions including the communication of Dynamic Operating Envelopes (DOEs) from the DSO to the aggregator, wholesale market interactions, local network support services and the data exchange required to facilitate the various interactions at scale.[1]

[1] AEMO, Project EDGE Project Info Pack, at edge-factsheet.pdf (aemo.com.au)

Figure 1-1: Project EDGE DER marketplace


Source: AEMO

Project EDGE's target outcome is to identify capabilities that can be replicated efficiently at scale across the NEM and to inform the development of a two-sided market that incentivises innovation and participation in the long-term interests of electricity consumers, consistent with the National Electricity Objective (NEO)[2].

**National Electricity Objective**

The NEO as stated in section 7 of the National Electricity Law (NEL) is:

> to promote efficient investment in, and efficient operation and use of, electricity services for the long-term interests of consumer of electricity with respect to:
>
> - price, quality, safety, reliability and security of supply of electricity
> - the reliability, safety and security of the national electricity system.

It is anticipated that changes to the National Electricity Rules (NER) could be required to enable implementation of Project EDGE. The Australian Energy Market Commission (AEMC) may only make a rule (new or amended) if it is satisfied that the rule will or is likely to contribute to the achievement of the NEO and therefore consideration of any changes to the current market framework in this context will be critical to Project EDGE implementation.

Project EDGE seeks to achieve its target outcome through a series of objectives, as identified below.

[2] In August 2022 energy ministers agreed to the introduction of an emissions objective in the NEO

| Project 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 |
| 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 |
| 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 |
| 8. Conduct a customer focused social science study to understand customer opinions on the complexities of DER integration |
| 9. Deliver best practice stakeholder engagement throughout the project with a commitment to solicit stakeholder input and knowledge sharing |
| 10. Deliver recommendations, supported with evidence, on how and when the concepts demonstrated should be implemented operationally. |

Project EDGE builds on the concepts explored in other market reviews and studies, including:

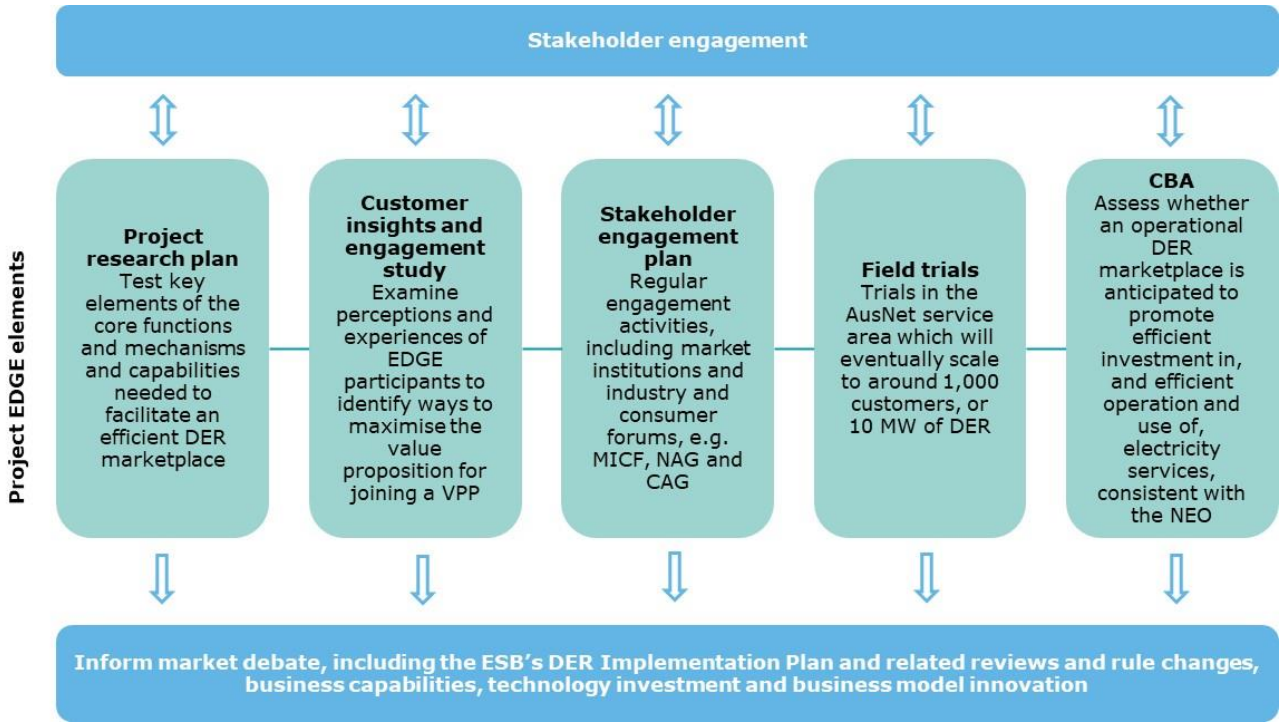
- Energy Security Board's (ESB) Post 2025 Market Design Project, including the ESB's DER Implementation Plan and subsequent rule changes and market reviews[3]
- Open Energy Networks Project, which considered how AEMO and Distribution Network Service Providers (DNSPs) could collaborate to enable DER to provide both wholesale market and local network services and sought to identify the most appropriate framework for building a two-sided marketplace[4]
- AEMO's Integrated System Plan (ISP) which specifically canvasses market reforms and working group activities being undertaken to support unlocking the potential of DER and provides load and DER assumptions for its future demand scenarios[5]
- The AEMC's Wholesale Demand Response Mechanism rule change, which permits consumers to sell demand response in the wholesale market either directly or through specialist aggregators[6]
- The AEMC's Electricity Network Economic Regulatory Framework Review, which considers whether the economic regulatory framework for electricity networks continues to support the delivery of the NEO in light of changes in the energy market[7]

[3] ESB, Post 2025 Market Design Project, at Energy Security Board | Post 2025 electricity market design project (aemc.gov.au)
[4] AEMO, Open Energy Networks Project, at AEMO | Open Energy Networks Project
[5] AEMO, 2022 ISP (June 2022), at 2022-integrated-system-plan-isp.pdf (aemo.com.au)
[6] AEMC, Wholesale demand response mechanism, final determination and rule (June 2020), at Wholesale demand response mechanism | AEMC
[7] AEMC, Electricity Network Economic Regulatory Framework 2020 Review – Final Report (October 2020), at EPR0085 - ENERF 2020 final report - 1 October 2020 (aemc.gov.au)

- Rule change requests, including the Access, pricing and incentive arrangements for distributed energy resources[8], Flexible Trading Arrangements[9], Scheduled Lite[10] and Mandatory Interoperability
- Market trials, including Western Australia's Distributed Energy Resources Orchestration Pilot (Project Symphony)[11], South Australia's Flexible Exports for Solar PV Trial [12] and AEMO's Virtual Power Plant (VPP) Demonstrations.[13]

Project EDGE seeks to further the work undertaken to date, by providing an evidentiary base to inform market debate, including through insights and knowledge sharing. The key elements of Project EDGE through which this will be achieved are outlined below.

Figure 1-2: Key elements of Project EDGE




Further information on these elements and findings published to date can be found at: AEMO | Project EDGE.

Importantly, this work does not seek to cut across or supplant the process of ongoing market reform being pursued by market bodies and agencies. Rather, it will seek to inform consideration of market design and the transitional pathways that would maximise benefits and minimise impacts for the market and its consumers, including through established consultation and existing engagement mechanisms.

[8] AEMC, Access. Pricing and incentive arrangements for distributed energy resources (August 2021), at Access, pricing and incentive arrangements for distributed energy resources | AEMC
[9] AEMC, Flexible trading arrangements for consumer energy resources, at Flexible trading arrangements for consumer energy resources | AEMC
[10] AEMO, Scheduled Lite: Draft High Level Design Draft Consultation Paper (June 2022), at Microsoft Word - Draft Scheduled Lite Consultation Paper v6.0 (aemo.com.au)
[11] AEMO, Project Symphony, at AEMO | Project Symphony
[12] SA Power Networks. Flexible Exports for Solar PV Trial | SA Power Networks
[13] AEMO, VPP Demonstrations, at AEMO | Virtual Power Plant (VPP) Demonstrations

## 1.2 Why now?

Australia's energy landscape continues to experience a rapid transition as large-scale synchronous generation plants reach end of life, and the uptake and establishment of renewable energy resources and DER grows rapidly. Decarbonisation, new technologies and consumer preferences are reshaping how customers interact with the electricity system and the energy market.

DER presents customers and industry with opportunities as it has the potential to deliver a range of electricity services that can support decarbonisation, optimise the value of consumers' investment in DER devices and enable cost-efficient market and non-network transmission and distribution solutions.

Households and businesses are continuing to invest in DER, with AEMO's 2022 ISP noting that:[14]

> *Today, ~30% of detached homes in the NEM have rooftop PV, their ~15 GW capacity meeting their owners' energy needs and exporting surplus back into the grid. By 2032, over half of the homes in the NEM are likely to do so, rising to 65% with 69 GW capacity by 2050, with most systems complemented by battery energy storage. Assuming that investment in distribution systems is coordinated with DER expansion for efficient operation and export, their 93 TWh of electricity would meet nearly one fifth of the NEM's total underlying demand.*

An increasingly distributed value chain has emerged, redefining the traditional roles of market actors, particularly DNSPs and their ability to facilitate a two-way flow of electricity. If DER are not effectively integrated into the electricity system, and unless the industry's operational toolkit evolves to be smarter and more dynamic, DER growth will continue to create challenges for managing the power system, with minimum system load, limited visibility, and unpredictable DER behaviour all impacting the ability to maintain reliable, secure and affordable electricity supply.

Substantial work on future-state market design has been progressed by the ESB, AEMO, Australian Energy Regulator (AER) and AEMC, with the objective of transitioning the NEM into a modern system capable of addressing these challenges and ensuring DER is coordinated and aligned with system and market signals, including through active management for efficient operation and export.

A two-sided market has the potential to provide an efficient and sustainable way to orchestrate and integrate DER into the electricity system and wholesale market, allowing all consumers to benefit from a future with high levels of DER through choice, pricing and innovation.

The realisation of a future state DER marketplace that orchestrates customer resources and optimises the NEM's net benefits, security and reliability will require market, technical, consumer protection and regulatory reform, supported by a strong social licence.

The design of a DER marketplace for the NEM should also recognise that the electricity market itself will continue to evolve in response to a broad range of factors including the pace of the transition to renewables, penetration rates of DER, policy settings and market reforms. Variations may also exist between jurisdictions and DNSPs when seeking to establish an implementation path between current state and future state market settings.

A transitional pathway to DER marketplace establishment will therefore be required, which allows benefits to be realised while supporting efficient investment through the identification and orderly management of step changes in areas such as scaling and harmonising IT infrastructure, roles and responsibilities, integration, participation and capability requirements and the allocation of costs.

[14] AEMO, 2022 ISP (June 2022), page 10, at 2022-integrated-system-plan-isp.pdf (aemo.com.au)

## 1.3 Role of the cost benefit analysis (CBA) within Project EDGE

A CBA compares the total estimated costs of a project to the community and economy with the total estimated benefits, determining whether the benefits outweigh the costs, and if so, to what extent. It provides a measure of a project's economic return.

CBAs are often undertaken to support decisions regarding investment and are the preferred quantitative assessment tool under most Australian government investment guidelines and by regulators. The CBA methodology for Project EDGE has been developed with consideration to the most recent guidelines for undertaking CBA. These are discussed in section 2.2.

| High Level CBA Approach |
| --- |
| 1. Base case definition |
| 2. Identification of alternative scenarios and assessment period definition |
| 3. Benefit specification and estimation |
| 4. Cost specification and estimation |
| 5. Modelling costs and benefits (incremental to the base case) |
| 6. Review, sensitivity testing and reporting. |

The CBA assesses the conditions under which a DER marketplace would be in the long-term interests of consumers of electricity (for example, through its expected impacts on DER operation, penetration and customer demand), tested through a base case and scenarios of varying complexity and sophistication, across at least one of the following key areas:

- Load and DER uptake and participation
- DOEs and market arrangements
- Inclusion or exclusion of a DER data hub and local services exchange (LSE).

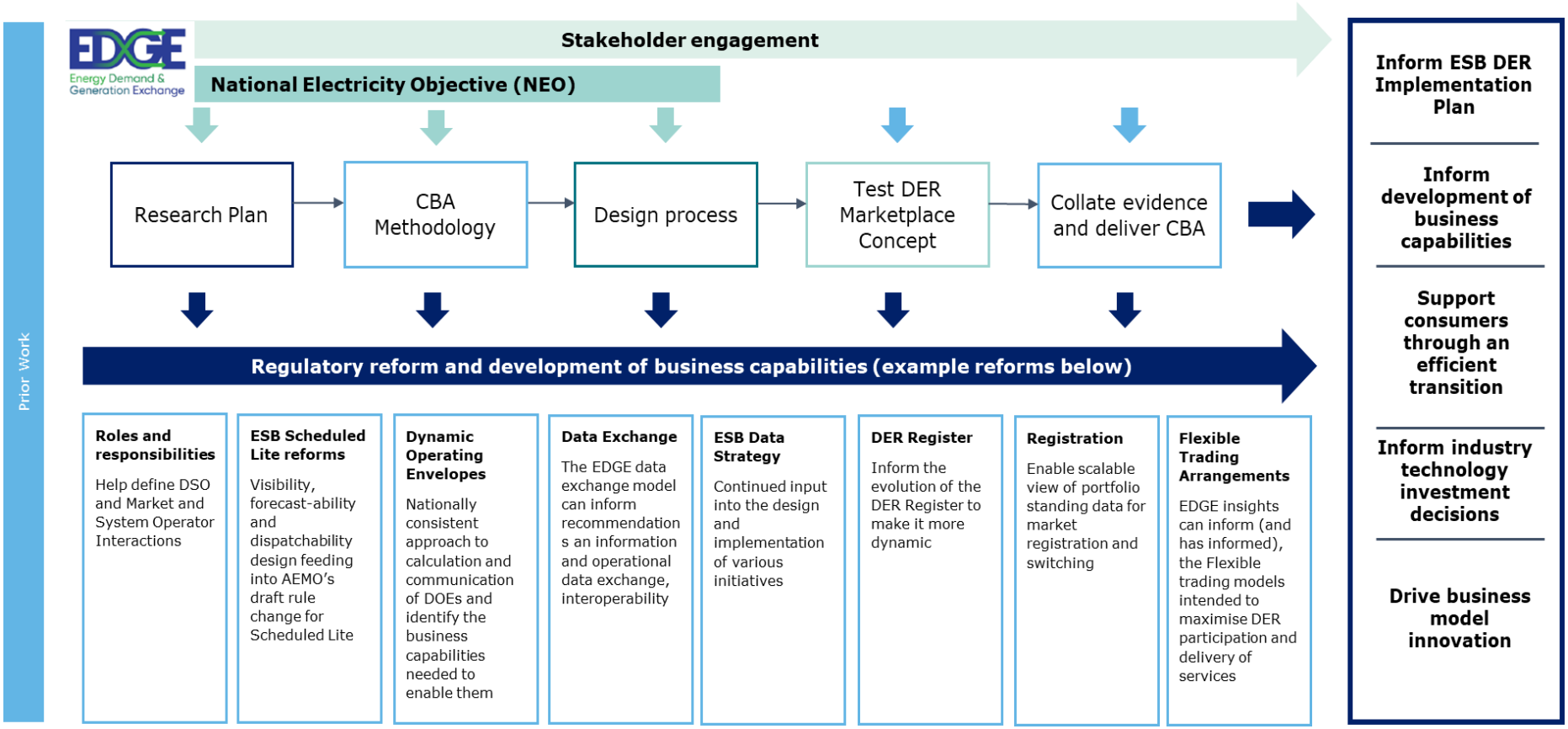
The CBA will reflect the spectrum of Project EDGE Operating Models on a transition path against DER penetration, indicating where practical if, and when, industry investment in more efficient and complex models may be warranted.

Deloitte Access Economics (Deloitte) will draw upon Project EDGE elements such as the Research Plan, trial outcomes and stakeholder engagement to inform the process of CBA design and development.

A comprehensive CBA will form a critical input into:

- An evidence base for demonstrating whether the Project EDGE marketplace enables aggregated DER to deliver efficient, secure, and coordinated wholesale and local network support services, in a manner that promotes the NEO
- Consideration of the regulatory changes that may be required to support DER marketplace establishment.

Figure 1-3: Role of the CBA within Project EDGE



## 1.4 Consultation on the Draft CBA Methodology Report

From July 2022 to September 2022 Project EDGE sought stakeholder feedback on the draft methodology that will underpin the CBA. Engagement with stakeholders on the draft methodology provided an early opportunity to test and challenge the robustness of the CBA's approach and underlying assumptions as well as a means of capturing additional information and views on methodology inputs, including costs and benefits.

The consultation process involved a combination of industry forums,[15] one-on-one targeted consultations with key energy market bodies (e.g. ESB, AER and AEMC), peak bodies (e.g. Energy Consumers Australia (ECA) and Energy Networks Association (ENA)) and select DNSPs, aggregators and global subject matter experts.

This consultation process, conducted independently from the Project EDGE project team (AEMO, AusNet Services and Mondo) and trial participants, offered an opportunity to transparently discuss Project EDGE and gather independent feedback.

Stakeholders also had the opportunity to lodge a written submission via email to EDGE@aemo.com.au.

The key milestones in the consultation process on the Draft CBA Methodology Report are highlighted below.

Table 1-1: Draft CBA Methodology Report milestones

| Milestone | Date |
|---|---|
| Circulation of Draft CBA Methodology Report presentation to stakeholder forums | 15 July 2022 |
| Discussion at Demonstration Insights Forum (DIF) | 19 July 2022 |
| Draft CBA Methodology Report released | 21 July 2022 |
| Discussion at Network Advisory Group (NAG) | 26 July 2022 |
| Discussion at DER Market Integration Consultative Forum (MICF) | 28 July 2022 |
| Submissions on Draft CBA Methodology Report due | 5 August 2022 |
| One-on-one targeted consultations with key energy market bodies (e.g. ESB, AER and AEMC), peak bodies (e.g. ECA and ENA) and select DNSPs, aggregators and global subject matter experts | July 2022 to September 2022 |

Key questions used for consultation on the draft methodology are provided in Appendix A (Table A-1). While these questions provided insight on specific matters on which guidance was sought, Project EDGE encouraged stakeholders to comment more broadly on any aspect of the methodology, including elements which may not have been captured in the draft methodology as it was presented.

[15] Forums utilised interactive tools such as Miro and Mural to capture stakeholder feedback

Feedback gathered during the consultation process has been utilised where appropriate to refine and update the CBA methodology.

## 1.5 Next steps

CBA analysis will commence in December 2022, following preliminary findings from the techno-economic modelling[16] by Energeia (Deloitte's project partner), field trial observations and release of preliminary trial findings by the University of Melbourne (UoM)[17].

CBA analysis and modelling will occur over the period December 2022 to February 2023, with CBA Report finalisation in late March 2023.

## 1.6 Stakeholder Consultation

Stakeholder engagement will continue to be a critical activity for the Project EDGE CBA. For a project like Project EDGE, where energy market participants and peak bodies are actively engaged in thought leadership around the broader energy transformation, engagement is key to their inclusion on the journey. Additionally, stakeholder engagement fosters greater collaboration across energy market participants, ensure transparency of process, and accelerates whole-of-system thinking as it relates to energy market maturation.

Engagement of external stakeholders on the CBA will continue to be carried out principally by Deloitte, independent of the project delivery team, to ensure independence of data collection and perceived influence from the Project EDGE participants to the CBA process. To date, this engagement has comprised a combination of industry forums, one-on-one targeted consultations and ad hoc discussions on specific issues.

Further detail on our stakeholder engagement approach and activities undertaken to date is provided in section 3.1.7.

## 1.7 General use restriction

This report is prepared solely for AEMO, AusNet Services and Mondo. This report is not intended to and should not be used or relied upon by anyone else and Deloitte accepts no duty of care to any other person or entity. The report has been prepared for the purpose set out in our agreement dated 25 August 2021. The use of this report or the advice contained herein should not be used outside that context.

[16] The process of estimating the whole-of-system technical and economic impact of the Project
[17] Where possible, additional trial findings will be included in the techno-economic modelling in January

# 2 Context



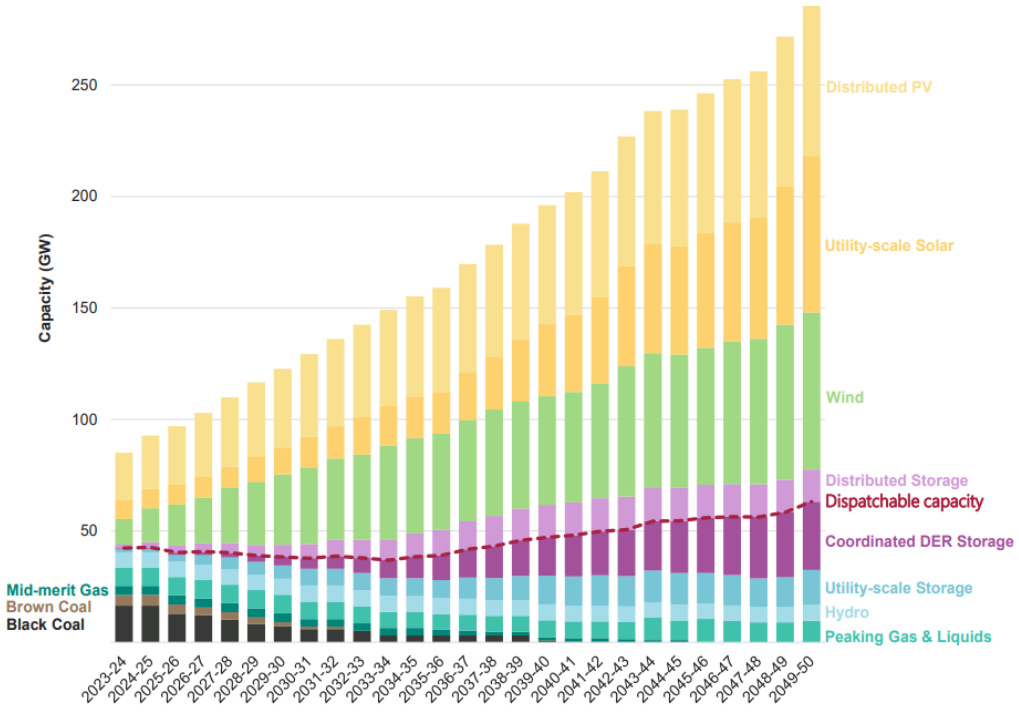
## 2.1 Context of Project EDGE

### 2.1.1 The NEM's challenge

The Australian energy sector is rapidly transitioning towards a decentralised 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 2022 ISP Step Change scenario[18] projects that by 2032, over half of the homes in the NEM are likely to have rooftop PV, rising to 65% with 69 GW capacity by 2050, with most systems complemented by battery energy storage. Assuming that investment in distribution systems is coordinated with DER expansion for efficient operation and export, their 93 TWh of electricity would meet nearly one fifth of the NEM's total underlying demand. This means that the NEM will need to cater for nearly five times the distributed PV capacity of today, and substantial growth in distributed energy storage.

Figure 2-1: Forecast NEM capacity to 2050, Step Change Scenario




Source: AEMO, 2022 ISP (June 2022)

The NEM is already experiencing challenges operating the system securely due to passive DER behaviour, for example universally exporting energy into the grid in the middle of the day is contributing towards record minimum system demand.

[18] Based on AEMO consultation this scenario was considered by energy industry stakeholders to be the most likely scenario to play out

Consistent with the ESB's DER Implementation Plan, the NEM institutions and industry are working to integrate DER into the power system and markets to enable it to become more 'active', responding to price signals that incentivise different behaviours to support grid security, greater variable renewable penetration and greater value for consumers.

### 2.1.2 Role of a two-sided market

As an increasingly distributed value chain has emerged, traditional roles of market actors, particularly DNSPs, are being redefined. If DER are not effectively integrated into the electricity system, and unless the industry's operational toolkit evolves to be smarter and more dynamic, DER growth will create challenges for managing the power system, with falling minimum system load, limited visibility, and unpredictable DER behaviour, all impacting the ability to maintain reliability and security of electricity supply and to realise broader market value.

Substantial work on future-state market design has been progressed by the ESB, AEMO, AER and AEMC, with the objective of transitioning the NEM into a modern system capable of addressing these challenges and ensuring DER is coordinated and aligned with system and market signals, including through active management for efficient operation and export.

A 'two-sided market' has the potential to provide an efficient and sustainable way to orchestrate and integrate DER into the electricity system and wholesale market, allowing all consumers to benefit from a future with high levels of DER through greater choice, better pricing and more rapid innovation.

The benefits (and challenges) of a two-sided market where the demand side and DER are actively engaged in the demand for, and supply of, electricity, and technology that can actively control the way in which intentions are revealed in the market has been recognised by the ESB:[19]

> *The clearest opportunity from the energy transition is the development of a two-sided market. A two-sided market can deliver benefits of improved efficiency and innovation, and customer benefits including better prices and more choice.*
>
> *However, the transition also includes challenges for security and reliability as supply and demand becomes more variable and uncertain, and the industry transitions away from generation that traditionally delivered security services (such as inertia and voltage control). Any new market design needs to realise the benefits and mitigate the risks involved in the transition*

The ESB has also acknowledged that DER integration trials will provide valuable insights for the development of the two-sided market design.[20]

As noted by the ESB, the realisation of a future state DER marketplace that orchestrates customer resources and optimises the NEM's net benefits, security and reliability is not without challenges, particularly through the process of transition.

The design of a DER marketplace for the NEM should therefore recognise that the electricity market itself will continue to evolve in response to a broad range of factors including the pace of the transition to renewables, penetration rates of DER, policy settings and market reforms. Variations may also exist between jurisdictions' implementation paths from their current state and future state market settings.

A transitional pathway to DER marketplace establishment will therefore be required which allows orderly management of step changes in areas such as scaling and harmonising IT infrastructure, roles and accountabilities, integration, participation and capability requirements and the allocation of costs.

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[19] ESB, Moving to a Two-Sided Market (April 2020), at 11 Nov 2020 - Two-Sided Markets | Energy Council - Trove (nla.gov.au)
[20] Ibid, page 26

### 2.1.3 Market reviews and studies to date

Project EDGE builds on the concepts explored in a range of other market reviews and studies, including those identified in Table 2-1.

Table 2-1: Related market reviews and studies

| Review / study | Key considerations | Relevance to Project EDGE |
|---|---|---|
| **ESB's Post 2025 Market Design Project**[21] | Establishes a DER Implementation Plan which addresses a broad range of technical, regulatory and market issues to support DER integration over a three-year period | The programs of work and associated market rules changes and market reviews resulting from the ESB's recommendations, particularly the Integration of DER and Flexible Demand workstream, will be considered both in the defining the base case and the scenarios that will represent incremental change from the base case. For example, the Flexible Trading Arrangements, Scheduled Lite and Mandatory Interoperability rule changes |
| **AEMO and ENA's Open Energy Networks Project**[22] | Considered how AEMO and DNSPs could collaborate to enable DER to provide both wholesale market and local network services and sought to identify the most appropriate framework for building a two-sided marketplace | Project EDGE will further consider the Hybrid Model proposed by the Open Energy Networks Project.<br><br>Project EDGE will also seek to build upon the following key inputs:<br>• The CSIRO Review of cost-benefit analysis frameworks and results for DER integration, a global review of cost-benefit analysis of distribution coordination and optimisation of DER[23]<br>• Baringa Partner's CBA of Open Energy Networks Project frameworks, which provided a high-level quantitative assessment of the costs and benefits of the frameworks[24] |
| **AEMO's 2022 ISP**[25] | Specifically canvasses market reforms and working group activities being undertaken to support unlocking the potential of DER and provides load and DER | The load and DER assumptions from AEMO's Step Change Scenario, considered the most likely to play out,[26] are proposed to be utilised in Energeia's techno-economic modelling |

[21] ESB, Post 2025 Market Design Project, at Energy Security Board | Post 2025 electricity market design project (aemc.gov.au)
[22] AEMO, Open Energy Networks Project, at AEMO | Open Energy Networks Project
[23] CSIRO, Review of cost-benefit analysis frameworks and results for DER integration (April 2019), at Microsoft Word - CSIRO_CBAReviewReport_13-05-2019.docx (aemo.com.au)
[24] Baringa Partners, Assessment of Open Energy Networks Frameworks (May 2020), at Assessment of Open Energy Networks Frameworks (aemo.com.au)
[25] AEMO, 2022 ISP (June 2022), at 2022-integrated-system-plan-isp.pdf (aemo.com.au)
[26] Ibid, page 33

| | | |
|---|---|---|
| | assumptions for its future demand scenarios | |
| **AEMC's Wholesale Demand Response Mechanism rule change[27]** | Permits consumers to sell demand response in the wholesale market either directly or through specialist aggregators | The wholesale demand response mechanism would be facilitated by a two-sided market, noting that a two-sided market may have broader scope. The implementation and use of this mechanism may inform market design choices |
| **AEMC's Electricity Network Economic Regulatory Framework Review[28]** | Considers whether the economic regulatory framework for electricity networks continues to support the delivery of the NEO in light of these changes in the energy market | The AEMC noted stakeholder frustration with the unresolved debate on the future respective roles of AEMO and DNSPs in managing the two-way grid, and that altering operations to support two-way flows is likely to have implications for some feature of the regulatory framework.[29] Project EDGE will seek to provide increased clarity on potential roles and responsibilities of market participants in a DER marketplace |
| **Market trials – including AEMO's VPP Demonstrations,[30] Western Australia's Distributed Energy Resources Orchestration Pilot (Project Symphony)[31] and South Australia's Flexible Exports for Solar PV Trial[32]** | There are a range of studies and pilot projects recently completed or currently underway in the market to test and validate opportunities for accessing the benefits of customer DER and increasing market participation | Engagement is occurring with the proponents of comparable trials and reviews to share insights and learnings across programs and further inform development and design |
| **Access, pricing and incentive arrangements for distributed energy resources[33]** | The rule change package seeks to integrate DER more efficiently into the electricity grid through a range of mechanisms.<br><br>Includes an approach to the quantification of customer export curtailment value (CECV) as it relates to DER integration and its impacts on DNSPs. | The AER's consolidated work on CECV improves the granularity of the CBA. |

[27] AEMC. Wholesale demand response mechanism, final determination and rule (June 2020), at Wholesale demand response mechanism | AEMC
[28] AEMC, Electricity Network Economic Regulatory Framework 2020 Review – Final Report (October 2020), at EPR0085 - ENERF 2020 final report - 1 October 2020 (aemc.gov.au)
[29] Ibid, page 14
[30] AEMO, VPP Demonstrations, at AEMO | Virtual Power Plant (VPP) Demonstrations
[31] AEMO, Project Symphony, at AEMO | Project Symphony
[32] ARENA, Projects, at Projects - Australian Renewable Energy Agency (ARENA)
[33] AEMC, Access. Pricing and incentive arrangements for distributed energy resources (August 2021), at Access, pricing and incentive arrangements for distributed energy resources | AEMC

A summary of recent market reviews and studies which have influenced the thinking within Project EDGE is provided at Appendix C - Summary of market reviews, studies and rule change.

Project EDGE seeks to further the work undertaken to date to provide an evidentiary base to inform market debate, including the ESB's DER Implementation Plan and related reviews and rule changes, business capabilities, technology investment and business model innovation.

### 2.1.4 Roles and Responsibilities

In 2018, AEMO and the ENA commenced the Open Energy Networks Project[34] which sought to identify the most appropriate framework to support establishment of a two-sided marketplace. The project included:

- Exploring the proposed frameworks required to integrate DER, including a more active DSO and the advent of distribution markets. Three frameworks were considered: a Single Integrated Platform; Two-Step Tiered; and Independent DSO. Ultimately, a Hybrid Model was proposed as the most appropriate for building a two-sided market, where market operation functions are allocated to AEMO and DNSPs optimise distribution system operation
- An international review to identify system operators that have begun considering comparable system architecture frameworks and the roles, responsibilities and control coordination for real-time operation of DER. Conceptual models were considered for the key roles identified.

The Open Energy Networks Project recognised that any Hybrid Model required further development and would need to be trialled to understand how best to implement it and maximise the efficiency and outcomes for customers and industry.

Project EDGE is intended to build on the outcomes of the Open Energy Networks Project and is looking to test market roles and responsibilities in line with the Hybrid Model, rather than creating new roles and responsibilities. These are:[35]

- Customer – customers may choose to invest in a broad range of DER devices and engage an aggregator to operate these devices on their behalf to receive additional value streams or alternative price outcomes, supported by consumer protections
- AEMO – in its capacity as NEM market and system operator under the NER, AEMO has overarching responsibility for security of the power system, including the distribution system. The NER also provide AEMO with the power to delegate its system security functions to NSPs. Project EDGE considers that it is appropriate for DNSPs to be responsible for calculating and communicating the limits of their distribution networks to give AEMO confidence all network limits are appropriately considered
- DSO – the existing DNSP role, enhanced with new business capabilities. DNSPs must build new capabilities, for instance to create DOEs that inform the limits in which DER must remain while delivering wholesale and/or local network support services. Project EDGE explores how DNSPs could procure network support services from DER aggregators in an LSE that facilitates structured bilateral procurement
- Aggregator – responsible for the aggregation of customer-owned DER and delivery of services. The aggregator role is undergoing an evolution in maturity but at its core remains to orchestrate customer-owned assets to deliver energy services. Project EDGE aims to enable innovation by making it easier for aggregators to deliver multiple services (wholesale and local) to multiple parties, and easier to exchange necessary data in doing so.

[34] ENA, Open Energy Networks Project.
[35] Project EDGE, Public Interim Report (July 2022), page 21, at Public Interim Report (aemo.com.au)

Project EDGE is testing the interactions of these market participants for both wholesale market integration and the LSE.

The Project EDGE DER marketplace would facilitate three core functions:

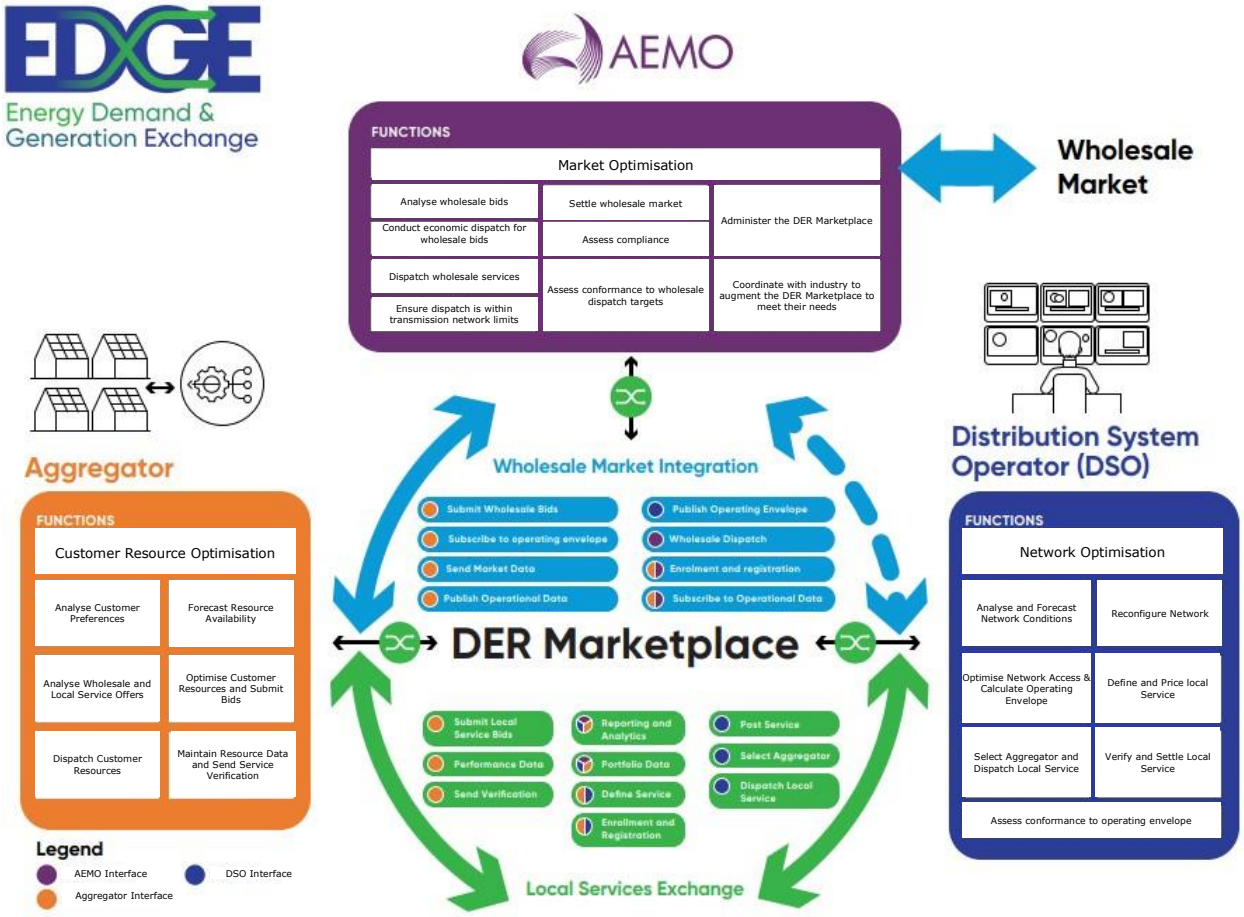
- Wholesale integration of DER - DER fleets must be dispatched as if they are participating in existing wholesale markets (energy), while considering distribution network limits in the dispatch process. Specifically, Aggregators operating as if they were a type of scheduled resource in an off-market setting, by submitting bi-directional offers and receiving/acting on dispatch instructions from AEMO
- Data exchange - set of capabilities and functions developed to facilitate streamlined data exchange between AEMO, DNSPs and Aggregators. Specifically, Project EDGE will facilitate the operation of a data hub concept
- LSE - an interface to facilitate visible, scalable and competitive trade of local DER services that enables DNSPs to manage local power security, power quality and reliability and enables Aggregators to stack local and wholesale value streams efficiently.

The Project EDGE DER marketplace is not intended to be a single, AEMO-run platform or capability. Rather, it is intended to reflect an integrated digital ecosystem that links many systems and capabilities across various industry participants to enable the efficient and scalable exchange of data and services.[36]

Figure 2-2 outlines the functions of each of the roles being developed by Project EDGE and how the roles interact and work together. As the project progresses, further insights and learnings on the roles, responsibilities and functions of each participant will be made available.

[36] Ibid, page 12

Figure 2-2: DER marketplace roles




Source: Project EDGE

## 2.2 Context for the CBA

### 2.2.1 Role of the CBA and purpose

A CBA is one of the key elements of Project EDGE.

CBA is an appraisal technique used to quantify the net economic benefit delivered by a specific project based on the estimation in monetary terms of all costs incurred and benefits realised as a result of the project's implementation.

The purpose of the CBA for Project EDGE is to identify and analyse whether the implementation of an operational DER marketplace is in the long-term interests of consumers consistent with the NEO and under which conditions. The CBA will also assess under which scenarios adding more complexity and sophistication to the DER marketplace may be justified. For example, it will consider how distribution network limits should be considered in wholesale dispatch and how DER participation in central dispatch should be progressively achieved.

Deloitte has been engaged to deliver a robust and transparent CBA and has partnered with Energeia, a recognised industry leader in energy research, advisory and techno-economic modelling.

The CBA methodology for Project EDGE has been developed with consideration to the most recent guidelines for undertaking CBA, including:

- AER, Cost benefit analysis guidelines - Guidelines to make the Integrated System Plan actionable[37]
- AER, Final - DER integration expenditure guidance note (June 2022)[38]
- Department of the Prime Minister and Cabinet, Guidance note on cost-benefit analysis (March 2020).[39]

### 2.2.2 CBA approach and key considerations

To complete the CBA, Deloitte and Energeia will apply the following high-level approach.

**High Level CBA Approach**

1. **Base Case definition**
   - The identification of a plausible base case is key to a CBA, as it provides the datum from which the impact of changes to market arrangements can be quantified, i.e. the benefits and costs of scenarios under consideration are measured as an incremental change from the specified base case.
   - This ensures that only the benefits and costs that can be reasonably attributed to the project are included in the analysis
   - Therefore, the base case needs to be carefully defined and agreed
2. **Identification of alternative scenarios and assessment period definition**
   - Develop multiple scenarios of varying complexity and sophistication incremental to the base case, representing different market arrangements and DER penetration levels
   - These scenarios are designed to identify the incremental costs and benefits of the Project EDGE DER marketplace based on different future electricity market arrangements and levels of DER market maturity. The scenarios are structured to ensure there is variation across at least one of three key areas:
     - Load and DER assumptions. For example, DER uptake, customer connection growth and electricity consumption growth
     - DOEs and market arrangements. For example, the frequency of constraint optimisation and participant profit maximisation
     - Inclusion or exclusion of a DER data hub and LSE
   - The assessment period is usually selected to reflect the estimated useful life of an asset or duration of the policy or market intervention. While the Project is a trial, the CBA will analyse the impacts of the DER marketplace being operationalised over the next 20 years
3. **Benefit and costs specification and estimation**
   - The specification of benefits involves identifying the impacts of the scenario that result in positive or desirable effects
   - Ideally benefits can be monetised; if not they should be able to be quantified; at a minimum they should be capable of being described
   - The specification of costs should take into account all the impacts that produce negative or undesirable effects
   - A useful way of looking at the costs is to identify the individuals or groups within the community that would be worse off as a result of the investment. All costs that are incurred in achieving the benefits should be captured

[37] AER, Cost benefit analysis guidelines - Guidelines to make the Integrated System Plan actionable (August 2020), at Cost benefit analysis guidelines (aer.gov.au)
[38] AER, Final – DER integration expenditure guidance note, at Final decision | Australian Energy Regulator (aer.gov.au)
[39] Department of the Prime Minister and Cabinet, Guidance note on cost-benefit analysis (March 2020), at Cost-Benefit Analysis | OBPR (pmc.gov.au)

- The identification of costs and benefits will be drawn from a combination of modelling, research and stakeholder engagement, including:
    - Energeia's whole-of-system techno-economic modelling platform, which includes a Wholesale Market Simulator that models wholesale market conditions and a Utility Simulator that models consumer behaviour.
    - Research and desktop analysis, including with reference to both relevant local and international market arrangements and with regard to the agenda for market reform and rule changes.
    - Internal and external stakeholder consultation, including through interactions with Project EDGE's technology subcontractors, DNSPs, aggregators, consumer representatives, and other stakeholders through a range of one-on-one discussions and industry forums.
- Outputs from field tests being conducted separately to the CBA work will be used where available to check and demonstrate the functionality of various operating envelope, market, demand and generation configurations.

**4. Modelling costs and benefits (incremental to the base case)**

- Modelling is undertaken to estimate the present values of those future costs and benefits that can be quantified in monetary terms. Where practical, costs and benefits will be monetised. If not, these will be quantified and at a minimum, captured and described
- The discounting of future costs and benefits reflects the time value of money and uncertainty of future cash flows

**5. Review, sensitivity testing and reporting.**

- Review preliminary results and refine benefit/cost specification and estimation. Results are expressed in the form of two key metrics: the benefit-cost ratio (BCR) and the net benefit
    - BCR = *Total present value benefits divided by total present value costs*
    - Net benefit (or cost) = *Total present value benefits less total present value costs*
- Other costs and benefits that cannot be monetised must also be documented to ensure they are not ignored
- Sensitivity analysis - the key assumptions that underpin the estimation of costs and benefits are flexed to understand the impact on the net benefit and BCR.

The methodologies to be applied to each element of the CBA methodology are discussed in greater detail in section 3 and section 4.

Key considerations informing the process of CBA development and analysis include:

- **Promotion of the NEO**. The CBA will identify and analyse whether the implementation of an operational DER marketplace is in the long-term interests of consumers and under which conditions (for example, DER operation, penetration and customer demand). If it proves to be in the long-term interests of consumers, the CBA will also assess under which scenarios adding more complexity and sophistication to the DER marketplace may be justified.

  Maintaining a line of sight through the CBA to the NEO will be important, both to ensure that consumer outcomes are optimised and in recognition that the effective establishment and operationalisation of a DER marketplace within the NEM could require changes to the NER. The AEMC, in assessing proposals for new or amended NER, will consider whether the change will or is likely to contribute to the achievement of the NEO.

- **Research questions and hypotheses.** UoM has developed a Project EDGE Research Plan that outlines priority research questions and associated hypotheses of the Project. Outcomes from the CBA will inform and test the research questions and associated hypotheses. The interaction between UoM's Research Plan and the CBA are discussed in more detail in section 3.2.4 and Appendix B – CBA interaction with research questions (Table B-1).

  Costs or benefits not directly captured by the techno-economic modelling but material to testing of the research hypotheses will be further investigated and methods determined to quantify the impact and feed into the CBA.

  Where practical, results of the CBA will be presented to align with relevant priorities, research questions and associated hypotheses within the UoM Project EDGE Research Plan.

- **Stakeholder engagement**. Stakeholder consultation is an important activity for any project. For a project like Project EDGE, where energy market participants and peak bodies are actively engaged in thought leadership around the broader energy transformation, engagement is key to their inclusion on the journey.

  Ensuring the CBA methodology is robust and sensible relative to stakeholder expectations is a priority, as is building a body of evidence to support what final assumptions are used in the CBA. This will also ensure credible and defensible results are derived.

  Specifically for the Project EDGE CBA, stakeholder consultation will include static and dynamic activities designed to capture energy market activities, thinking and strategic trend setting, to review, categorise and action thinking on relevant energy market topics.

  Static review of materials such as working papers, reports and stakeholder comments to published work will be considered, as will interactive consultation such as regular public workshops and one-on-one stakeholder meetings with targeted stakeholders such as the AEMC, ESB and AER.

  Discussions with these parties and other key energy market contributors will ensure the assumptions that underpin the CBA are refined in line with stakeholder views and reflect the latest data points. The list of key stakeholders will be reviewed and expanded, as needed, pending project evolution and emerging requirements.

### 2.2.3 CBA development process to date

CBA development work undertaken to date has focused on development of the CBA methodology reflected in this report, including the CBA base case, scenarios, assumptions and quantification methodologies.

Key areas of incremental development over time have included:

- Refinement of the DOE and market arrangements incorporated into the 10 scenarios discussed in section 3.2 to be tested through the techno-economic modelling. To ensure that increasingly sophisticated DOE and marketplace arrangements are captured by the scenarios, DOE and market arrangements scenario elements have been defined and assigned to each scenario:
  - Optimisation frequency
  - Co-optimisation arrangements

  - Optimisation methodology
  - Objective functions
  - The existence of any data exchange hub
  - The existence of any LSE.
- Identifying the cost and benefit categories to be included in the CBA and detailing the input sources:
  - Techno-economic modelling - the costs and benefits in the CBA are taken in part from the outputs of the Energeia whole-of-system modelling platform, which is itself comprised of modelling sub-platforms, including a customer behaviour model. Outputs from the techno-economic modelling will be augmented by the inclusion of factors and frictions driven by the stakeholder engagement process
  - Market sounding –costs in the CBA will also be derived from market testing undertaken by AEMO, AusNet Services and Mondo, including through discussions with their technology subcontractors and others as needed. These costs will be further validated and tested where practical with stakeholders through the process of engagement
- Identifying market reviews and rule changes with potential impact on the base case and scenarios and identifying how these should be represented in the base case and scenarios
- Categorising stakeholders and identifying key external stakeholder consultation touchpoints. These touchpoints represent different stages of the development of the CBA methodology.

Each of these areas of development are discussed in greater detail throughout this report.

### 2.2.4 What to expect from the CBA

The purpose of the CBA is to establish a clearer understanding of the overall benefits of the marketplace activities in EDGE, through quantification of various costs and benefits. Improved understanding of the costs and benefits will help Project EDGE achieve its aim to establish a clear road map for energy industry participants in a future where DER integration improves market efficiency.

Throughout CBA development, opportunities and next steps will be identified, developed and reviewed with key stakeholders. The iterative nature of the CBA development process will provide multiple touch points for stakeholders to be involved and informed.

The final CBA and accompanying report, scheduled for delivery in mid-2023, will include:

- Assessment of Project EDGE in alignment with its intended purpose and objectives
- Identification of scenarios upon which Project EDGE value is enhanced
- Impacts on consumers and scenarios which have the greatest positive or negative impact on the long-term interests of electricity consumers
- Identification of potential rule changes
- Reconciliation against concurrent projects and initiatives
- Alignment to technical requirements and broader trial outcomes.[40]

[40] Project EDGE, Public Interim Report (July 2022), page 21, at Public Interim Report (aemo.com.au)

The table below shows the breakdown by which the CBA results will be presented.

Table 2-2: CBA results breakdown

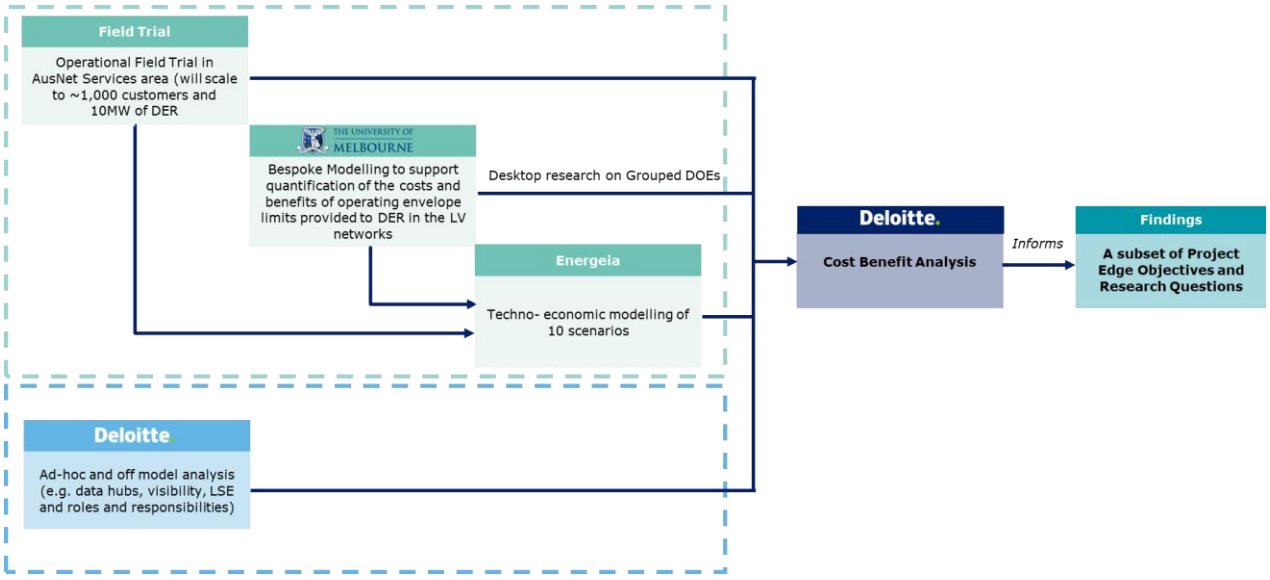
| Result breakdown | Rationale |
|---|---|
| **Overall** | Across each scenario the overall BCR summarises the impact on the entire electricity system (in comparison to the base case). |
| **Relative to each research question** | The CBA assessment will focus on how outputs align to relevant priorities, research questions and associated hypotheses (see Appendix B). |
| **Reference groups** | Costs and benefits attributed to each reference group provide insight into which aspects of the market and system bear both costs and benefits. |
| **Focused Considerations** | Results broken down in terms of key areas of focused consideration (e.g., DER Data Hubs, LSE and Visibility). |

# 3 CBA Methodology


## 3.1 Methodology overview

Deloitte has been engaged to deliver a robust and transparent CBA and has partnered with Energeia, a recognised industry leader in energy research, advisory and techno-economic modelling. This section elaborates on the CBA methodology used for Project EDGE and specifically discusses the methodology (including use of scenarios), scope and coverage across scenarios and the assumed roles and services by market actors. A summary of tools utilised to quantify energy market activities such as techno-economic modelling conducted by Energeia and market sounding provide the core of the methodology, with support by specialised modelling done by the University of Melbourne (UoM). The importance of regular and in-depth stakeholder consultation is highlighted. Subsequent sections provide more detail on assumptions, scenarios, costs and benefits assumed for reference groups and inputs and outputs of the model.

Figure 3-1: Project EDGE CBA Overview




### 3.1.1 Approach – scenarios, reference groups, inputs and outputs, tools

The Project EDGE CBA seeks to determine if an operational DER marketplace is in the long-term interests of consumers in the NEM, including any conditions which may maximise this value. This CBA will build on the knowledge of prior work on the quantification of DER integration as characterised by international market scans and through in-depth reviews of Australian market reviews and studies referenced in section 2.1.3.

Scenario analysis will be used to test the value of the Project EDGE DER marketplace within future market environments with varying key parameters (such as economic growth, demand, DER uptake, DOE and market arrangement). Core functions of the Project to be assessed under the CBA are:

- **Wholesale integration of DER** – aggregated DER fleets are dispatched into wholesale electricity markets (energy and ancillary services), while considering distribution network limits (including DOEs) in the dispatch process. Aggregators in the DER marketplace would effectively operate as a type of scheduled resource in an off market setting by submitting bi-directional offers and receiving and acting on dispatch instructions from AEMO
- **Scalable data exchange** – a set of capabilities and functions developed on the platform to facilitate streamlined data exchanges between AEMO, DSOs and DER aggregators. The CBA for Project EDGE will test the incorporation of a DER data hub concept as a way to provide this functionality as compared to alternatives
- **LSE** - the platform will facilitate visible, scalable and competitive trade of local DER services that allow DNSPs to manage local power quality and reliability. The use of a common platform for trading wholesale energy services and local services could allow DER aggregators to stack local and wholesale value streams efficiently

The CBA approach to be undertaken has been developed in consultation with stakeholders and consideration of CBA guidelines, including:

- AER, Cost benefit analysis guidelines – guidelines to make the Integrated System Plan actionable (August 2020)
- AER, DRAFT DER integration expenditure guidance note (July 2021)
- Department of the Prime Minister and Cabinet, Guidance note on cost-benefit analysis (March 2020).

**High Level CBA Approach**

1. Base Case definition
2. Identification of alternative scenarios and assessment period definition
3. Benefit specification and estimation
4. Cost specification and estimation
5. Modelling costs and benefits (incremental to the base case)
6. Review, sensitivity testing and reporting.

### 3.1.2 Scope and coverage

The Project EDGE CBA aims to provide the incremental costs and benefits across each scenario, in comparison to a base case.

Inputs to the CBA, quantitative or otherwise, have been collected through consultation with Project EDGE participants and stakeholders, and desktop research, to ensure appropriate levels of depth, granularity and increasing levels of complexity.

### 3.1.3 Applicability to the NEM

The Project EDGE CBA will consider the whole-of-system (NEM region) impact. Although the trial data is collected in the AusNet distribution area of Victoria, the trial data will be extrapolated to the NEM.

Energeia who are conducting the techno-economic modelling for Project EDGE, will extrapolate AusNet topology data (Project EDGE trial jurisdiction) across the NEM. For impact on the transmission and distribution networks this will occur via:

- Estimating the average impact by asset category e.g., feeder type (e.g. CBD, urban, short rural and long rural), substation type (e.g. HV/STS zone substation categories), customer mix (accounting for DER penetration levels and also smart meter levels) and expanding by multiplying out based on counts of other DNSPs and unit price differentials (e.g. 11kV vs. 22kV)

In addition, the impact on the wholesale market will be expanded based on AEMO's 2022 ISP forecast new generator entry and exit, unit price relativities and fuel.

### 3.1.4 Tools – modelling, market sounding, and other analysis

A range of tools and analytical activities are utilised in the development of the CBA. The costs and benefits in the CBA are quantified mainly from the outputs of the Energeia's techno-economic modelling, and through ongoing market sounding. This section provides an overview of the various tools.

#### (1) Techno-economic modelling

The costs and benefits in the CBA are taken in combination from the outputs of the Energeia whole-of-system modelling.

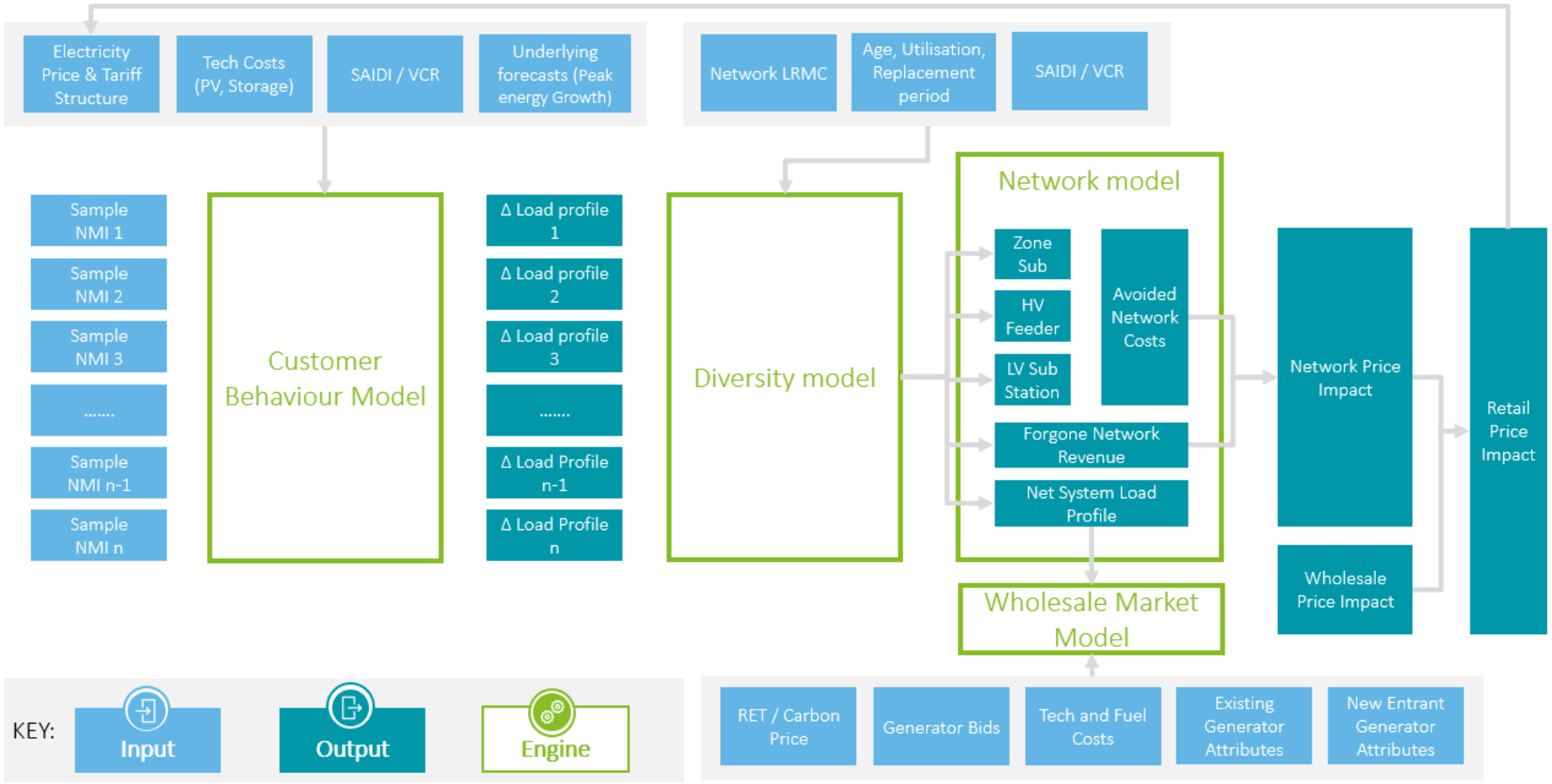
**Whole-of-System Model.** The Energeia propriety whole-of-system modelling platform is comprised of modelling sub-platforms:

- Wholesale Market Simulator – models NEM Regional Reference Prices (RRPs), resource dispatch and new entry by state, year, and scenario
- Utility Simulator – models customer behaviour, including DER adoption, 30 minute[41] interval load profiles, distribution network assets, and network and retail tariffs by DNSP, year and scenario.

Energeia's bottom-up modelling methodology is depicted in Figure 3-2. It shows how Energeia models customer behaviour including DER adoption, which is then turned into 30-minute interval load profiles, which are mapped to distribution and transmission assets, costs and revenues, the NEM and ultimately network and retail tariffs, which feed back into the consumer behaviour model. Energeia has developed a series of propriety tools to represent a whole-of-system energy market simulation.

[41] Note: While the NEM has shifted to five-minute settlement (5MS), empirical data accessed for these models means 30 minute internal load profiles will be modelled

Figure 3-2: Energeia Techno-Economic Modelling Methodology



**(2) Market sounding**

Preliminary costs in the CBA will be derived from market testing undertaken by AEMO, AusNet Services and Mondo, including through discussions with their technology subcontractors and other technology vendors as required. These costs will be further validated and tested, where practical, with stakeholders through the process of engagement and from trial outcomes.

Preliminary cost categories and estimates, to guide ongoing development, include:

- Market Operator platform costs - see section 4.3 for a detailed discussion on Data Exchange Platforms
- Distributed Energy Resources Management System (DERMS) costs
- Aggregator Platform Development costs.

### 3.1.5 University of Melbourne (UoM) Modelling of Operating Envelopes (OEs)

Additional bespoke modelling conducted by the UoM will support Energeia's techno-economic model. UoM's modelling will be used to support quantification of the costs and benefits of operating envelope limits provided to DER in the LV networks.

In consultation with Deloitte, Energeia and the Project EDGE participants, the UoM will provide data sets from three representative LV networks (city, suburban, and regional). The city and suburban networks are sourced from a CSIRO study[42] which clustered approximately 71,000 LV networks into 23 representative LV networks. The regional network will be based on one of the regional networks that is being tested in the Project EDGE field trials. This data will be subdivided into data sets for the years of 2025 to 2050 in five-year intervals (NB: data from 2022 will also be provided as a reference point).

To align with the CBA, the DER penetration scenarios of the AEMO Step Change and the High DER Scenario[43] will be used by UoM. Two DER participation levels will be considered.

- Firstly, where only customers signed up to a VPP participate in the DER marketplace (with VPP participation levels each year provided by Energeia and assuming that ownership of a BESS is required to participate in a VPP).[44]
- Secondly, where all customers with controllable DER are participating in the DER marketplace.

In addition, the CBA will refer to the work conducted by UoM under the "DER to Network to Market" interaction studies to analyse how new DSO functions like dynamic voltage regulation and local network services can be used in a targeted manner to alleviate network constraints where there is a benefit to the wholesale energy market. The outputs of the UoM study (which will be presented as a separate workstream) include valuing (using actual historical data) the market benefit that can be created by these functions.

### 3.1.6 Field trial

The field trial will be used to parameterise the modelling of DOE impacts by considering how they have worked in practical application under a variety of conditions, as opposed to what the modelling forecasts under perfect information.

For example, if on a given feeder, 200 kW of network capacity was predicted by the DOE to be available for the day ahead, but in reality, there was 220 kW available, the techno-economic modelling (TEM) would need to account for this forecasting error to be credible.

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[42] CSIRO, National Low-Voltage Feeder Taxonomy Study (Nov 2021)
[43] The High DER Scenario assumption figures are taken from Energeia's 2021 Renew DER Optimisation (Stage II) final report. The engagement received funding from ECA. Energeia was the technical consultant for this engagement and modelled its own Consumer High DER scenario. It compared the assumptions of this scenario with those of the AEMO Step Change Scenario and utilised many of the same underlying factors
[44] This has been assumed for Project EDGE modelling purposes. We acknowledge some market participants are considering participating in VPP markets using a fleet of smart hot water systems

This data will be used to develop an estimate of forecasting error under a wide variety of conditions such as forecasting horizon and frequency, network type, time of day, DER penetration and will be applied to the DOE impact on the TEM.

### 3.1.7 Stakeholder engagement – principles and approach

Stakeholder engagement is a critical activity for the Project EDGE CBA, ensuring that the assumptions that underpin it are refined independently, in line with stakeholder views, and reflect the latest information available via transparent process. Additionally, stakeholder engagement fosters greater collaboration across energy market participants, ensures transparency of process, and accelerates whole-of-system thinking as it relates to energy market maturation.

Engagement of external stakeholders regarding the CBA will be carried out principally by Deloitte, independent of the project delivery team, to ensure independence of data collection and perceived influence from the Project EDGE participants to the CBA process.

#### Guiding principles

The stakeholder consultation process will be conducted in line with the following guiding principles:

- Include stakeholders as part of the journey and part of the broader team to maximise the opportunity for stakeholder feedback at any point to ensure transparency and rigour
- Transparency in data collection, approach, results
- Consider, process, and respond to feedback wherever appropriate
- Provide specific considerations to targeted stakeholders to minimise the risk of missing out on key relevant insights
- Employ a consultative approach to reduce project outcome risk
- Employ a staged approach to allow for regular consideration
- Provide gateways for decision making, achieve clear finality on decisions and move-forward points.

#### Consultation Process

A key part of the stakeholder engagement process for the CBA is to ensure all project stakeholders (defined below) will have an opportunity to review and consult on the methodology, assumptions, draft findings, and ultimately, are aware of the Project EDGE findings as part of their energy market activities.

For the Project EDGE CBA, stakeholders are consulted directly through one of two means:

- Presentation through existing forums facilitated by AEMO such as:
  - the DIF: a panel of industry experts to provide feedback on project design and implementation
  - the NAG: a focused panel of distribution network stakeholders led by AusNet, facilitating discussion and feedback on network specific aspects of projects
  - the MICF: a retailer and aggregator focused forum engaging stakeholders on integration topics to provide feedback on arrangements supporting DER integration
  - the Consumer Engagement Forum: a community and customer group engagement, intended to gauge viewpoints of consumers
- Targeted consultation with a minimum of Group 1 Stakeholders (prioritisation described below) throughout the project delivery.

Deloitte will maintain a regular schedule of briefings through the duration of the CBA development, as well as undertake further targeted consultation on an as-needed basis should issues arise.

As queries and matters for clarification arise, Deloitte will seek out further consultation with key stakeholders on an ad-hoc basis. This may include additional one-on-one meetings, review of written correspondence submitted via the Project EDGE website, project team or dedicated project email account, or through data collection obtained via market scan, conference attendance or literature review.

### Stakeholders Groups

The external stakeholders that are consulted for the CBA component of Project EDGE are a subset of the overall project stakeholders, including key energy market governing bodies, policy entities, regulatory bodies, peak bodies, research bodies, industry participants, aggregators and end-users. They are categorised into three groups.

**Group 1 stakeholders** are market institutions whose day-to-day functions shape energy market and operating environment now and in future. These stakeholders are captured in our list of 'targeted stakeholders', and in relation to Project EDGE include:

- The Project EDGE participants (AEMO, Mondo, UoM, AusNet Services, and ARENA)
- AEMC
- ESB
- AER
- ENA.

Deloitte has already commenced valuable discussions with these stakeholders.

**Group 2 stakeholders** are energy market participants represented in Project EDGE whose buy-in is required to shape CBA inputs have unique considerations or conditions which lead to greater project interests and impact. They include:

- DNSPs, including comparable trials (e.g., SA Power Networks Flexible Exports for Solar PV Trial, Project Symphony)
- Aggregators
- Consumer groups.

The methods of consultation for Group 2 stakeholders include presentations at forums and collecting data from AEMO post project discussion at other forums. Periodic 1:1 consultation is also hosted as required.

**Group 3 stakeholders** include key reference groups whose expertise and broader energy market knowledge is valued for example:

- Researchers
- Governments
- Peak bodies and local community groups
- Industry.

Group 3 stakeholders can be informed and consulted through the Project EDGE forums, data collection from AEMO post project discussion at other forums, or through other methods as needed. Additional consultations will be undertaken through AEMO facilitated open forums with broader public involvement encouraged through interaction with the public release of reports and webinars.

A confidential record of stakeholder consultation is captured in a CBA-relevant consultation register together with minutes for each discussion. Feedback is consolidated according to type, analysed and consulted with the broader Project EDGE CBA team to assess relevance and materiality. Issues are managed individually and progressed to an end through the CBA development process.

## 3.2 CBA Scenarios[45]

Project EDGE uses scenarios to test under which conditions a DER marketplace would be in the long-term interests of consumers of electricity and the communities within which they operate. The scenarios present conditions of increasing and variable complexity and sophistication such that various aspects of the DER marketplace are fully considered.

[45] The CBA scenarios have been developed in consultation with AEMO, AusNet Services and Mondo to represent different DER uptake levels and market arrangements that could eventuate into the future. We acknowledge that other feasible scenarios exist for inclusion however consider the selected CBA scenarios to best test the project research questions and associated hypotheses.

Ten (10) scenarios, representing different market arrangements and DER penetration levels, have been designed to measure the incremental costs and benefits of the Project EDGE DER marketplace based on different future electricity market arrangements and levels of DER market maturity.

There are two main groups of load and DER assumptions, creating two base cases (scenarios 1 and 6) against which variations of DOE and market arrangements are used to create varying complexity and sophistication in the market for which costs and benefits will be captured.

This section outlines key areas of variation, supporting assumptions, key elements and impacts and describes in detail which scenarios will test different research questions.

### 3.2.1 Key areas of variation

The scenarios are structured to ensure there is variation across at least one of three key areas:

- Load and DER uptake and participation
- DOE and market arrangements
- Inclusion or exclusion of a DER data hub and LSE.

The key elements that varied across the 10 scenarios can be seen in Table 3-2 and further defined and explained in sections 3.2.2 and 3.2.3.

Table 3-1: DOE and Market Arrangements Definitions

| DOE[46] and Market Arrangement Definitions[47] | |
|---|---|
| **Constraint Optimisation Frequency** | The frequency (**Daily** or **Intra-day**) of updating the constraint optimisation settings that would govern the safe operating distribution network limits. |
| **Co-optimisation model**<br>Proportion of active DER that participates in the DOEs and marketplace arrangements | **VPP only** means only DER that is participating in a VPP would be participating in the DOEs and any DER marketplaces.<br>**100%** means all new DER connected to the distribution network would be participating in the DOEs and any DER marketplaces through enforcement of standards that ensures interconnectivity. |
| **DOE optimisation methodology**<br>Methodology that DNSPs use to set their DOE limits for participating DER | **LV data driven** option involves a load flow calculation using low voltage network impedance models, customer data and operational forecasts to set these limits.<br>**Approximation** means the DNSP, when setting the DOE limits, derives an analytical approximation of the network capacity using mainly historical network and AMI data. |

[46] DOEs are currently being considered by the majority of the NEM's DNSPs. SA Power Networks (SAPN), AusNet Services and Energy Queensland are among some the DNSPs leading the development of DOEs in Australia.
There are various ongoing projects and trials at different scales and maturities that are testing different DOE dimensions. Eight DNSPs are currently offering DOE services in a trial capacity, with other DNSPs currently in the planning stage. The CBA will consider the asynchronous rollout of DOEs across different DNSP regions in the NEM to account for this variability.
[47] Explained in more detail in section 3.2.3

| | |
|---|---|
| **DOE objective function**<br>The objective for the DOEs | **Maximise service** involves allocating DER capacity to the DER, with the aim to maximise the volume of export or import from them. In this approach, higher DOE will be allocated to DER facing lesser network constraint. |
| **VPP standards and Point to Point integration** | VPP standards include standards that enable VPPs to control and orchestrate their participating DER assets, provide visibility of their coordinated actions to DNSPs and AEMO, and that maintain high cyber-security levels. Platform standards are standards that enable DER that is not participating in VPPs to easily participate in the Project EDGE DER marketplace or an equivalent. |

Table 3-2: CBA Scenario Elements

| Scenario Element | AEMO Step Change Load and DER Assumptions | | | | | The High DER Scenario Load and DER Assumptions | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **1 (Base Case)** | **2** | **3** | **4** | **5** | **6 (Base Case)** | **7** | **8** | **9** | **10** |
| **Load and DER Assumptions** | | | | | | | | | | |
| **Solar Uptake** | AEMO Step Change (Final 2022 ISP) | | | | | High DER[48] | | | | |
| **Battery Uptake** | | | | | | | | | | |
| **Electricity Consumption Growth** | | | | | | AEMO Step Change (Final 2022 ISP) | | | | |
| **EV Uptake** | | | | | | | | | | |
| **VPP Uptake** | | | | | | | | | | |
| **Customer Connection Growth** | | | | | | | | | | |
| **Heat Pump Water Heating Uptake** | Energeia to develop equivalent figures | | | | | Energeia to develop equivalent figures | | | | |
| **DOE and Market Arrangements** | | | | | | | | | | |
| **Constraint Optimisation Frequency** | Annual | Daily | Daily | Intra-day | Intra-day | Annual | Daily | Daily | Intra-day | Intra-day |

[48] Taken from Energeia's 2021 Renew DER Optimisation (Stage II) final report. The engagement received funding from ECA.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **DOE Co-optimisation Model** | N/A | VPP Only | VPP Only | 100% | 100% | N/A | VPP Only | VPP Only | 100% | 100% |
| **DOE Optimisation Methodology** | N/A | Approximation[49] | Approximation | LV Data Driven | LV Data Driven | N/A | Approximation | Approximation | LV Data Driven | LV Data Driven |
| **DOE Objective Function** | N/A | Maximum Service | Maximum Service | Maximum Service | Maximum Service | N/A | Maximum Service | Maximum Service | Maximum Service | Maximum Service |
| **VPP Standards and Point to Point Integration** | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| **Data Hub** | ✗ | ✗ | ✓ | ✗ | ✓ | ✗ | ✗ | ✓ | ✗ | ✓ |
| **LSE** | ✗ | ✗ | ✓ | ✗ | ✓ | ✗ | ✗ | ✓ | ✗ | ✓ |

Note that Scenarios 3, 5, 8 and 10 include a DER Data Hub and LSE, which together represent the Project EDGE DER marketplace. The DOE and market arrangement variables also become increasingly sophisticated between Scenario 1 and Scenario 5, as well as between Scenario 6 and Scenario 10. These more sophisticated arrangements are expected to require increased costs to implement compared to less sophisticated operating envelopes or market arrangements but may also provide more value and increased benefits to the market through their more efficient operations and lower curtailment.

[49] The Approximation optimisation method considered in the Project EDGE scenarios represents a "hybrid" objective function which seeks to maximise the service contribution at the individual connection points. This is in practice limited by a conservative analytical estimation of the overall LV network hosting capacity (this is because the calculation of the LV network hosting capacity is not based on a load flow optimisation but rather based on an analytical approach which derives the available network capacity from the point at which the first LV network constraint occurs. This needs to be accounted for under scenarios 2,3,7 and 8.

### 3.2.2 Supporting assumptions

The general assumptions underpinning the CBA are detailed in the table below.

Table 3-3: General CBA assumptions

| Assumption | Detail |
|---|---|
| Period of analysis | 20 years |
| Base year | FY23 |
| Discount rate (lower bound)[50] | 4.83%[51] (subject to change). |
| Sensitivity analysis | Will be undertaken on select key cost and benefit parameters to test how robust the outputs are to different inputs |
| Load and DER uptake | Detailed in 3.2.2 |
| DER Controllability | There is sufficient control required from active DER to achieve scenario outcomes |
| DOE Complexity | Progression in DOE complexity follows pathway detailed in 3.2.3 |
| VPP Standards | Standards and integration required to achieve each scenario's arrangements are implemented |
| Rule Changes | Assumed rule changes with impact to EDGE are shown in 3.2.3 |

#### Load and DER assumptions

To capture the incremental benefit of the marketplace under different load conditions and DER penetration rates, two scenarios are utilised and depicted in Table 3-4:

1. AEMO's Step Change Scenario from its 2022 Integrated System Plan (ISP)[52], reflected in Scenarios 1-5
2. The High DER Scenario[53], reflected in Scenarios 6-10.

There are seven load and DER assumptions that will drive both sets of DER scenarios:

- Customer connection growth
- Customer electricity consumption growth
- Solar uptake
- Battery uptake

[50] As per AER CBA guidelines the lower boundary discount rate should be the regulated cost of capital, based on the AER's most recent regulatory determination
[51] AER (April 2021), Final Decision AusNet Service Distribution Determination 2021-2026, at https://www.aer.gov.au/system/files/AER%20-%20Final%20decision%20-%20AusNet%20Services%20distribution%20determination%202021%E2%80%9326%20-%20Overview%20-%20April%202021.pdf
[52] AEMO, 2022 ISP (June 2022), at 2022-integrated-system-plan-isp.pdf (aemo.com.au)
[53] Energeia (2020). Renew DER Optimisation (Stage II): Final report (For Renew), page 4 and page 32, at https://energeia.com.au/wp-content/uploads/2022/02/Renew-DER-Optimisation-Final-Report-210930v2.pdf

- Electric vehicle (EV) uptake
- Heat pump water heating uptake
- VPP uptake.

Table 3-4: Load and DER assumptions and DER service use case assumptions for the CBA scenarios

| Scenario | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Load and DER Assumptions** | | | | | | | | | | |
| Solar Uptake | AEMO Step Change (Final 2022 ISP) | | | | | High DER[54] | | | | |
| Battery Uptake | | | | | | | | | | |
| Electricity Consumption Growth | | | | | | AEMO Step Change (Final 2022 ISP) | | | | |
| EV Uptake | | | | | | | | | | |
| VPP Uptake | | | | | | | | | | |
| Customer Connection Growth | | | | | | | | | | |
| Heat Pump Water Heating Uptake | Energeia will develop equivalent figures | | | | | Energeia will develop equivalent figures | | | | |

**The ISP Step Change Scenario (Scenarios 1-5):** As stated in the Milestone 2 Public Interim Report, AEMO's Step Change Scenario from the Final 2022 ISP, and its load and DER assumptions are provided in an associated assumptions report and workbook.[55] This scenario involves a consistently fast-paced transition from fossil fuels to renewable energy resources in the NEM. AEMO's Step Change Scenario is considered by consulted stakeholders as that most likely to occur.[56]

**The High DER Scenario (Scenarios 6-10):** The High DER Scenario represents a more accelerated level of DER penetration than the AEMO Step Change Scenario, allowing a comparison of market arrangements in terms of economic value for a higher rate of DER penetration.[57] The High DER Scenario was developed to represent an economic environment that stimulates greater levels of DER adoption. It uses price trends of solar PV and storage to model the optimal DER configuration for key customer classes that maximises their benefits to develop customer weighted estimates of DER adoption and sizing, coincident maximum demand, grid consumption, and hourly

[54] Taken from Energeia's 2021 Renew DER Optimisation (Stage II) final report. The engagement received funding from ECA.
[55] AEMO, 2022 Inputs, Assumptions and Scenarios Workbook (2021), at https://aemo.com.au/en/energy-systems/major-publications/integrated-system-plan-isp/2022-integrated-system-plan-isp
[56] AEMO, 2022 ISP (June 2022), page 28, at https://aemo.com.au/-/media/files/major-publications/isp/2022/2022-documents/2022-integrated-system-plan-isp.pdf?la=en
[57] The High DER load and DER assumption figures are taken from Energeia's 2021 Renew DER Optimisation (Stage II) final report. The engagement received funding from ECA. Energeia was the technical consultant for this engagement and modelled its own Consumer High DER scenario. It compared the assumptions of this scenario with those of the AEMO Step Change Scenario and utilised many of the same underlying factors

load profiles. Load and many of the assumptions of the AEMO Step Change Scenario are maintained for consistency.[58]

While the ISP also provided a scenario with higher DER adoption than the AEMO Step Change Scenario (i.e. Hydrogen Superpower) the High DER Scenario was ultimately selected given greater alignment with the Project EDGE thesis. This was based on:

- **Stakeholder endorsement**: the High DER Scenario was accepted by Renew, the ECA and other consumer advocates, retailers and DNSPs on the project consultation committee, as being representative of a credible consumer-focused scenario. Consumer-focus is more aligned with EDGE strategic project objectives than hydrogen market development.
- **Commercial applicability:** the High DER Scenario will likely better showcase the pathway to a high DER future. As it is underpinned by commercial factors relating directly to DER uptake, it would enable a fuller understanding of the potential long-term implementation and policy pathways. Whereas the Hydrogen Superpower scenario (the only ISP scenario consistent with limiting global warming to 1.5°C while also largely replacing natural gas with hydrogen for domestic use and building a hydrogen export industry) is predicated on a substantial shift in energy demand by hydrogen electrolysers and material anticipated policy change, rather than commercial factors relating directly to DER.

The High DER and AEMO Step Change Scenarios are compared below. The comparison was developed by Energeia for the 2021 Renew DER Optimisation (Stage II) final report.

Table 3-5: Comparison of load and DER assumptions

| | Scenario: **AEMO Step Change** | Scenario**: High DER** |
|---|---|---|
| **Key Scenario Drivers** | | |
| **Distributed Technology Prices** | | |
| Solar PV | AEMO Step Change | Trend |
| Storage | AEMO Step Change | Trend |
| **Estimated Distributed Technology Adoption Rates** | | |
| Solar PV | 39% by 2030<br>49% by 2040 | 90% by 2030<br>93% by 2040 |
| Storage | 14% by 2030<br>24% by 2040 | 80% by 2030<br>90% by 2040 |

As shown in Table 3-5 above, there are load and DER assumptions that were not included in the AEMO Step Change Scenario or the High DER Scenario. These assumptions would also play a role in the CBA framework. For example, the ability for heat pump heating to act as a controllable and adjustable load could enable it to provide services in the DER marketplace. Energeia will develop its own assumptions in these areas as part of this process that will be broadly reflective of the scenarios above.

[58] Energeia (2020). Renew DER Optimisation (Stage II): Final report (For Renew), page 4 and page 32, at https://energeia.com.au/wp-content/uploads/2022/02/Renew-DER-Optimisation-Final-Report-210930v2.pdf

**CBA Scenario 1 (Base Case) key assumptions:** The inclusion of a base case is key to a CBA, as it provides the datum from which the impact of changes to market arrangements can be quantified. The base case is captured by Scenario 1 and 6.

Scenario 1 represents a conceivable yet conservative outcome where future DER integration does not include a singular DER marketplace that provides the services requested by AEMO or DNSPs. It also represents a datum of rudimentary operating envelopes from which we can capture the changes in market expenditure as a result of increased sophistication in operating envelopes and trading arrangements.

Scenario 6 is used as an alternative base case comparison point for a DER marketplace under different load and DER uptake outcomes. Scenario 6 has the same assumptions as Scenario 1, except that load and DER penetration levels are assumed to follow the High DER Scenario forecasts rather than the AEMO Step Change forecasts. The purpose of these scenario variations is to avoid inaccurate comparisons from using Scenario 1 as the base case for comparing Scenarios 7, 8, 9 and 10, that incorporate a higher load and DER uptake assumptions.

Table 3-6: Base case - Scenario 1 and 6 elements

<table>
<tr><th></th><th>Scenario 1</th><th>Scenario 6</th></tr>
<tr><td colspan="3">Load and DER Assumptions</td></tr>
<tr><td>Solar Uptake</td><td rowspan="6">AEMO Step Change (Final 2022 ISP)</td><td rowspan="2">High DER[59]</td></tr>
<tr><td>Battery Uptake</td></tr>
<tr><td>Electricity Consumption Growth</td><td rowspan="4">AEMO Step Change (Final 2022 ISP)</td></tr>
<tr><td>EV Uptake</td></tr>
<tr><td>VPP Uptake</td></tr>
<tr><td>Customer Connection Growth</td></tr>
<tr><td>Heat Pump Water Heating Uptake</td><td>Energeia will develop equivalent figures</td><td>Energeia will develop equivalent figures</td></tr>
<tr><td colspan="3">DOE and Market Arrangements</td></tr>
<tr><td>Constraint Optimisation Frequency</td><td>Daily</td><td>Daily</td></tr>
<tr><td>Co-optimisation Model</td><td>VPP Only</td><td>VPP Only</td></tr>
<tr><td>DOE Optimisation Methodology</td><td>Approximation</td><td>Approximation</td></tr>
<tr><td>DOE Objective Function</td><td>Nameplate Pro-rata</td><td>Nameplate Pro-rata</td></tr>
<tr><td>VPP Standard and Point-to-Point Integration</td><td>✓</td><td>✓</td></tr>
<tr><td>Data Hub</td><td>⊗</td><td>⊗</td></tr>
<tr><td>LSE</td><td>⊗</td><td>⊗</td></tr>
</table>

Further detail on the scenario elements and their impacts for the different CBA scenarios is provided above and in section 3.2.3.

### 3.2.3 Key elements and impact on scenarios

#### DOE, DER data hub and local services exchange

DOE and market arrangements are important variables that would likely affect the costs and benefits of implementing a DER marketplace. The 10 CBA scenarios incorporate variation of sophistication in these areas to assess the associated impacts.

[59] Taken from Energeia's 2021 Renew DER Optimisation (Stage II) final report. The engagement received funding from ECA.

A data hub and LSE are key complimentary elements of the Project EDGE DER marketplace. The impact of the data hub and LSE is tested in both rudimentary and increasingly sophisticated market arrangements with two DER penetration scenarios. This allows testing of the hypothesis that, together, the data hub and LSE will provide greater value in high DER scenarios, where DER curtailment would otherwise be high. It is expected that value will be maximised when the DER data hub and LSE act in combination, this case is tested in multiple scenarios (i.e. Scenarios 3,5,8 and 10).

We have considered testing of the LSE and DER data hub in isolation; however, it was deemed the additional value generated by investigating this was not material to the objectives of the project. These results could be inferred from results comparing scenarios without a data hub with scenarios that contain a data hub.

**Constraint optimisation frequency**: Electricity distribution networks possess a finite capacity to facilitate DER exports to the network and DER imports from the network, leading to constraints on imports or exports being required at certain times to ensure that safe operating network limits are not breached. Constraint optimisation frequency therefore is the frequency of updating the constraint optimisation settings that would govern the safe operating distribution network limits, and by extension the safe upper and lower bounds for DER exports and imports involving the distribution network[60].

Scenarios 2 - 3 with low DER penetration assumptions and Scenarios 7 - 8 with high penetration assumptions will also include an assumption that these constraint optimisation settings would be adjusted by the relevant DSO on a daily basis. The other scenarios include an assumption that the DSO will do so multiple times within the same day.

The frequency of intra-day adjustments of DOE constraint optimisation frequency for these scenarios will be agreed upon through consultation with relevant stakeholders, particularly DNSPs. This factor will be incorporated into the relevant scenarios by adjusting the settings in the network model at the techno-economic modelling stage.

Adjusting the constraint optimisation more frequently than once per day should reduce uncertainty for both DNSPs and parties seeking to provide DER services. It should also provide increased network hosting capacity without sacrificing reliability because the DOEs limits will reflect reduced uncertainty and therefore more closely reflect the network's true limits at any given time. It is anticipated that reduced uncertainty will increase the supply of services from DER which will reduce network spend, benefitting all consumers and increase aggregator revenue which will enable better product development and value sharing, benefitting aggregator customers with DER.

It is noted that the cost of updating the constraint optimisation more frequently would be greater than doing so less frequently, as it would require more extensive communications infrastructure to manage a higher duty cycle.

**Distribution constraint co-optimisation model:** This assumption covers the proportion of active DER that participates in the DOEs and marketplace arrangements.

The two co-optimisation models that have been incorporated into different scenarios are:

- VPP Only: Only DER that is participating in a VPP would be participating in the DOEs and any DER marketplaces, meaning dynamic signals on the safe upper and lower bounds for both imports and exports are only sent to those DER, the behaviour of other DER will be uncertain. All other active DER (solar and batteries, stand-alone batteries, heat pump water heaters or EVs) and all passive DER (solar PV that does not have an associated battery storage system) as non-participating DER would not be subject to the dynamic envelope, and would therefore be able to export and import under static limits unless their inverter trips them off automatically to protect the distribution network from adverse

[60] The drivers of changing constraint optimisation are external factors such as weather and consumer behaviour that are difficult to accurately predict over a long period of time. Hence why they need to be regularly updated

outcomes or DNSPs remotely disconnect customer DER, which can occur in South Australia and Western Australia.[61]

- 100%: All new DER connected to the distribution network would be participating in the DOEs and any DER marketplaces through enforcing or updating standards to ensure interconnectivity. Existing DER will gradually phase out, leading to 100% participation in DOEs. Before that occurs, non-participating DER would not be subject to the dynamic envelope, and would therefore be able to export to the grid under static limits unless their inverter trips them off automatically to protect the distribution network from adverse outcomes or DNSPs remotely disconnect customer DER. All consumers' rights to electricity as an essential service will be preserved under this scenario.

Scenarios 1 - 3 with low DER penetration assumptions and Scenarios 6 - 8 with high penetration assumptions will also include an assumption that only VPPs and the DER included in those VPPs would participate in DOEs. The other scenarios include an assumption that 100% of active DER would participate in DOEs, regardless of whether the DER participates in a VPP or not.

**DOE optimisation methodology:** This assumption covers the methodology that DNSPs would use to set their DOE limits for participating DER connected to their network:

- The LV Data driven option involves using low voltage impedance network models and customer data to set these limits. This methodology will be included as an assumption for Scenarios 4, 5, 9 and 10.
- Alternatively, the DSO can use approximations[62] of network capacity and customer demand for network utilisation to set its DOE limits. This option will be included as an assumption for Scenarios 1 - 3 and 6 - 8.

The LV Data driven option involves a load flow calculation to set these limits, which would produce the most accurate DOEs, thereby allocating hosting capacity more efficiently, but at higher cost due to greater load data monitoring, communications and processing requirements.

Alternatively, the DSO can use approximations of network capacity and customer demand for network utilisation to set its DOE limits, which would be cheaper for the DSO but also less accurate, meaning less hosting capacity would be available overall.

These alternative options could be incorporated into the CBA by changing the DOE levels and their associated costs based on the aforementioned trade-offs.

**Objective Function:** The objective function is the optimisation objective for the DOEs. Maximise service volume involves allocating DER capacity to the DER, with the aim to maximise the volume of export or import from them. In this approach, higher DOE will be allocated to DER facing lesser network constraint.

To enable maximum service DOEs need to be increasingly sophisticated, which entails increased costs for DNSPs to develop the associated level of sophistication. However, DOEs targeted towards more efficient outcomes would provide increased whole-of-system market benefits.

**VPP Standards and point-to-point integration**: VPP standards include standards that enable VPPs to control and orchestrate their participating DER assets, provide visibility of their coordinated actions to DNSPs and AEMO, and that maintain high cyber-security levels. Platform standards are standards that enable DER that is not participating in VPPs to easily participate in the Project EDGE DER marketplace or an equivalent.

The operating assumption for this variable is that any standards and integration required to achieve each scenario's DOE method would be implemented. This means the variable is included in all of the scenarios.

**The DER data hub and LSE:** The LSE is a market interface that would facilitate the trade of DER-based local network support services. The LSE is intended to complement the existing DNSP

[61] Government of South Australia, Department of Energy and Mining, 'Regulatory Changes for Smarter Homes' (2020), at Regulatory changes for smarter homes | Energy & Mining (energymining.sa.gov.au)

[62] The Approximation optimisation method considered in the Project EDGE scenarios represents a "hybrid" objective function which seeks to maximise the service contribution at the individual connection points. This is in practice limited by a conservative analytical estimation of the overall LV network hosting capacity (this is because the calculation of the LV network hosting capacity is not based on a load flow optimisation but rather based on an analytical approach which derives the available network capacity from the point at which the first LV network constraint occurs. This needs to be accounted for under scenarios 2,3,7 and 8.

reliance on network and non-network based services through providing visibility of local service needs to many sellers, encouraging price competition from aggregators and reduced barriers to entry by the use of standardised operating procedures and service definitions. DER-based local network support services may offer economic alternatives to current non-network solutions for distribution network operators.

The data hub is the DER marketplace component that enables efficient and scalable data exchange between marketplace actors. CBA scenarios that include LSE assumes that data exchange is managed through a hub. This leverages the standardisation, established trust and existing integrations to maximise value to the system and all electricity consumers. It is expected that this will increasingly be the case as DER penetration and active participation in markets via new entrants scales up. This is due to the positive feedback loop expected to exist between a data hub providing market participants lower cost data exchange integrations to access and deliver DER-based services and the price competition and service reliability enabled by greater market liquidity.

The scenarios which include both an LSE and a data hub are scenarios 3, 5, 8 and 10. The majority of these scenarios either share the same DER and load uptake assumptions or the same DOE and marketplace assumptions. All other scenarios do not include an LSE or a data hub.

This allows for comparison of how different DER and load outcomes or different DOE and market arrangement outcomes would affect the costs and benefits of implementing a DER marketplace without a data exchange hub.

Energeia consulted with the project team regarding the proposed DOE arrangements to be included within the scenarios:

- Optimisation frequency
- Co-optimisation arrangements
- Optimisation methodology
- Objective functions

Energeia's proposed approach is to estimate the impact of different levels of visualisation and optimisation on the level of DER curtailment:

- **Visualisation** – This will ideally be estimated based on EDGE field trial experience. Development of forecasting errors using field trial data or other comparable data will be an alternative approach if required. More frequent and complete data will reduce the level of contingency required, and therefore the level of curtailment.

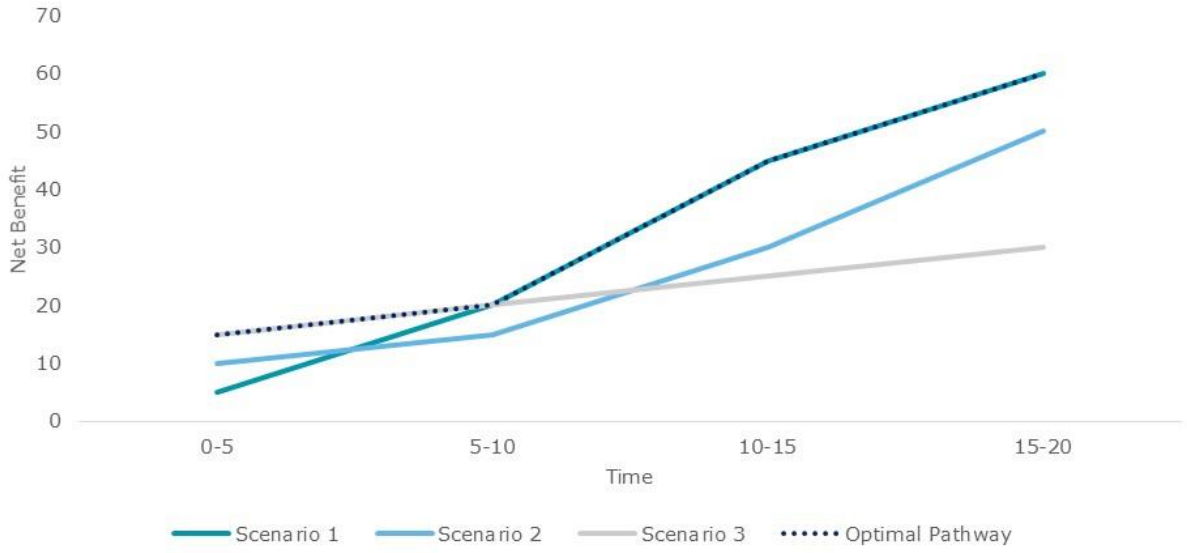
- **Industry Arrangements** – The impact of different industry arrangements, mainly the co-optimisation arrangements and the target operating model, will be modelled by UoM using its load flow model and DOE engine across the range of typical networks (urban, short and long rural) and DER penetration levels and resource mixes.

Each CBA scenario is aligned with an assumed:

- DOE arrangement including DOE Co-optimisation Model, DOE Optimisation Methodology, DOE Objective Function and Constraint Optimisation Frequency and
- Market arrangement including concepts such as the DER data hub and LSE.

With each scenario assuming a different DOE and Market arrangement (e.g. some scenarios assume no DER data hub or LSE) it allows for comparison across the 20-year time horizon to determine at different load and DER uptake levels what the most efficient DOE and market arrangement is. This 'efficient investment pathway' will be derived post undertaking the analysis through examining the highest net benefit scenario at specific time intervals (see figure below).

Figure 3-3: Hybrid Development of DOE and Market arrangements (Example only to illustrate concept)




### Rule changes and their regulatory market impacts

In addition to DOE and DER variables, it is necessary to consider other regulatory changes as variables that could affect the different CBA scenarios and their associated costs and benefits.

The AEMC, as the rule maker for the NEM, is one of the main institutions responsible for setting the key regulations that govern this market. Through its own internal work program and its participation in the ESB's DER integration plan, the AEMC is considering the optimal ways to integrate DER into the NEM and maximise the benefits to consumers that it provides. These changes would likely have impacts on both DER marketplace and non-DER marketplace scenarios.

The AEMC's final determination for the Governance of DER rule change is already covered in this report. Rule change processes which have been finalised will be monitored for any transitional or implementation impacts across participants and jurisdictions, e.g., Access, pricing and incentive arrangements for distributed energy resources rule change.

Future rule changes which the AEMC and the ESB have committed to that could have impacts on the outcomes of this CBA were also identified and analysed. Specifically, analysis was undertaken of the rule changes related to DER uptake, DER standards or DOEs, that are expected to occur in the future[63].

These regulatory changes are reflected in the implementation objectives outlined in the ESB's DER integration plan. These rule changes and their expected impacts are summarised in Table 3-7.

[63] This involved a comprehensive review of the most relevant electricity market body documents to identify planned NEM design changes that may impact Project EDGE, including:

1. ESB, DER Implementation Plan- reform activities over three-year horizon (2021), page 3, at https://www.datocms-assets.com/32572/1639638279-attachment-a-der-implementation-plan-three-year-horizon-december-2021.pdf.
2. ESB, DER Implementation activities for Horizon One - Attachment C (2021), page 11, at https://www.datocms-assets.com/32572/1639638288-attachment-c-der-implementation-plan-reform-activities-for-horizon-one-december-2021.pdf
3. AEMO, 2022 ISP (June 2022), at 2022-integrated-system-plan-isp.pdf (aemo.com.au)
4. AEMC. Rule change projects (n.d.), at https://www.aemc.gov.au/our-work/changing-energy-rules/rule-changes

Table 3-7: Future rule changes, their expected impact and CBA incorporation options (as at August 2022)

| Rule change | Objective | Implications | Expected impacts | Proposed CBA incorporation |
|---|---|---|---|---|
| Rule changes requiring new solar/storage installations to comply with DOEs | Requiring new DER to automatically switch off when needed by a DNSP's DOE from 2024-2026 | It is proposed that all DER would need to comply with rudimentary DOEs for all scenarios | Material | Scenarios 2-3 assume capability rather than compliance<br><br>Scenarios 4-5 assume compliance<br><br>Representation in the co-optimisation model |
| Scheduled Lite rule change | VPPs could voluntarily let AEMO know their dispatch plans | Improved AEMO/DNSP visibility of VPP intentions | Moderate | None |
| New Flexible Trading Arrangements rule changes to establish Flexible Trader Model 2 put forward by the ESB | Enable end users to separately manage their controllable electrical resources from their passive load, without needing to establish a 2nd connection point to the distribution network. | Enable end users to be rewarded for their flexibility without needing to change their on-demand energy use, supporting transition to a two-sided market. | Moderate | All scenarios |
| Rule changes associated with mandatory interoperability standards | Prevent customer DER assets from being locked-in to one service provider or service | More customer convenience, leading to increased VPP competition | Moderate | All scenarios |
| Governance of distributed energy resources technical standards | AEMC to use its existing powers to support development and implementation of DER technical standards | Improved VPP benefits and participation | Minor | None |
| Medium-Term Projected Assessment of System Adequacy (MT PASA) rule change | Enhance information on generator availability in MT PASA | Enhanced visibility of network condition. May lead to more efficient requests by AEMO/DNSPs for load shifting/demand response by VPPs | Minor | All scenarios. Impact expected to be immaterial |

After assessing these rule change requests, one future rule change request (or potential rule changes) was identified which is expected to have a material impact on the CBA overall outcome. That area of future change is presented in the ESB DER implementation plan as involving "requiring new solar/storage installations to comply with DOEs".[64] Following stakeholder engagement with the ESB and market bodies, it is understood that this could occur in one of two ways, with differing outcomes:

- The rule change would require new solar and storage installations to comply with technical settings that would allow the DER to participate in a DOE. However, DOE participation for the DER would not be mandated and compliance with the NER would focus on enabling customer discretion to opt-in to the DOE
- The rule change would not only require new solar and storage installations to be compatible with DOE technical settings but would also require those installations to participate in the DOE itself, i.e. participation would be mandated.

Following stakeholder feedback, the first option (opt-in) will be incorporated into the CBA.

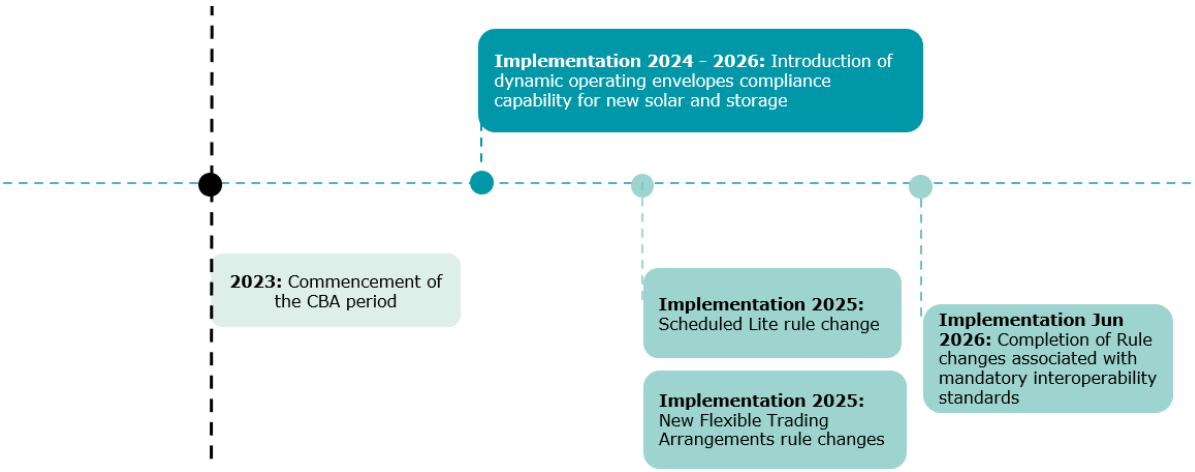
The Project EDGE CBA team also noted that the flexible trading arrangements rule change could implement either of two different models:[65]

- An extension of the existing Small Generator Aggregator framework that would separate a customer's use or production of energy services at a single site into two uni-directional or bi-directional connections, involving two separate meter installations. Customers could engage different traders, retailers or aggregators at each connection point. A component of this is being implemented as part of the Integrating Energy Storage Systems (IESS) rule change.
- Allowing simple additional sub-meters to be installed alone with the installation of new DER. The customer would therefore continue to only have one meter and connection to the distribution network.

Following stakeholder feedback, the second option (additional sub-meters) will be incorporated into base case assumptions and used across each scenario. However, we do not consider that there would be significant differences between the impacts of either model on the CBA as in absence of sub-meters, customers' DER would be utilised by Retailers (Financially Responsible Market Participants, FRMPs) to provide services.

Anticipated timeframes for the implementation of these rule changes are summarised in Figure 3-4 below.

Figure 3-4: Rule change implementation timeframes




[64] ESB, DER Implementation Plan- reform activities over three-year horizon (2021), page at https://www.datocms-assets.com/32572/1639638279-attachment-a-der-implementation-plan-three-year-horizon-december-2021.pdf

[65] ESB, Post-2025 Market Design – Final advice to Energy Ministers – Part C – Appendix (2021), pages 39-40, at https://esb-post2025-market-design.aemc.gov.au/32572/1629945838-post-2025-market-design-final-advice-to-energy-ministers-part-c.pdf

While rule change initiation or consideration periods have been provided for these rule changes, the ESB and the AEMC at this stage have not yet outlined possible transitional implementation periods following the rule change final determinations. These periods can vary greatly depending on the amount of additional adjustment needed to the rule change during the process. Where these periods are unclear, the timeline for CBA incorporation of the rule change outcomes focused on the earliest rule change final determination date provided by the ESB.

For the purposes of the CBA, the rule change requiring new solar and storage installations to be able to comply with DOEs is incorporated as an assumption into Figure 3-4 through the 2024-2026 timeframes for the introduction of dynamic operating envelopes.

### 3.2.4 Link to research questions and activities

The UoM has developed a Project Research Plan[66] that outlines priority research questions and associated hypotheses for Project EDGE to ensure that electricity consumers' interests are met in line with the NEO.

Deloitte has linked research questions reflected in the Research Plan and outputs of the CBA (e.g., how the outputs from the CBA will inform and test the relevant research questions). Additional research questions and associated hypotheses will be tested via other activities such as literature reviews, customer engagement, technical analysis and field trials.

To extend the granularity of the CBA methodology, Deloitte has also mapped the research questions and associated hypotheses against the techno-economic modelling scenarios (where relevant) for the purpose of showing how comparing different techno-economic modelling scenarios can provide more comprehensive answers to the research questions.

Table B-1 in Appendix B – CBA interaction with research questionslists the research questions and associated hypotheses that will be informed and tested by the outcomes of the CBA. It also discusses the methods which will be used to explore these research questions by comparing different CBA scenario inputs and outcomes.

### 3.2.5 Defining reference groups

Reference groups are the groups for which we care about costs and benefits for the CBA. Establishing appropriate reference groups is important in determining which costs and benefits we are interested in and what is or isn't a transfer payment.

The Project EDGE reference groups are as follows:

| Reference Group | Description | Services under EDGE |
|---|---|---|
| **Generators** | Entity who owns and operates electricity generation connected to the NEM | Provides energy to the NEM and participates in the wholesale market |
| **Market Operator** | Manager of the market, enabling market participation of generation and load connected to the distribution network (DER). In the case of EDGE, the market operator is AEMO | Dispatch participants and administer the data exchange of the DER marketplace |
| **Transmission Network Service Provider** | Entity responsible for controlling and operating a transmission system | Ensures transmission network is reliable and efficient |

[66] UoM, Project EDGE Research Plan (February 2022), at master-research-plan-edge.pdf (aemo.com.au)

| | | |
|---|---|---|
| **Distribution System Operator** | Entity responsible for controlling and operating a distribution system. The DSO is a new role for a DNSP to dynamically manage capacity and operate its network | Matching DER access to available network capacity and procuring local network support services to meet specific needs<br>Provides DOEs and assess bids |
| **DER Aggregators** | Entity that bundles DERs to operate as single resource (VPP) in the distribution market. Under EDGE, aggregators group participants to deliver electricity services, including wholesale services to AEMO and local network services to the DSO | Allow active consumers to participate in DER marketplace. |
| **DER Consumers (Active)** | Consumers with DER that have the ability to be active participants in the distribution network | Allow control of DER by aggregator/customer agent for energy system export/import. |
| **All Consumers (Passive + Active)** | All energy consumers | N/A |
| **Whole-of-System** | Energy system as a whole | N/A |

### 3.2.6 Cost and benefits, including measurement and how quantified

Table 3-8: Reference group costs and benefits

| Reference Groups | Costs / Benefits | Description of Measurement | Quantification | Scenario Relationship |
|---|---|---|---|---|
| **Generators** | Generation Build Out Costs (Capex) | Build out of generative capacity occurs in system modelling with the Wholesale Market Simulator outputting a breakdown of capex costs for each individual generator in the NEM. | Techno-economic Modelling Output | All 10 scenarios |
| | O&M Costs | Operation and maintenance costs transferred away from generators relative to amount of generative capacity. Wholesale Market Simulator outputs a breakdown of Opex costs for each individual generator in the NEM. | Techno-economic Modelling Output | All 10 scenarios |
| | Energy Revenue | Electricity provided to the NEM by Generators. Wholesale Market Simulator outputs a breakdown of revenues for each individual generator in the NEM. | Techno-economic Modelling Output | All 10 scenarios |
| **Market Operator** | Data Exchange Platform Costs (Capex) | Upfront platform costs determined through technology subcontractor, with industry validation | Scenario comparison with and without the hub<br><br>$ value of upfront costs with potential incremental changes based on complexity and size of a marketplace | Scenarios 3, 5, 8 and 10 |
| | Data Exchange Platform Costs (Opex) | Ongoing platform costs determined through technology subcontractor, with industry validation | Scenario comparison with and without the hub<br><br>$ value per annum with potential incremental changes based on complexity and size of a marketplace | Scenarios 3, 5, 8 and 10 |
| **Transmission Network Service Provider** | Network Service Provider (NSP) | DER based non-network solutions impacting requirement for network augmentation or replacement (i.e. longer asset longevity and/or smaller replacement requirement) to be determined by Utility Simulator modelling. | Techno-economic Modelling Output | All 10 scenarios |

| Reference Groups | Costs / Benefits | Description of Measurement | Quantification | Scenario Relationship |
|---|---|---|---|---|
| | System Capex and Opex | | | |
| **Distribution System Operators** | DERMS Platform (Capex) | Platform development cost inputs to be provided through Technology Subcontractor, with industry validation | $ value of upfront platform development costs | Scenarios 3, 5, 8 and 10 |
| | DERMS Platform (Opex) | Platform operation and integration costs to be provided through Technology Subcontractor, with industry validation | $ value per annum | Scenarios 3, 5, 8 and 10 |
| | DER Enablement Costs (e.g., LV sensors and AMI) | Model to determine network benefit of DER enablement with enablement costs to be sourced via DNSP consultation | DNSPs to be consulted to define input costs for sensors etc. | All 10 scenarios |
| | Network Service Provider (NSP) System Capex and Opex | DER based non-network solutions impacting requirement for network augmentation or replacement (i.e. longer asset longevity and/or smaller replacement requirement) to be determined by Utility Simulator modelling. | Techno-economic Modelling Output | All 10 scenarios |
| | Cost of complying with laws, regulations, and administration | Compliance costs to be based on stakeholder engagement, using cost expectations based on current or previous similar experience. | $ value for operators to comply with relevant laws/regulations | All 10 scenarios |
| **DER Aggregator** | Aggregator Platform Development Costs | Aggregator platform costs (including data exchange integration costs and OEMs) to be determined through Technology Subcontractor, with industry validation. | $ value of upfront costs for platform deployment<br><br>Including $ value of integration costs with the Data Exchange Platform | All 10 scenarios |

| Reference Groups | Costs / Benefits | Description of Measurement | Quantification | Scenario Relationship |
|---|---|---|---|---|
| | Program Revenue | Accounts for the further capacity unlocked resulting from the reduction in DER curtailment and voltage management. | Techno-economic Modelling Output | All 10 scenarios |
| | Cost to Serve (including customer acquisition and support costs) | Costs to serve additional customers derived through stakeholder engagement with Aggregators | $ value of costs for customer acquisition/marketing and customer management | All 10 scenarios |
| | Cost of complying with laws, regulations and administration | Compliance costs to be based on stakeholder engagement, sourcing cost expectations based on current or previous experience from Aggregators. | $ value of aggregator complying with relevant laws/regulations | All 10 scenarios |
| **DER Consumers (Active)** | DER Technology Costs | The cost of DER technology including the purchase (e.g. equipment) and install annualised over the life of the asset, included in Utility Simulator modelling. Qualitative discussion to be included on the impact of incentives | Techno-economic Modelling Output | All 10 scenarios (1-5 lower active DER than 6-10) |
| | Revenue from sale of DER services | Revenue generated from consumer participation in the electricity market based on forecasted market penetration of DER, cost of electricity, and type of tariff available | Techno-economic Modelling Output | Scenarios 2 - 10 |
| **All Consumers (Active + Passive)** | Electricity Bill Impact | Wholesale pricing and retail tariffs determined as primary outputs of the Utility Simulator and Wholesale Market Simulator modelling | Techno-economic Modelling Output | All 10 scenarios (1-5 lower active DER than 6-10) |
| **Whole-of-System** | Visibility for DSOs and Market Operator on distributed generation | Examining the uplift from a limited level of DER visibility to DER being fully scheduled | $ value of change in costs and benefits associated with the uplift | All 10 scenarios |

| Reference Groups | Costs / Benefits | Description of Measurement | Quantification | Scenario Relationship |
|---|---|---|---|---|
| | leading to more efficient system operations | | | |
| | $CO_2$ emissions | Quantity of $CO_2$-e emissions reported in techno-economic model based on the generation from renewable capacity available | Techno-economic Modelling Output | All 10 scenarios |

### 3.2.7 What this will show

The outputs from quantitative and qualitative inputs and outputs will flow through to provide the results of the CBA that will be presented to directly align with relevant priorities, research questions and associated hypotheses within the UoM Project Research Plan.

This will form the basis for how the CBA will be interpreted as well as how summary conclusions and next steps will be developed. The table below shows the breakdown by which the CBA results will be presented.

Table 3-9: Cost benefit results breakdown

| Result breakdown | Rationale |
|---|---|
| **Overall** | Across each scenario the overall BCR summarises the impact on the entire electricity system (in comparison to the base case). |
| **Relative to each research question** | The CBA assessment will focus on how outputs align to relevant priorities, research questions and associated hypotheses (see Appendix B). |
| **Reference groups** | Costs and benefits attributed to each reference group provide insight into which aspects of the market and system bear both costs and benefits. |
| **Focused Considerations** | Results broken down in terms of key areas of focused consideration (e.g., DER Data Hubs, LSE and Visibility). |

### 3.2.8 Stakeholder engagement

Prior to final results of the CBA, comprehensive validation of inputs and outputs will be completed. Validation will be an ongoing and iterative part of the CBA process to ensure that interim assumptions, inputs and outputs make both logical and realistic sense and align with stakeholder expectations. Ongoing validation will ensure that the modelling and CBA results do not present any scenarios that would technically infeasible, or which do not align with the Project trial functionalities.

## 3.3 Other concepts for review

Through the process of CBA methodology development, the following concepts have been identified:

- **DER Marketplace Impact on DER Uptake** - The establishment of a DER marketplace such as that assumed in Project EDGE has the potential to affect the uptake of DER. It is feasible to assume that as market arrangements progress and potentially become more profitable for participants, the uptake of DER increases. The complexity of modelling such interdependencies at a trial stage and the uncertainty of how to interpret results inferred the decision to use AEMO ISP rates of DER uptake as an input, rather than trying to introduce this as a dependent variable.
- **DER Marketplace Impact on Revenue Streams -** The progressive implementation of the different market arrangements (e.g., the flexibility afforded to market participants under a data hub compared to point-to-point model) tested within Project EDGE is expected to facilitate the development of innovative revenue streams and business

models. Currently, the make-up of these revenue streams and business models is unknown, however it is feasible to assume they could provide further benefit going forward. Discussion will be included on the flexibility of platforms in terms of their ability to accommodate new product offerings which may be indicative of additional value.

- **Frequency Control Ancillary Services (FCAS) –** FCAS are a provision of load to minimise frequency issues (one type of ancillary services). FCAS is an important value driver in the pursuit of a DER marketplace; however, it is intentionally not a component of the EDGE field trial due to the fact that other trials such as the AEMO VPP Demonstrations have explored FCAS provisioned by VPPs in detail.[67]

  The Project EDGE CBA will consider both Regulation FCAS and Contingency FCAS at a high level. Regulation FCAS will be considered via the impact of increased visibility (e.g., predictability and controllability) for the market operator. Contingency FCAS will be assessed via the impact increased market participation could have on market liquidity.

[67] AEMO, VPP Demonstrations, at AEMO | Virtual Power Plant (VPP) Demonstrations

# 4 Focused Considerations


Through interrogation of the Project EDGE ecosystem, the following five areas have emerged as requiring focused consideration:

1. The **'roles and responsibilities'** of energy market participants as they relate to the operation of the Open Energy Networks Project Hybrid Model under Project EDGE
2. The significance of energy market participants having **'visibility'** on where DERs are installed and how they behave to best support 'forward looking' and 'situational awareness' decision making
3. The role of data provision and exchange via different configurations (termed **'scalable data exchange approaches'**)
4. The ability to enable the efficient and scalable trade of local network services (via a **'local services exchange'**) that DNSPs procure from aggregators representing customers and their DER devices
5. The optionality (e.g., flexibility, time intervals, data requirements, social and economic considerations) associated with operating envelopes (including **'grouped DOEs'**).

These five focused considerations have been divided into discrete work streams under the CBA, as their increased complexity and sophistication required independent thought and consideration prior to their integration into the CBA.

This section details these focused considerations, to better inform and increase the robustness of the CBA.

## 4.1 Roles and responsibilities

### 4.1.1 Introduction

Section 2.1.4 identified the market roles and responsibilities for each actor within the Project EDGE marketplace as they relate to wholesale market integration, data exchange and the LSE.

Project EDGE tests one of the potential arrangements described under the Hybrid Model of the Open Energy Networks Project[68]. Table 4-1 details a number of the Open Energy Networks Project functions (most relevant to guiding Project EDGE implementation) which are necessary for developing the key capabilities required to progress towards a Hybrid Model.

[68] Energy Networks Australia, Open Energy Networks Project Energy Networks Australia Position Paper (May 2020), at www.energynetworks.com.au/resources/reports/2020-reports-and-publications/open-energy-networks-project-energy-networks-australia-position-paper/

Table 4-1: Functions required to progress to a Project EDGE DER marketplace.

| Function | Function Description | Activity | Activity Description |
|---|---|---|---|
| **Distribution constraints development** | New function: To develop distribution network constraints in the form of long-term operating envelopes that will be a key input into distribution level optimisation | DER engagement | Identify long-term requirements for DER services to alleviate distribution network constraints and engage with DER to understand the availability and capability of resources to provide services |
| **Aggregator DER bid and dispatch** | Aggregates local DER installation to provide bids into the markets (within provided operating envelopes). | Aggregator Market Engagement | Aggregator bids into the wholesale (and ancillary service) markets (e.g. FCAS and others) within its provided operating envelope and responds to dispatch instructions. |
| **Wholesale-distributed optimisation** | Enhanced function: Integrate distribution level optimisation results into existing wholesale market optimisation | Receive distribution network market offers and run dispatch engine | Receive market offers from distribution network end customers and run the dispatch engine for wholesale market optimisation |
| **Data and settlement (network services)** | Enhanced function: Financial settlement of network support and control ancillary services at distribution and transmission level | Settlement of bilateral contracts for network services | Gathering data and ensuring the co-optimisation of wholesale and local services |
| **DER register** | New function: AEMO to provide DER register based on rule requirements | Establish, maintain and publish or share DER register data | Periodically gather up to date DER information from market participants. Share disaggregated data and publish aggregated locational and technical data of DER with relevant market participants |

| | | | |
|---|---|---|---|
| **Connecting to DER** | Enhanced function: Regulatory, technical[69] and commercial arrangements on the connection of DER to the distribution network | Manage DER connections | Manage arrangements for the commercial and technical control of connections – as allowed by the signed connection agreement and regulatory frameworks. |

[69] From late 2022, Queensland will follow Western Australia and South Australia (who have similar requirements) in introducing the requirement for new or upgraded solar PV and battery installations with an inverter capacity above a defined threshold to be capable of being remotely turned down or switched off in emergency situations

### Rationale for selecting the alternative arrangements of roles and responsibilities

The Hybrid Model of the Open Energy Networks Project reflects what is understood to be a broadly agreed industry position on future roles and responsibilities under a DER marketplace for delivering these functions.

While Project EDGE reflects one possible arrangement of roles and responsibilities under the Hybrid Model, the CBA will consider a discrete number of alternatives to test whether the proposed Project EDGE arrangements are optimal when assessed against specified criteria.

The alternative arrangements of roles and responsibilities represent a subset of the functions listed above, identified from stakeholder feedback through the Open Energy Networks Project process and Project EDGE consultation to date, and with aim of minimising significant deviations from the market's current roles and responsibilities (i.e. instead focusing on enhancing or extending current roles within the existing regulatory framework to optimise costs, in line with the NEO). To remain consistent with the industry consulted position to date, the alternative roles and responsibilities below are considered within the parameters of the Hybrid Model.

Other functions will be tested via the scenarios outlined in section 3.2.

Table 4-2: Alternative arrangements of roles and responsibilities considered

| Function | Project EDGE Arrangement | Alternative Arrangement |
|---|---|---|
| **Data and settlement (network services)** | 1. **Aggregators:** Transmit to DSOs DER service-delivery verification data for use in LSE settlement via the EDGE data exchange hub | **3rd party** (e.g., metering coordinators), **as opposed to an aggregator,** transmits pattern approved standardised metering data as service-delivery verification data to DSOs |
| **Data and settlement (network services)** | 2. **DSOs:** simulate settlements for LSE following verification of service via telemetry data, and communicate through the EDGE data exchange hub | **AEMO, as opposed to DSOs,** uses existing market arrangements to manage settlements and prudentials associated with LSE services |
| **Connecting DER** | 3. **DSOs:** monitor and enforce compliance with the DOEs | **3rd party** (e.g., metering coordinator or retailer (participant needs to have the data)**, as opposed to DSOs,** uses pattern approved standardised metering data to calculate compliance outcome. **AER, as opposed to DSOs,** establishes and maintains an approved framework of DOE compliance rectification measures (enforcement measures deemed by the AER are carried out either by a 3rd party or the DSO depending on the severity) |

| | | | |
|---|---|---|---|
| **Wholesale-distributed optimisation** | 4. | **Aggregator -** constructions wholesale bi-directional offer with knowledge of portfolio capacity committed to successful LSE bids, placing these at low price bands to ensure they are cleared in central dispatch by AEMO. | No feasible alternative identified under the Hybrid Model |

### 4.1.2 Analysis approach

The alternative arrangements for roles and responsibilities will be assessed through a multi-criteria analysis (MCA). MCA is an appraisal technique that uses objectives, criteria, measures, weighting and scoring approaches to rank and compare options. Importantly MCA provides a framework to consider the trade-offs between different arrangements for roles and responsibilities.

The MCA will provide a qualitative assessment (outside the CBA) of alternative roles and responsibilities arrangements compared to the Project EDGE roles and responsibilities arrangement.

The table below describes the criteria and weightings proposed to be applied through the MCA. The criteria and weightings were developed in alignment with the NEO and Project EDGE objectives.

Table 4-3: Multi Criteria Analysis

| Criteria | Weighting | Description | Criteria sub questions |
|---|---|---|---|
| **Delivers value to consumers** | 35% | Does the framework encourage competition between parties that promote the long-term interests of consumers (e.g., lower costs and pricing, innovation, quality services and more consumer choice)? | 1. Does the framework of roles and responsibilities encourage competition in favour of the consumer?<br>2. To what extent does the framework for roles and responsibilities improve consumer value? |
| **Efficiency** | 20% | Does the framework encourage efficient investment, operation, and use of electricity services? | 1. Is the efficiency of investment, operation and use of electricity services enhanced under the framework of roles and responsibilities according to the NEO? |
| **Adaptability** | 20% | Is the framework responsive and adaptable to market changes over time (e.g., shifts in accountability in response to changes in DER penetration and market participation)? | 1. How flexible is the framework for roles and responsibilities and is it designed with a long-term outlook (i.e. room to adapt to different market eventualities)?<br>2. Is responsiveness to market changes improved under the framework for roles and responsibilities? |
| **Opportunities and incentives** | 15% | What are the opportunities, market signals and commercial incentives for businesses and do they align with the long-term interests of consumers? | 1. To what extent are commercial incentives aligned with consumer interests?<br>2. Do market signals provide an improvement in accurate information for the responsive parties? |
| **Allocation of risk** | 10% | Does the framework allocate risks and accountabilities to the parties who are in the best position to manage them and have incentives to do so? | 1. Is risk and accountability assignment improved by the role and responsibility framework?<br>2. What incentives are in place for parties to manage the risks and accountabilities and do they minimise risk (including cyber security risks)? |

Learnings from international jurisdictions with regards to roles and responsibilities at a system level or aligned to specific functions, will be used to inform analysis. This recognises that other markets have, or are experiencing, similar challenges in the management of high DER uptake.

The two jurisdictions selected to support the MCA analysis are the United Kingdom[70] and New Zealand.[71] These jurisdictions were identified from a longer list of jurisdictions, including a number with similarly high DER uptake forecasts to Australia, such as California, Germany and the Netherlands. The United Kingdom and New Zealand which both have lower DER uptakes (compared to Australia) were selected based on their relevance to the Australian Market (e.g., market and regulatory architecture) and to Project EDGE and the alternative arrangements for roles and responsibilities considered within the Hybrid Model.

**Jurisdiction 1 – United Kingdom**

***Relevance to the Australian Market***

- **Market architecture** - The United Kingdom has one market operator that is separate from Transmission Network Owners (ESO), regulated TSO and DSOs, generators and retailers, and one national regulatory authority (Ofgem)
- **The United Kingdome Open Networks Initiative** - The United Kingdom also selected a Hybrid model, that requires expanded DSO functionality and coordination between the system operator and DSOs

***Relevance to the Project EDGE and Counterfactual***

- **Alterative Arrangement 1 -** 3rd party (e.g., metering coordinators), as opposed to aggregators, transmits pattern approved standardised metering data as service-delivery verification data to DSOs
- **Alternative Arrangement 2** - AEMO, as opposed to DSOs, uses existing market arrangements to manage settlements and prudential associated with LSE services
    - In the *Power Potential* trial, the **DSO was responsible for validating settlement data** and authorising the Finance team to make payment to DERs, while National Grid was required to develop a new settlement process.

**Jurisdiction 2 – New Zealand**

***Relevance to the Australian Market[72]***

- **Market architecture** - New Zealand has one market operator (that is also the TSO), regulated DNSPs, generators and retailers, and one national regulatory body (the Electricity Authority)
- **Open Network Reform** - New Zealand has been monitoring international development (including Australia) closely and initiated its Open Network project in 2019.

***Relevance to the Project EDGE and Counterfactual***

- **Alterative Arrangement 1 -** 3rd party (e.g., metering coordinators), as opposed to aggregators, transmits pattern approved standardised metering data as service-delivery verification data to DSOs

[70] EnergyNetworks (2019), Open Network Project, Project initiation document (post consultation) phase 3, at https://www.energynetworks.org/industry-hub/resource-library/open-networks-2019-prj-phase-3-pid-post-consultation.pdf
[71] Electricity Authority (New Zealand, 2019), Background on Open Networks project, at https://www.ea.govt.nz/development/work-programme/evolving-tech-business/open-networks/background/
[72] Oakley Greenwood (2015), Comparison of NZEM and Australian NEM, at https://www.ea.govt.nz/assets/dms-assets/19/19226Appendix-B-Report-from-Oakley-Greenwood.PDF

  - The system operator of New Zealand (Transpower) developed a Flexibility Management System, that can dispatch DER, record participation, and undertake post-performance data analysis through to enabling payment.

- **Alternative Arrangement 3** - AER, as opposed to DSOs, establishes and maintains an approved framework of DOE compliance
  - Although New Zealand does not have DOEs, the Electricity Authority (New Zealand equivalent of the AER) has function to monitor and enforce distributors and distributed generators' obligations with regard to Export Congestion arrangements and Export Limits. Regulator function could potentially expand to include DOE compliance.

## 4.2 Visibility

### 4.2.1 Introduction

Visibility refers to knowing where DER are installed on the network and how they behave to enable situational awareness and forward-looking operational and network planning. It is relevant to the roles of both and the Market Operator as well as Network Service Providers.

Network visibility across multiple timescales is critical to the integration and management of DER. Visibility relates to predictability (e.g. knowing what to expect and therefore the ability to do what is needed to keep the system balanced between supply and demand) and controllability (e.g. signalling market participants to pull the right levers to maintain reliable operation).

A power system without visibility of high levels of price responsive DER would lead to a reduction in demand forecast accuracy, making managing operational risks to the power system (e.g. system security and blackouts) much more difficult.

The ultimate intent of greater visibility is to support increased market certainty through more accurate scheduling and enable the market operator to operate the market more efficiently and facilitate broader participation in market dispatch. In addition, an understanding of the current and future operating state of the network is a requirement for calculating and publishing operating envelopes, a function which is important to local Network Service Providers.

### 4.2.2 Approach to CBA analysis

The assessment of visibility is focused on the impact for market participants in shifting from the current state whereby there is limited visibility of DER based only on:

- DER participating in the wholesale demand response mechanism[73] and
- DER participating as a Market Ancillary Services Provider (MASP) providing FCAS services

To a future state whereby DER is fully scheduled ('visibility with controllability') and aligned with generator performance standards and data communication standards[74]. With DER being fully scheduled, it is assumed aggregators provide AEMO with a 20-band bi-directional offer (10 for load, 10 for generation) that will be re-bid at 5-minute intervals. AEMO will then use the bids to clear the market (informing aggregators at what level they have been dispatched).

The current state whereby there is limited visibility of DER (and DER is not scheduled therefore limited 'controllability') aligns with Scenario 1 and 6 (as presented in table 3-2). Whereas all other scenarios account for 'visibility with controllability' (e.g. market participants have the capabilities

[73] The WDR mechanism allows demand side (or consumer) participation in the wholesale electricity market at any time, however, most likely at times of high electricity prices and electricity supply scarcity
[74] AEMO is currently conducting a Review of Power System Data Communication Standard (https://aemo.com.au/consultations/current-and-closed-consultations/review-of-power-system-data-communication-standard). The costs relating to how frequently telemetry is transmitted as well as other general obligations when exchanging data over public internet, would be associated with meeting the outcomes of this Review.

required to pull the right levers to maintain reliable operation) and assume DER is fully scheduled.[75]

The shift from current state to future state will be examined across two timescales; NEM real time operators and operational forecasting.

Table 4-4: Timescales of power system operating elements, applicable to DER

| Seconds | Minutes | Hours | Days (Short Term PASA) | Months | Years (Medium Term PASA) |
|---|---|---|---|---|---|
| Real time operations | | | | | |
| | Operational forecasting | | | | |

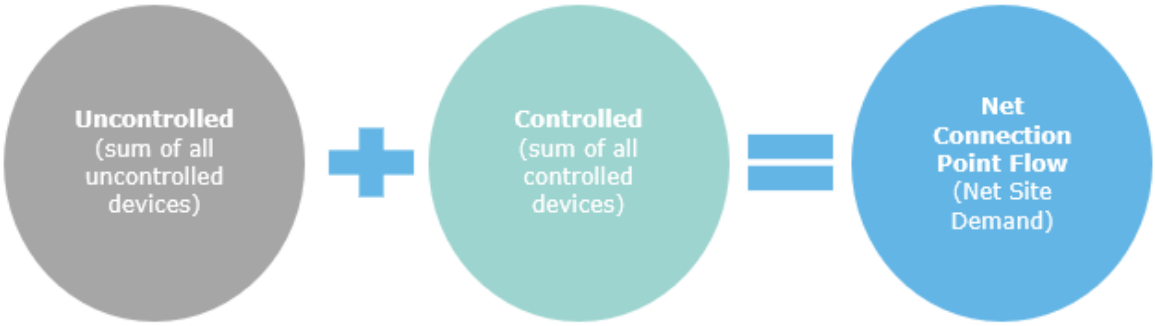
Source: AEMO

The assessment of visibility for the purposes of this CBA will consider two wholesale energy bi-directional offered functions based on where the offered quantity of energy is measured:

- Net Connection Point Flow (Net NMI) – measured at the connection point (NMI-level) and aggregated across the aggregator's portfolio, including both controllable and uncontrollable generation and load
- Flex Only – measured at a common measurement point behind the meter–representing the aggregation of all controllable DER assets at a site –and aggregated across the aggregator's portfolio. Flex Only ignores uncontrollable customer load and generation at a site.

It is noted that Flex Only bidding and portfolio telemetry (unlike Net NMI) will focus on the sum of all controllable devices (load and/or generation) across the participant's portfolio of NMIs – and not individual devices.

Figure 4-1: Simple illustration of Net NMI vs Flex bid quantities




**Market Operator**

The key pillars for the market operator relevant to this area of focused consideration include:

- **Visibility** through near real time portfolio telemetry and bids (impacted by the Review of Power System Data Communication Standard going forward)

[75] Scenarios 1 and 6 do not assume Scheduled Lite exists while all other scenarios assume DER is fully scheduled. Therefore, case study analysis (outside scenario analysis) will consider the costs / limitations associated with Scheduled Lite in comparison to an arrangement whereby DER is fully scheduled.

- **Predictability** (via generated forecasts) through knowing what to expect and therefore the ability to do what is needed to keep the system balanced between supply and demand
- **Controllability** (via dispatch instructions) through allowing the market operator to pull the right levers to maintain reliable operation. This requires all necessary systems and technology (utilised to manage operation) to be fully functional.

Table 4-5: Incremental costs and benefits[76] associated with a progression towards future state from current state

| Market Participant | Costs | Benefits |
|---|---|---|
| Market Operator | The technology and resource costs below are based on recent guidance from the AEMO control room and operational forecasting teams using the mature enduring end state for DER (Stage 2 as per Baringa Partners, Assessment of Open Energy Networks Frameworks) as the starting point for assessment and then validated this against recent (Aug 2022) AEMO NEM2025 reform program Visibility work package costs[77]<br>• Forecast short-term network state (~$10m)<br>• Update market dispatch engine (~$22m)<br>• Establish, maintain and publish or share DER register data (~$10m)<br>• Uplift required to allow the market operator to undertaken independent conformance monitoring of DER Aggregations (systems) – assume 1 day for one FTE per month for the purpose of cost for self-forecasting (based on semi scheduled self-forecasting effort currently).<br>=~$43m across the 20-year time horizon.[78] | <u>Real time operations</u><br>The shift in visibility for the market operator is expected to reduce the likelihood of the following events[79]:<br>• LOR 2 Events which can entail the activation of RERT - Average RERT activation size (across last X years) x Average cost per MWh x % reduction in average RERT activation)<br>• LOR 3 Events which can entail involuntary load shedding Average Load shedding size (based on duration of load shedding event and average consumption converted to kWh) x VCR (weighted for residential/ business $/kWh) x % reduction in probability of load shedding)<br>• System black (For example September 2016 System Black in South Australia resulted in significant economic loss)[80]<br>• Management of minimum demand resulting in fewer Minimum System Load Market Notices (this benefit will be discussed qualitatively)<br><u>Operational forecasting</u> |

[76] DER penetration levels will impact the frequency of events (and therefore the magnitude of costs and benefits for market participants).
[77] To assess the applicability of cost figures in Baringa Partners, Assessment of Open Energy Networks Frameworks (May 2020) we have undertaken discussions with AEMO Control Room, IT and Operational Forecasting subject matter experts and assessed the more recent gate 1 business case for the NEM2025 reform program (August 2022). The cost for P3 WP2 Visibility (Scheduled Lite and SCADA Lite) is $33m from the commencement of the implementation phase of the Work Package and over a 10-year Program evaluation period ending on 30 June 2032.
[78] The cost of the DER Ops Desk (not yet operational) to manage aggregation portfolios and interactions is assumed to be captured within this cost.
[79] The total amount of these 'events' will likely increase with an increased penetration of renewables. However, increased visibility for the market operator is expected to reduce this total.
[80] The magnitude of economic loss could have been higher had the event occurred in a jurisdiction within the NEM with higher loads.

| | | |
|---|---|---|
| | | • Optimising overall system profile (e.g. DER to reduce peak demand) reduction in peak demand X AEMO forecasted Peak Demand (10% POE) x augmentation cost avoided ($/kW/annum)<br>• Reduced wholesale energy costs to the market participants as better price information makes the market more efficient and less reactive (will be discussed qualitatively). |
| **Market Participant** | **Costs[81]** | **Benefits** |
| DNSP | • Gather network data (including data ingestion) - procure and install current and voltage measurement sensors and communications to head-end at distribution transformers<br>• Data transfer (latency linked to DOE calculation operating model)<br>• Establish, maintain and publish or share DER register data. | <u>Real time operations and operational forecasting</u><br>• Improved understanding of LV network operational status and network capacity utilisation. The confirmation of accurate network LV models, in conjunction with distribution transformer and smart meter measurement data, provides increased opportunities for improved network management, including:<br>○ Reduced risk of unplanned asset failure (overloading of transformers, LV circuits, LV Fuse operations) which result in lower asset replacement costs, USAIDI improvements, and potential Guaranteed Service Level (GSL) payments in cases where the outage tips DNSP over the GSL threshold)<br>○ Reduced phase loading unbalance resulting in increased network utilisation and DER hosting capacity (this benefit will be discussed qualitatively) |

[81] Costs in many of these areas will vary based on the DOE arrangements (e.g., costs for near real-time updating of DOEs are expected to be materially higher than those for a daily or intra-day).

| | | |
|---|---|---|
| | | • Decreased risk of customer power quality of supply issues. The additional measurement points and LV network modelling provide an enhanced ability to manage LV customer voltages either through network planning activities or dynamically through operational actions<br>  ○ Reduction in voltage non-compliance for customers (this benefit will be discussed qualitatively)<br>• The additional measurement points and LV network modelling enable a more exact determination of available network capacity for DER operation via DOE allocation<br>  ○ Reduced network constraints (due to moving away from conservative limits) and therefore increased energy released (this benefit will be discussed qualitatively) |
| Aggregators | • Cost associated with gathering all forecast data (e.g., customer data profiles) including data ingestion<br>• Data transfer costs (e.g. how frequently telemetry is transmitted (e.g. 20 seconds vs 1 minute vs 5 minute). This will be impacted by the outcomes of the Review of Power System Data Communication Standard<br>• Cost associated with establishing, maintaining and publishing or sharing DER portfolio registration data. | • The progressive implementation of the different market arrangements tested within Project EDGE is expected to facilitate the development of innovative revenue streams and business models. Currently, the make-up of these revenue streams and business models is unknown, however it is feasible to assume they could provide further benefit going forward. Qualitative insights will be included on how different market arrangements could accommodate additional value streams. |
| Consumers[82] | • Assumed a portion of the above costs are passed onto consumers. | • More efficient market (via increased visibility for AEMO), network (via increased visibility for DNSPs) and additional value streams available (via aggregator having more information and |

[82] It is assumed all consumers participating in the DER marketplace will have a smart meter and therefore the cost has not been incorporated

therefore better decision-making capabilities).

## 4.3 DER Data hubs

### 4.3.1 Introduction

Based on an expected high proliferation of DER, the volume and scale of data and control signals to be exchanged between market participants will be vastly different to today. Supporting this shift will require industry, market institutions, governments, customers, and other stakeholders to actively engage on the following challenges:

- Establishing and maintaining relationships between customers, devices, and participants for processes such as service enrolment, registration, and the facilitation of customer device inter-operability
- Scaling and harmonising IT infrastructure across the industry to manage the volume of data (and storage) being exchanged across all markets and participants, while ensuring performance, maintenance, security, and resilience
- Managing communication, credentials and integrations between market participants and relevant third parties (for example, 'agents' who can control the output of solar PV).

Project EDGE intends to test how to effectively harness digital technologies to enable secure and efficient ways to exchange data between industry participants at scale, to facilitate DER service delivery. Specifically, Project EDGE aims to test two core hypotheses:

> *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*
>
> *A decentralised data hub model is the most efficient solution that could deliver the most net benefit to NEM customers.*

To support the functions of a digitised, marketplace as proposed by Project EDGE, the scalable data exchange approaches considered must allow at a minimum the following use cases:

- **DER Register** - an accurate and dynamic registry of all DER located across all networks. In Project EDGE, it is assumed that an accurate and dynamic register should include portfolio or fleet-based information (e.g., which aggregator or consumer controls devices). It is also assumed that this registry would expand on the current NEM DER Register[83]
- **DOEs** – enabling DNSPs to offer a new dynamic export/import limit option to DER customers and VPPs whose systems have the technical capability to self-manage. This would allow DNSPs to signal the true capacity of the network on a locational and time-variant basis, so customers' imports and exports would only be limited at those times and in places where there is a capacity constraint[84]
- **Retailer Dynamic Export Limits** – dynamic export limits could be originated by retailers and enable dynamic adjustment of export by customer DER to provide the retailer financial protection at times of negative wholesale prices in which they would pay for customer exports
- **LSE for DER** - a solution to facilitate structured, scalable, bilateral procurement of local network services between the DSO and aggregators.

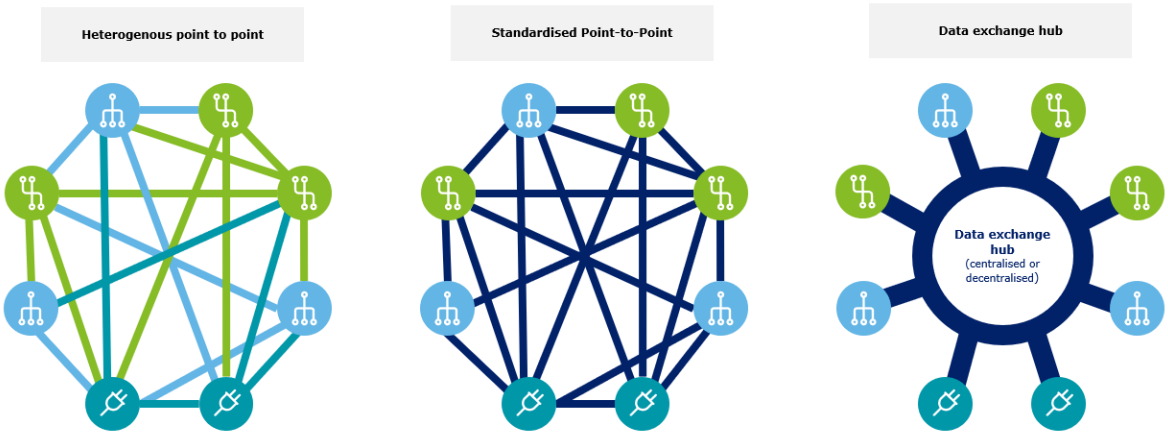
The concept of network wide efficient data exchange for DER trading is still nascent. To that end, there is a spectrum of approaches with increasing levels of complexity and sophistication to exchange data among multiple parties including:

[83] AEMO, Distributed Energy Resource Register, at https://aemo.com.au/en/energy-systems/electricity/der-register
[84] SA Power Networks (January 2019), LV Management Business Case

- **Heterogenous point-to-point** – parties establish individual connections to share data with no preferred methods or protocols
- **Standardised point-to-point** – parties establish individual connections to share data with agreed preferred methods or protocols
- **Data exchange hub** - connect once to a data exchange hub to share data with all parties, under agreed protocols.

The figure below highlights the differing approaches to data exchange.

Figure 4-2: Data exchange approaches




Source: AEMO

### 4.3.2 Data Exchange approaches considered

From analysis of data exchange issues at scale, Project EDGE has identified three data exchange approaches for evaluation. Considering that work in industry is underway to standardise DOEs (IEEE2030.5) the heterogeneous point-to-point was descoped assuming that the industry would also work toward standardisation, to an extent, of additional future participant to participant services. AEMO currently operates a centralised Data Exchange Hub (e-Hub) for the retail market and project analysis found plausible merit in a decentralised data hub architecture in the context of a high scale DER future.

- **Point-to-Point solution (standardised)**
  - A do-nothing scenario applied to DER where new use cases are implemented in absence of mandated use of a data hub, with the application of agreed industry standard communication processes and terminology, in a direct fashion among participants. For example, in the case of DOEs each DNSP could develop their own server aligning to the 2030.5 Common Smart Inverter Profile for Australia
  - Each customer agent would be required to register with each DNSP
  - Integrations via standardised[85] APIs for existing market interactions and via duplicated APIs for new DER data exchange use cases (such as local network support services and other participant to participant use cases that may arise in future)
  - Data models (as they relate to bespoke internal systems), software, and hardware architectures, and integration methods can differ between DNSPs.
- **Data Exchange Hub Centralised solution**

[85] It is hypothesised that a standardised point-to-point arrangement would result in integration cost savings compared to a heterogenous point-to-point arrangement

- Data is exchanged through a centralised data hub via a centralised broker (assumed to be AEMO in Project EDGE) who operates the hub and receives and transfers data according to agreed rules. For example, in the case of DOEs, the DSO could send DOEs attached to NMIs to the hub; the broker then uses the NMI reference to allocate DOEs into registered aggregator portfolios and sends the appropriate DOEs to each aggregator. This can all be automated but would require a broker to be responsible for executing the process according to the agreed rules
- Two concepts are being considered for the Data Exchange Hub Centralised solution
    - Centralised Hub (eHub) - augmented-e-hub to perform additional daily and intra-day use cases (e.g., DOEs, portfolio telemetry)
        - Integrations via standardised APIs (for all data exchange use cases)
        - Governance undertaken by the existing Information Exchange Committee (incorporating new DER data exchange use cases)
        - Existing standardised processes centralised within AEMO
    - Centralised Hub (Project EDGE implementation)
        - Participant containers for integration
        - Streamlined centralised governance with industry input
        - Existing standardised processes centralised within AEMO

- **Data Exchange Hub Decentralised solution**
    - Participant containers for integration
    - Removes the need for a centralised broker role, both in terms of hosting the hub and in operating the hub to transfer data through it
    - Uses open source and decentralised technology that is hosted by nominated participants in nodes. While any participant is allowed to host a node, hosting rights are defined in the governance structure
    - Data exchange is based on rules and permissions, machine to machine. There is a shared, single source of truth for the rules, participant identities and their permissions (which eliminates the need for the broker role)
    - Pass through capability enables messages to be sent by a sender without knowing the destination recipient (e.g., Single DOE payload is partitioned by code to relevant aggregators/customer agents).

The key elements of each data exchange option identified by Project EDGE are detailed in the following table.

Table 4-6: Key elements of each data exchange option

| | Point-to-point solution (standardised) | Data Exchange Centralised Hub solution (note: considering integration via a) standardised APIs; and b) participant containers) | Data Exchange Decentralised Hub solution |
|---|---|---|---|
| **Description (e.g., architecture)** | • Each DNSP procures its own digital infrastructure solution for dynamic DER management (aligned with standards)<br>• DNSPs contract service provider(s) to host digital environments<br>• Data is managed and stored by each DNSP<br>• All participants (e.g., aggregators) must manage direct point-to-point integration with each DNSP<br>• Each DNSP independently manages Identity and Access Management (IAM) arrangements for its solution<br>• Data is accessed based upon roles and permissions defined by the DNSP<br>• Each DNSP creates and maintains a DER Register for devices on its network in addition to the current NEM wide DER Register<br>• Each DNSP (or application service provider that built infrastructure) can build applications that extend solution. | • AEMO defines a common data model and common command signals between parties in consultation with industry<br>• Industry-wide data exchange hub is built that receives and stores all relevant data from all participants and directs messages to the correct recipient(s) based on roles (e.g. DOEs, LSE trade)<br>• A standardised transaction platform is established by AEMO for all DNSPs to integrate with their LSE implementations<br>• Each DNSP and market participant maintains a single, defined integration approach with the data hub<br>• AEMO contracts service provider(s) to host the digital environment<br>• Data is managed and stored by AEMO<br>• AEMO manages IAM for the solution<br>• Data is accessed based upon roles and permissions defined by AEMO<br>• AEMO expands and maintains the NEM DER Register for all devices across all networks<br>• AEMO (or application service provider that built hub) can build applications that extend solution. | • Decentralised data hub is open source, shared digital infrastructure where multiple parties host nodes that provide the data exchange infrastructure services<br>• Shared infrastructure includes an LSE application which enables each DNSP to operate their own LSE to issue service needs for 'tender'<br>• Data is stored by participants and storage service providers<br>• DNSPs and market participants maintain a single integration, with multiple integration options available (e.g., self-hosting container or subscribe to service providers hosting integration nodes)<br>• Data is accessed based upon role permissions and verifiable credentials associated with digital and decentralised identities (DIDs)<br>• A decentralised ledger acts as single register of identity across all networks (and DIDs are anchored to this ledger)<br>• Standing data is stored in a decentralised fashion, synchronised using Distributed Ledger (DLT). Option for some standing data to be stored on ledger is being investigated. |

| | | | |
|---|---|---|---|
| **Governance** | • Each DNSP controls its own solution (aligned with agreed methods/protocols)<br>• All participants (retailers and aggregators) must comply with DNSP decisions<br>• Each DNSP is responsible for ensuring the solution remains fit for purpose<br>• Each DNSP undertakes industry consultation as necessary<br>• Each DNSP manages its own implementation of 2030.5 utility server. | • AEMO is central administrator and broker, defines rules, roles, and integration methods<br>• All participants (e.g., aggregators) must comply with AEMO decisions<br>• AEMO is responsible for ensuring the hub remains fit for purpose<br>• AEMO facilitates industry consultation. | • Mix of shared and individual governance<br>• Shared governance includes decisions relating to:<br>- Eligibility and requirements for hosting infrastructure nodes and providing infrastructure services<br>- Integration patterns, data models, and standards for roles and applications<br>• Individual governance includes decisions relating to:<br>- Hosting infrastructure, or providing infrastructure services<br>- Approach to integration<br>• Roles and rules for independent solutions built on top of the shared infrastructure (e.g., independent LSE solutions). |
| **Commercial** | • DNSPs incur capex and opex for procuring and hosting the solution<br>• All participants incur capex and opex for managing individual integrations with each DNSP. Cost allocation will likely be bespoke.<br>• All DNSPs may pay licence fees to vendors (or whichever party owns the intellectual property associated with the solution) to manage the infrastructure. | • AEMO incurs capex and opex for procuring and hosting the solution<br>• DNSPs and market participants incur capex and opex for managing integrations<br>• All parties may pay licence fees to vendors to manage the infrastructure. AEMO or its vendors (whichever party owns the intellectual property associated with the solution) captures all revenue and value. | • Industry jointly owned infrastructure incurs capex for procuring the solution.<br>• Industry jointly owned infrastructure incurs opex for hosting the solution; all parties who participate in the solution 'own' a piece of it, and thus capture a portion of revenue and value<br>• Participants who choose to host infrastructure nodes are paid for service provision<br>• DNSPs and market participants incur opex and capex for managing integration<br>• There are no license fees associated with the open-sourced software underpinning the data exchange hub, and any participant is free to modify and extend the software for their own purposes, within an industry governance framework designed to avoid duplication of effort but support timely innovation. |

| | | | |
|---|---|---|---|
| **Performance and Scalability** | • Assuming 13 DNSPs and 100 retailers each want to connect with 100 customer agents – approximately 11,300 point-to-point connections to build and maintain<br>• Limited by each DNSP's solution specification<br>• Each DNSP would be responsible for verifying aggregators operating within its network territories, tracing NMIs to specific agents and aggregators. | • AEMO is solely responsible for mapping DERs to NMIs, and maintaining a 'master database' of credentials and relationships between aggregators and DNSPs<br>• Every DOE transaction involves three parties: AEMO acts as the message broker and is responsible for configuring data exchange channels and associated partitioning between aggregators and DNSPs. | • AEMO, aggregators and DNSPs collectively maintain a shared database for mapping DERs to NMIs, but have control within their own credentials and have some permissions to define their own relationships based on attributes<br>• DNSPs broadcast DOE by NMI, hub logic partitions and deliver to relevant Aggregator channels, with a copy provided to AEMO. DNSPs are able to establish direct communications (unicast channels) with select participants as required but are incentivised to use established channels. |
| **Risks** | • Significant risks and liabilities with respect to privacy and security<br>• Vendor lock in | • Risk of vendor lock in if implementation specifications are too rigid<br>• If central database of all participant identities, roles and credentials is compromised, there are cascading impacts on other processes and organisations. This risk exists and is managed today within AEMO. | • Each actor within the system must develop robust, independent processes and policies to securely manage their own identities and credentials. In Project EDGE this relates to each data hub users' data exchange container deployment in their own environment. |
| **Considerations** | • Data exchange methods are highly diverse (APIs, FTP, SCADA, and manual)<br>• Data (and processes) are replicated across siloed system and organisational boundaries<br>• Significant maintenance requirements as participants evolve and customers' churn<br>• Limited incentives for long-term innovation<br>• Each integrated participant must advise the DNSP of changes to the DER portfolio or fleet. Where this includes an EV, this may require multiple DNSP notifications for a single device. | • Relies on a single broker (e.g., AEMO) to operate infrastructure and manage access permissions credentials for all parties<br>• Broker is responsible for storing all data from all participants, and directing messages to the correct recipient(s)<br>• Broker could be single point of failure (a failure in the hub can be a bottleneck for multiple processes and organisations)<br>• Restricts innovation (e.g., to enable independent LSEs). | • Requires stakeholder engagement and education due to the novel architecture, governance framework, and commercial model<br>• Requires further testing in the energy sector<br>• Requires build out of service nodes. |

### 4.3.3 Approach to CBA analysis

The following methodology is proposed to test the two core hypotheses outlined in section 4.3.1, based on the scalable data exchange approaches and parameters developed by Project EDGE.

**Step 1 – Identify the functionality and use cases associated with each data exchange approach**

Table 4-7: High level functionality by data exchange approach

| | Point-to-Point solution (standardised) | Data Exchange Hub Centralised solution | Data Exchange Hub Decentralised solution |
|---|---|---|---|
| **Integration** | Point-to-Point with Standards via standardised APIs for existing market interactions and via duplicated APIs for new DER data exchange use cases | Centralised Hub (integration via a) standardised APIs (eHub and b) participant containers) | Decentralised Hub (pass-through messages) |
| **Identity Management** | Point-to-Point Identity (using Azure Active Directory) | DLT for Identity Management (external certificates and Hash on DLT) | DLT for Identity Management (external certificates and Hash on DLT) |
| **Data Storage** | Localised – NoSQL, Relational (no DLT) | Centralised – NoSQL, Relational (no DLT) | Decentralised - hosted by a few select organisations and also included on DLT[86] |

Source: AEMO

In Project EDGE, data exchange transactions to operate the DER marketplace pass through the data exchange hub and include bi-directional offers, dynamic operating envelopes, dispatch instructions and aggregator portfolio telemetry data.

All use cases listed below relate to facilitating interactions between market participants or market participants accessing up to date information. Note only use cases 'in field trial scope' are considered for the purposes of the CBA. Additional use cases are expected to develop incrementally over time.

Table 4-8: Data exchange use cases

| Data exchange use cases (included in EDGE CBA) | Point-to-Point solution (standardised) | Data Exchange Hub Centralised solution | Data Exchange Hub Decentralised solution |
|---|---|---|---|

[86] Compliments a decentralised data exchange hub by providing an immutable source of truth audit trail containing a version history of registration and standing data records only, not transactional data or settlements

| | | | |
|---|---|---|---|
| **Efficient transmission of DOEs** | Aggregators and DNSPs have an integration with each other to establish and maintain | 1x integration with the hub for each aggregator and DNSP, send 1x message via a central message broker for partitioning | Standardised, more directly via decentralised message bus |
| **Participant & Device IDAM** | Participants store and maintain each other's identities | Can utilise DLT for identities | Can utilise DLT for identities |
| **Facilitate efficient uptake of new DER use cases where participants want to interact directly with many other participants: e.g.**<br>• **negative spot price protection (Retailer Dynamic Export Limits)**<br>• **local services procurement** | Establish additional integrations, identity verification | Leverage existing identity verifications<br>Configure another channel to interact with the use case | Leverage existing identity verifications<br>Configure another channel to interact with the use case<br>Potential to use DLT for Device Register with appropriate roles and permissions |

Source: AEMO

**Step 2 – Identify the cost and benefit categories associated with each data exchange approach**

Each data exchange approach will have a unique costing structure,[87] influenced by a number of key factors:

- Timing and scalability (e.g., DNSPs will progress at different speeds in regard to DER uptake and data exchange use cases)
- Incorporation of new use cases
- Number of participants and volume of data
- Roles and responsibilities.

[87] During consultation aggregators identified that the shortlisted data exchange approaches should be scoped and costed by technology experts given the associated complexity and scale

Table 4-9: Costs by data exchange approach (including source)

| Cost Category[88] | Description | Relevant Market Participants | Fixed and/or variable costs | Point-to-Point solution (standardised) | Data Exchange Hub Centralised solution | Data Exchange Hub Decentralised solution[89] |
|---|---|---|---|---|---|---|
| **Initial Infrastructure Build** | Initial platform development costs | AEMO – Centralised Data Hub<br>DNSPs – Decentralised Data Hub | Fixed ($) | | √<br>Initial platform development costs for a) extending the e-Hub to perform additional daily and intra-day use cases (DOEs, Telemetry) (Source: AEMO) and b) participant integration via containers (Source: AEMO and EWF) | √<br>(Source: AEMO and EWF) |
| **Integration Costs (including compliance costs)** | Costs associated with market participants managing integrations – will be impacted by economies of scale | AEMO<br>DNSPs<br>Aggregators | Variable - Cost per integration ($) x Integration (#) | √<br>Costs associated with aggregators managing integration with each DNSP | √<br>Costs associated with aggregators managing integration (Source: Aggregators) | √<br>Costs associated with aggregators managing integration (Source: Aggregators) |

[88] Initial cost estimates will be provided by the identified source and will be tested with stakeholders as appropriate
[89] Overhead costs from a cross-industry governance process similar to the Information Exchange Committee (IEC) will be considered qualitatively

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | (Source: Aggregators)<br>Costs associated with AEMO managing integration with each DNSP (to receive DOEs) and Aggregators (Source: AEMO) | Costs associated with DNSPs managing integration (Source: AusNet Services) | Costs associated with DNSPs managing integration (Source: AusNet Services) |
| **IAM** | Cost associated with verifying participants and ongoing management of platform security/ resilience | All | Variable - Cost per integration ($) x Integration (#) | √ | √<br>IAM costs for a) extending the e-Hub to perform additional daily and intra-day use cases (DOEs, Telemetry) (Source: AEMO) and b) participant integration via containers (Source: AEMO and EWF) | √<br>(Source: AEMO) and EWF) |
| **Data Storage (e.g., DER Register or portfolio registration)** | Establishing and maintaining DER database and electronic registration process | AEMO<br>DNSPs<br>Aggregators | Fixed ($) and Variable - Cost per integration ($) x Integration (#) | √ | √ | √ |
| **Project Management Costs (FTEs)** | Ongoing project management costs | AEMO<br>DNSPs<br>Aggregators | Fixed ($) and Variable - Cost per FTE ($) x FTEs (#) | √ | √ | √ |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Hosting and Licence Fees** | Provision of hosting and licensing services | DNSPs for Point-to-Point solution<br>AEMO – Centralised Data Hub<br>All Market Participants – Decentralised Data Hub | Fixed ($) | √ | √<br>Hosting and Licence Fees for a) extending the e-Hub to perform additional daily and intra-day use cases (DOEs, Telemetry) (Source: AEMO) and b) participant integration via containers (Source: EWF) | √<br>(hosting fees only)<br>(Source: EWF) |
| **Support Services** | Ensuring data exchange approach remains fit for purpose | DNSPs for Point-to-Point solution<br>AEMO – Centralised Data Hub<br>All Market Participants – Decentralised Data Hub | Fixed ($) | √ | √<br>Support Services for a) extending the e-Hub to perform additional daily and intra-day use cases (DOEs, Telemetry) (Source: AEMO) and b) participant integration via containers (Source: EWF) | √<br>(Source: AEMO and EWF) |

On a theoretical level, a point-to-point approach to data exchange will likely have significant difficulties in meeting the scale and complexity of the data challenges under a high DER penetration scenario. In comparison, a data hub approach will likely be able to scale to meet these data challenges and also facilitate additional incremental benefits.

Table 4-10: Benefits by data exchange approach

| | |
|---|---|
| **Point-to-Point solution (standardised)** | • Flexibility and autonomy for DNSPs in procuring local services solution<br>• DNSPs have flexibility and control over DER database for their own jurisdiction. |
| **Data Exchange Hub Centralised solution (compared to Point-to-Point)** | • Reduces complexity and cost by reducing the number of integrations<br>• Simplifies reporting, reconciliation, and incident management<br>• Easier to coordinate and perform maintenance and system updates over time. |
| **Data Exchange Hub Decentralised solution (compared to Point-to-Point)** | • Eliminates bottleneck for data exchange and retrieval from a central broker, facilitating greater scale of data exchange and storage at performance levels required by the market<br>• Open-source solution is a common industry framework for digital identities and data exchange, so any participant (or application service provider) has the opportunity to build applications upon this infrastructure<br>• Flexible service provision and resilience: Participants can host independent 'nodes' or subscribe to existing ones, while distributing infrastructure eliminates single points of failure<br>• Dedicated channels: Participants can configure data exchange with many (broadcasts), or directly (unicast)<br>• Self-managed identity: Each participant manages their own identity and credentials<br>• Shared governance: Rules, roles, and responsibilities are defined via industry governance and enforced in code<br>• Innovation potential: Participants can build custom apps on top of shared infrastructure, and new use cases can be established building value for the market e.g., dynamic export limits<br>• Single source of truth (DLT) with DIDs and verifiable credentials enabling all participants (and 3rd parties) to read/write (based upon permissions) the DER register. |

**Step 3 - Calculate the costs and benefits associated with each data exchange approach**

Project EDGE offers the opportunity to test a data exchange hub and will allow processes, functions and timing to be further evaluated.

Significant analysis (e.g., extensive market testing and due diligence with technology providers) is required to accurately cost the data exchange approaches to a point where an accurate determination of cost differential could be made.

Initial cost estimates will be sourced from AEMO, AusNet Services, Aggregators (participating in Project EDGE), Energy Web Foundation (EWF) and desktop research (as shown in table 4-9).

These cost estimates will be tested with stakeholders (to ensure differentiation across market participants for each cost category where necessary) and supplemented by a literature review of international data exchange approaches.

Given the inherent uncertainty associated with costing these data exchange approaches sensitivity analysis will be undertaken.

The calculation of benefits will primarily be determined via quantifying any cost reductions / avoidance.

**Step 4 – Assessment of two core hypotheses**

The following approach is proposed to test the core Project EDGE hypotheses of whether the data hub model provides a scalable and long-term approach compared to point-to-point and whether a decentralised data hub model is the more efficient solution that could deliver the most net benefit to customers:

- Compare the costs and benefits between the Point-to-Point solution (standardised) and Data Exchange Hub Centralised solution considering the timing associated with the financial requirement for the data exchange hub (e.g., cost effective compared to point-to-point) and the operational requirement for the data exchange hub (based on rule changes and DER penetration levels)

- If a Data Exchange Hub Centralised solution provides a scalable and long-term approach for DER marketplace data exchange compared to the Point-to-Point solution (standardised) a comparison of the costs and benefits between the two data exchange hub solutions (i.e. centralised and decentralised) will be undertaken.

## 4.4 LSE

### 4.4.1 Introduction

With increasing penetration of DER, there is increasing opportunity for aggregation of DER to provide services to the local distribution networks, with the consequential effect of deferring or avoiding capital or operational investments by the DSO. These local services represent a value stack for the DER.

The Local Service Exchange[90] acts as the interaction platform for aggregators and DSOs to trade local services. The LSE application sits on top of the data hub which acts as the transaction mechanism for the provision of local services by aggregators to DSOs. This includes the submission of offers, exchange of contracts, scheduling and delivery of the service and the settlement of transactions based on service verification recorded via the data hub.

Given the potential complexity for aggregators participating across many DNSP jurisdictions standardising contract terms, timing, service definitions, data exchange infrastructure and the LSE interface as much as possible via industry guideline would likely maximise aggregator participation in LSE.

[90] The Project EDGE LSE framework will facilitate and trial visible, scalable and competitive trade of local DER services that enable DNSPs to manage network power security and reliability using local DER and in turn allow DER Aggregators to stack local and wholesale value streams efficiently

The cost benefit analysis considers the local services exchange as the transaction mechanism for the provision of services to DSOs on a local level, as distinct from the system-wide wholesale markets managed by AEMO.

The cost of the LSE is related to the platform development, integration and verification cost for participants and the costs for provision of data which may be required to actively participate, if different from that required for monitoring of DOEs. The benefit of the local services exchange is expected to be realised for DSOs in greater efficiency in network infrastructure spending and therefore lower costs to consumers.

The LSE is hypothesised (assuming significant aggregator uptake) to encourage greater benefits by way of DSOs realising lower DER-based network support service costs and firmness of response through having access to a greater, more liquid, pool of service providers (aggregators). Participating DER customers will provide generation or controllable load, for which they are paid, to aggregators who package these services to provide to DSOs.

Services provided by the aggregators are defined below, with each expected to command a different premium. Notably the variable nature of DER in terms of generation from solar but also the amount of firming available as a battery discharges / recharges in response to service requests create significant complexity.

Table 4-11: Summary classification of local services

| Service | High Firmness | Medium Firmness | Low Firmness |
|---|---|---|---|
| **Demand increase / reduction** | **Network planning** Longer term contract with guaranteed availability and agreed pricing | **Operational planning** Shorter term contract with negotiated availability pricing | **Spontaneous operational** Similar to spot market, no guaranteed availability and pricing set by market or negotiated earlier |
| **Voltage management** | **Network planning** Longer term contract with guaranteed availability, agreed pricing and autonomous operation | **Forecast market need** Shorter term negotiated availability and pricing | **Spontaneous market need** Shorter term contract with uncertain availability and pricing set by the market or negotiated earlier |

### 4.4.2 Approach to CBA Analysis

The Project EDGE trial will test some functionality of the local service exchange with the intention to understand the ability of DSOs to utilise the system to enhance network management. Additionally, the CBA will consider the impact of roles and responsibilities and associated capability requirements of participants in response to the LSE and consider indicative costings derived from the trial and industry in considering the economic merits of the LSE.

The interaction of the LSE and the data hub, where the hub serves as the message bus and repository for service need and transaction verifying data, becomes critical when considering the potential impact of service provision on necessary data. The Hub and LSE while considered in detail separately are interactive and therefore the assessment lens applied will consider the impact of one on the other.

The table below summarises the costs which may be required to actively participate in the LSE.

Table 4-12: Summary of costs created by actively participating in the LSE

| LSE Cost Item | Participant/s | Relevant Data Exchange Approach | | |
|---|---|---|---|---|
| | | Point-to-Point solution (standardised) | Data Exchange Hub Centralised solution | Data Exchange Hub Decentralised solution |
| Establishing the LSE Application (Capex) | Central Hub Broker (assumed to be AEMO) | | √ | |
| Establishing the LSE Application (Capex) | DSO[91] | | | √ |
| Hosting and managing the LSE Application (Opex) | Central Hub Broker (assumed to be AEMO) | | √ | |
| Hosting and managing the LSE Application (Opex) | All shared digital infrastructure hosts | | | √ |
| Modelling for service valuation and definition, registration, identity management and portfolio management systems and processes (Capex) | DSO | √ | √ (leverage existing identity and portfolio registrations from hub) | √ (leverage existing identity and portfolio registrations from hub) |
| Portfolio registration updates (Opex) | Aggregators | √ | √ (leverage existing identity and portfolio registrations from hub) | √ (leverage existing identity and portfolio registrations from hub) |
| Integration Costs (Capex)[92] | DSO and Aggregators | √ | √ | √ |
| Integration management and support costs (Opex) | DSO and Aggregators | √ | √ | √ |
| Submission of offers, exchange of contracts, scheduling and delivery of the service and the settlement of transactions (Opex) | DSO and Aggregators | √ | √ | √ |
| DER service-delivery verification data (Opex) | DSO and Aggregators | √ | √ | √ |
| Payments to Aggregators based on the services to the local distribution networks provided | DSO | √ | √ | √ |

[91] Does not include the backend solutions costs
[92] In addition to the integration cost required to facilitate DOEs under a data hub (however it is expected that cost efficiencies could exist based on this integration already being established)

The table below summarises the value created for different participants in the DER marketplace by the introduction of a LSE. The magnitude of each value stream will be tested with stakeholders.

Table 4-13: Summary of value created by LSE

| Participant | Value created |
|---|---|
| **DSO** | • Increased flexibility in the management of network constraints<br>• Deferral of capital expenditure |
| **Aggregator** | • Increased value to customers for delivery of additional services at a local level |
| **AEMO** | • Increased visibility of and market access of cost competitive DER capacity released by management of DNSP network constraints |

The LSE as currently envisaged, facilitates trade between aggregators and DSOs. The local nature of the services provided suggest there may be significant value in aggregations of customers at a local geographic level. That is, aggregators will be able to provide a better service to DSOs if they have many customers on the same street or near a network constraint. Therefore, it's permissible to assume there may be a secondary market for aggregators to effectively sub aggregate participating DER in a way that provides a more efficient service provision to DSOs and which would also provide benefit to the release of value to participating DER.

## 4.5 Grouped DOEs

As the prevalence of DER rapidly increases in the NEM, the optionality (e.g., flexibility, time intervals, data requirements, social and economic considerations) associated with operating envelopes has emerged as a key area for assessment.

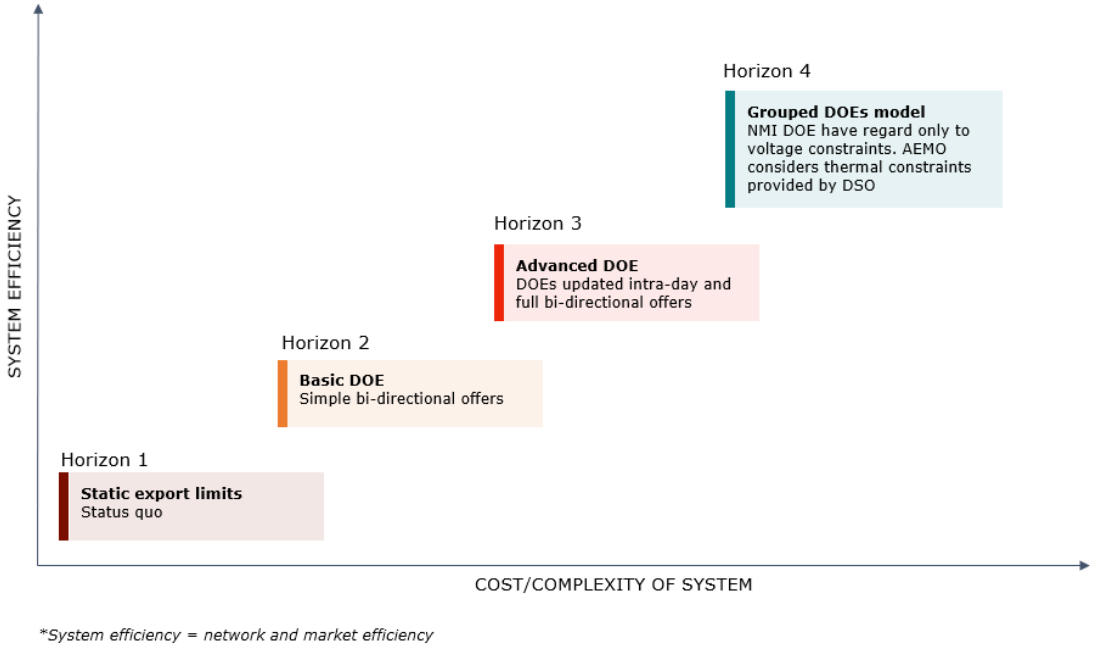
Project EDGE is investigating several methods for DOE[93] calculation, allocation and market dispatch operating models. For example, a broad spectrum of market dispatch models is being considered based on a simplicity-efficiency trade-off.[94]

These models are represented by:

- Static Operating Envelopes – Static NMI level limits on export
- Basic DOE – NMI-level operating envelopes for export and import, calculated and dynamically updated using an approximation forecast provided on a day ahead basis to aggregators to consider in simple bi-directional offer construction (price-taking)
- Advanced DOE - DOEs are updated on an intra-day basis using a low voltage data model and utilised by aggregators to construct fully scheduled bi-directional offers (price-setting)
- Grouped DOEs – Aggregators are provided NMI DOEs with respect to voltage constraints while AEMO considers thermal constraints of an upstream network element provided by the DSO (e.g., nodal thermal limits linked to market optimisation) (refer to figure below).

[93] A dynamic operating envelope essentially provides upper and lower bounds on the import or export power in a given time interval for either individual DER assets or a connection point
[94] AEMO (June 2022), *Project EDGE Public Interim Report – Page 44*, <https://aemo.com.au/initiatives/major-programs/nem-distributed-energy-resources-der-program/der-demonstrations/project-edge/project-edge-news-and-knowledge-sharing>

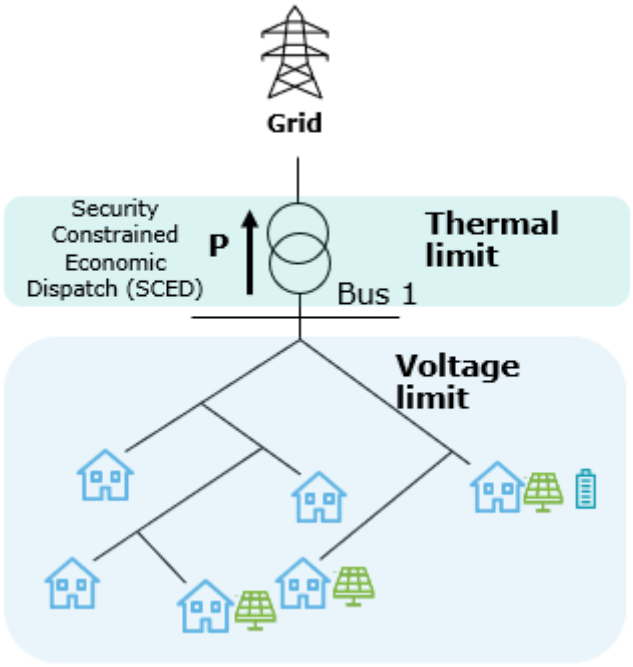
Figure 4-3: Spectrum of the simplicity-efficiency trade-off for distribution network limits and wholesale dispatch




Source: AEMO

Under the Grouped DOE model, aggregators bid and dispatch instructions are produced through a grouped-level security constrained economic dispatch (SCED) process to maximise the economic efficiency and utilisation of the network under the constrained node. Aggregators must manage their compliance with NMI level DOEs (voltage limits).

Figure 4-4: Location of thermal and voltage limits




Source: AusNet

The Grouped DOE model is hypothesised to result in increased market efficiency[95] that would require a more complex solution:

- AEMO will have increased interaction with DSOs (e.g., AEMO receives thermal constraints from DNSPs and shares dispatch outcomes with DSOs) and aggregators (e.g., aggregators bid per thermal constraint (multiple) and AEMO pre-solves the bid stack for a group of NMIs under thermal constraint before solving the wholesale merit order, and provides 'grouped' dispatch instructions corresponding to NMIs under thermal constraints)
- DSOs and aggregators will have increased interaction with each other (e.g., DSO sends the recalculated DOE to aggregators).

The Project EDGE field trial will test the Basic DOE and Advanced DOE 'target operating models' whereas the technical performance of the Grouped DOE model will be assessed via desktop analysis (that considers current and future applicability of the Grouped DOE model and a description of what conditions are required for the Grouped DOE model to be viable) by UoM as it was not feasible to build this capability within the project timeline.

[95] Assuming 100% participation. Assumption made for ease of analysis because if there are non-participating loads/generation, these are not included in the Aggregator bids and therefore a simple comparison of aggregated bids to a nodal thermal constraint for market optimisation is not effective

# Appendix A – Key consultation questions

Table A-1 provides a summary of the key questions for consultation raised throughout the Draft CBA Methodology Report and during the stakeholder engagement process (July 2022 to September 2022).

Table A-1: Questions for consultation

| Question | Question |
|---|---|
| **1** | To what extent does the framework for roles and responsibilities tested under Project EDGE improve consumer value and encourage competition in favour of the consumer? |
| **2** | Considering that DNSPs have differing requirements in managing increased DER penetration, is the gradual rollout of DOEs assumed under the base case reasonable? |
| **3** | Are there additional costs and benefits that should be considered? |
| **4** | Are there additional considerations that should be incorporated in the CBA that are not referenced? |
| **5** | What proportion of aggregator revenue do you anticipate will be associated with energy services compared with ancillary services such as FCAS? |
| **6** | Are there any barriers to implementing the Project EDGE framework for roles and responsibilities? What would make them infeasible (e.g., a market or policy change)? Please provide examples where possible? |
| **7** | What alternative arrangements for roles and responsibilities under a Hybrid Model of the Open Energy Networks Project should be considered? Are there alternative arrangements outside the Hybrid Model that should be considered? |
| **8** | Do you agree with the identified costs and benefits of increased visibility (across different market participants)? How are they best quantified? |
| **9** | Are any additional use cases essential for 'day 1'? What use cases do you foresee being established over the next 5-10 years? What would be the trigger for enabling these use cases? |

| | |
|---|---|
| **10** | What are the key considerations/risks from an Australian Energy Sector Cyber Security Framework perspective associated with a Data Exchange Hub solution? |
| **11** | Who should set the standards and arrangements under the Data Exchange Hub Decentralised solution? |
| **12** | Does a Data Exchange Hub Decentralised solution appear feasible? Have any key considerations/concerns not been identified? |
| **13** | What parameters drive extrapolation for each cost category under a DER data hub? |
| **14** | Are the cost and benefit categories listed accurate for each data exchange approach based on the assumed use cases? Do you have any high-level estimates based on previous work that could be provided? |
| **15** | As an aggregator participating in the LSE, what constraints do you foresee given the LSEs need for DER to be clustered in a local area? |
| **16** | Is the assumption that the LSE will be most efficient from a whole-of-system perspective if facilitated through a data hub reasonable? |

# Appendix B – CBA interaction with research questions and activities

The table below lists the research questions and associated hypotheses from UoM's Research Plan that will be informed and tested by the outcomes of the CBA[96]. It also discusses the methods which will be used to explore these research questions and activities by comparing different CBA scenarios.

Table B-1: CBA relevant Research questions and their links to the scenarios

| CBA relevant Research Question (RQ) | Associated Hypotheses (Hp) | CBA Assessment Method | Required Scenario Comparison (across the 20-year time horizon) | Relevant section in the CBA Methodology Report |
|---|---|---|---|---|
| **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.C** Enabling aggregators to deliver multiple services whilst minimising market complexity can enable them to provide valuable and simple offers to customers to activate their DER. | Determine the cost and benefits of the aggregators to participate in simple and sophisticated markets. | • Scenario 3 vs 5 (against the base case) shows the impact of aggregators utilising the LSE under different DOE and market arrangements<br>• Scenario 8 vs 10 (against the base case) reflects the same comparison as above assuming higher DER uptake assumptions. | Section 3.2.1, 3.2.2 and 3.2.3 |
| **RQ.2** Does the DER marketplace promote efficient investment in, and efficient operation and use of, electricity services for the long- | **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. | Whole-of-system assessment under simple arrangements and extrapolated out based on DER forecasts. | • Scenario 3 vs 5 (against the base case) shows the impact of a DER Marketplace utilising different DOE and market arrangements<br>• Scenario 8 vs 10 (against the base case) reflects the | Section 3.2.1, 3.2.2 and 3.2.3 |

[96] UoM, Project EDGE Research Plan (February 2022), at master-research-plan-edge.pdf (aemo.com.au)

| CBA relevant Research Question (RQ) | Associated Hypotheses (Hp) | CBA Assessment Method | Required Scenario Comparison (across the 20-year time horizon) | Relevant section in the CBA Methodology Report |
|---|---|---|---|---|
| term interests of consumers? | | | same comparison as above assuming higher DER uptake assumptions. | |
| | **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. | Assessment of the impacts to the DNSP procurement of local services and resulting deferment of network capex/replacement expenditure (repex) through standardisation of the definition and trade of local network services. | • Scenario 3 and 5 (against the base case) shows the impact of the LSE on DNSP costs (capex and opex)<br>• Scenario 8 and 10 (against the base case) reflects the same comparison as above assuming higher DER uptake assumptions. | Section 3.2.1, 3.2.2, 3.2.3 and 4.4.2 |
| | **Hp.C** A data hub model reduces cost and complexity of data exchange and provides an economically efficient and scalable approach for DER marketplace. | Comparative assessment of the difference in costs for providing wholesale and local service types operating via the data hub concept against integration using a direct point-to-point model. | • Scenario 3 vs 5 (against the base case) shows the impact of a DER Marketplace utilising different DOE and market arrangements<br>• Scenario 8 vs 10 (against the base case) reflects the same comparison as above assuming higher DER uptake assumptions<br>This assessment will consider both a Centralised (e-hub and Project EDGE implementation) and Decentralised data hub. | Section 3.2.1, 3.2.2, 3.2.3 and 4.3.3 |
| **RQ.3** How does operating envelope design impact on the efficient allocation of network capacity while enabling the provision | **Hp.A** The design of the operating envelopes has a material impact on the network operation and provision of different wholesale energy and local services. | Assessment of the value unlocked from different levels of sophistication in dynamic operating envelope design. | • Scenario 2 (against the base case) shows the impact of a Maximum Service DOE Objective Function | Section 3.2.1, 3.2.2, 3.2.3 and 4.4.2 |

| CBA relevant Research Question (RQ) | Associated Hypotheses (Hp) | CBA Assessment Method | Required Scenario Comparison (across the 20-year time horizon) | Relevant section in the CBA Methodology Report |
|---|---|---|---|---|
| of wholesale energy and local network services? | | | • Scenario 3 reflects the same comparison as above assuming a DER Marketplace<br>• Scenario 4 (against the base case) shows the impact of<br>a) intra- day constraint optimisation frequency<br>b) 100% DOE Co-optimisation<br>c) LV Data Driven DOE Optimisation Methodology and<br>d) Maximum Service DOE Objective Function<br>• Scenario 5 reflects the same comparison as above assuming a DER Marketplace. | |
| | **Hp.B:** Accounting for uncertainty in the calculation of operating envelopes improves the technical and economic outcomes of the marketplace. | Assessment of the economic value unlocked due to different designs of operating envelopes (with a DER Marketplace). | • Scenario 3 vs 5 (against the base case) shows the impact of different DOE arrangements with a DER Marketplace<br>• Scenario 8 vs 10 (against the base case) reflects the same comparison as above assuming higher DER uptake assumptions. | Section 3.2.1, 3.2.2 and 3.2.3 |
| | **Hp.C** It is possible to increase efficiency of operating envelope design and implementation as DER penetration increases | Assessment of the economic value unlocked due to different designs of operating envelopes | • Scenario 7-10 (against the base case) reflects the same comparisons as above (RQ3 Hp. A) | Section 3.2.1, 3.2.2 and 3.2.3 |

| CBA relevant Research Question (RQ) | Associated Hypotheses (Hp) | CBA Assessment Method | Required Scenario Comparison (across the 20-year time horizon) | Relevant section in the CBA Methodology Report |
|---|---|---|---|---|
| | | against the cost of sophistication. | assuming higher DER uptake assumptions. | |
| **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? (linked to RQ.2Hp.B) | **Hp.A** Network reliability can be managed through the provision of local network services from customer-owned assets. | Reliability is an implicit assumption in the model and not variable, meaning the comparison of cost-of-service provision with the same reliability forms the metric of efficiency. Consequently, reliability and feasibility are not explicitly tested in the model and the trials will act as key verification of this technical feasibility. | • All scenarios - investment by DNSPs is quantified under each scenario allowing determination of potential cost reductions under increasing provision of network services by customers. | Section 3.2.1, 3.2.2, 3.2.3 and 4.4.2 |
| **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. | The CBA will refer to (as a separate workstream) the work conducted by the UoM under the "DER to Network to Market" interaction studies to analyse how new DNSP/DSO functions like dynamic voltage regulation and local network services can be used in a targeted manner to alleviate network constraints where there is a benefit to the wholesale energy market. The outputs of the UoM study include valuing (using actual historical data) the market benefit that can be created by these functions. | | Section 3.1.4 and 3.1.5 |

Table B-2: CBA relevant Research activities

| Research Activity | What | Why | Assessment Method | Relevant section in the CBA Methodology Report |
|---|---|---|---|---|
| Roles, responsibilities and associated risks of participants | Record the practical role / responsibilities within the hybrid model conducted by each party and map the risks to all actors whilst participating in different models or roles. | To map the division of roles/responsibilities within the hybrid model in practical terms and to determine if the risks are best given to the parties which are able to manage them. | • Undertaking a MCA will provide a qualitative assessment (outside the quantitative CBA) of alternative roles and responsibilities arrangements (defined in section 4.1.1) compared to the Project EDGE roles and responsibilities arrangement. | Section 4.1 |
| Desktop assessment of data hub models vs. point-to-point integrations | Desktop assessment of the advantages / disadvantages of the data hub model vs point-to-point integrations, considering the following factors:<br>- scalability<br>- flexibility<br>- barriers to entry<br>- ability to innovate<br>- technology agnostic | To understand which model provides a scalable and long-term approach for DER Marketplace data exchange | • The following approach is proposed to test the hypotheses of whether the data hub model provides a scalable and long-term approach compared to point-to-point and whether a decentralised data hub model is the more efficient solution that could deliver the most net benefit to customers:<br>○ Compare the costs and benefits between the Point-to-Point solution (standardised) and Data Exchange Hub Centralised solution considering the timing associated with the financial requirement for the data exchange hub (e.g., cost effective compared to point-to-point) and the operational | Section 4.3 |

| Research Activity | What | Why | Assessment Method | Relevant section in the CBA Methodology Report |
|---|---|---|---|---|
| | | | requirement for the data exchange hub (based on rule changes and DER penetration levels)<br>○ If a Data Exchange Hub Centralised solution provides a scalable and long-term approach for DER marketplace data exchange compared to the Point-to-Point solution (standardised) a comparison of the costs and benefits between the two data exchange hub solutions (i.e. centralised and decentralised) will be undertaken. | |

# Appendix C - Summary of market reviews, studies and rule change

This Appendix provides a brief overview of the market reviews, studies and rule changes (current and proposed) referenced in this report (as at August 2022).

## C.1 Reviews

### ESB's Post 2025 Market Design Project DER Implementation Plan[97]

***Overview***

The ESB's electricity market redesign final advice (August 2021) included a DER Implementation Plan to address a broad range of technical, regulatory and market issues to support DER integration over a three-year period.

The DER Implementation Plan sequences immediate and initial regulatory, technical and market reforms that address emerging risks and builds capability to deliver benefits to all consumers from high levels of distributed energy resources and new energy services, to deliver the following outcomes:[98]

- Consumers are rewarded for their flexible demand and generation, have options for how they want to engage (including being able to switch between DER service providers), and are protected by a fit-for-purpose consumer protections framework
- The wholesale market supports innovation, the integration of new business models and has a more efficient supply and demand balance
- Networks are able to accommodate the continued uptake of DER and two-way flows and are able to manage the security of the network in a cost-effective way
- AEMO has the visibility and tools it needs to continue to operate a safe, secure and reliable system, including maintaining system security associated with minimum load conditions.

***Relevance to Project EDGE***

The programs of work and associated NER changes and market reviews resulting from the ESB's recommendations, particularly the Integration of DER and Flexible Demand workstream supporting implementation of the DER Implementation Plan, will be considered both in the defining the base case and the scenarios that will represent incremental change from the base case.

A number of the reviews and NER changes supporting the outworking of the DER Implementation Plan's recommendations by the AEMC, the AER and AEMO are discussed below.

[97] ESB, Post 2025 Market Design Project, at Energy Security Board | Post 2025 electricity market design project (aemc.gov.au)
[98] ESB, Post-2025 Market Design Final Advice to Energy Ministers (Part A), page 20, at 1629944958-post-2025-market-design-final-advice-to-energy-ministers-part-a.pdf (datocms-assets.com)

### AEMO's 2022 Integrated System Plan (ISP)[99]

***Overview***

AEMO's ISP sets out an optimal development path which identifies investments that meet the future needs of the NEM, including actionable and future ISP projects (transmission projects or non-network options), and development opportunities in "distribution assets, generation, storage projects or demand-side developments that are consistent with the efficient development of the power system".[100] The ISP's planning horizon extends to 2050, to reflect Australia's 2050 net zero emissions target.

The ISP analyses four scenarios spanning a range of plausible futures with varying rates of emission reduction, electricity demand, and decentralisation. It assumes that all DER generation made available under each scenario can be exported into the network.

AEMO's ISP 2022 considered that stakeholders viewed the most likely scenario to be the relatively fast Step Change Scenario. The Step Change Scenario reflects a rapid consumer-led transformation of the energy sector and co-ordinated economy-wide action, involving a consistently fast-paced transition from fossil fuels to renewable energy resources in the NEM.

AEMO has noted that since then, momentum towards decarbonisation has accelerated, confirming the Step Change scenario as a solid foundation for planning NEM investment.[101]

***Relevance to Project EDGE***

For the purposes of the CBA, the load and DER assumptions from AEMO's Step Change Scenario, are proposed to be utilised as one of the two scenarios to be applied in Energeia's techno-economic modelling to capture the incremental benefit of the marketplace under different load conditions and DER penetration rates.

### AEMC's Electricity Network Economic Regulatory Framework Review[102]

***Overview***

Considers whether the economic regulatory framework for electricity networks continues to support the delivery of the NEO in light of these changes in the energy market, including the AEMC's priority reform considerations for distribution and transmission network regulation over an 18 month period, and how this fits with longer term market reforms led by the ESB.

***Relevance to Project EDGE***

The AEMC noted stakeholder frustration with the unresolved debate on the future respective roles of AEMO and DNSPs in managing the two-way grid, and that altering operations to support two-way flows is likely to have implications for some feature of the regulatory framework.[103] Project EDGE will seek to provide increased clarity on potential roles and responsibilities of market participants in a DER marketplace.

## C.2 Rule changes

It is necessary to consider recently completed and pending rule changes and market reform programs as variables that could affect the CBA scenarios and their associated costs and benefits.

As part of the CBA development process, Deloitte has and will continue to monitor the most relevant electricity market body documents to identify NEM design changes that may impact Project EDGE. A register is maintained of these changes and their expected timing, the magnitude of the anticipated impact for the CBA, and whether the potential impact will be managed within or

[99] AEMO, 2022 ISP (June 2022), at 2022-integrated-system-plan-isp.pdf (aemo.com.au)
[100] NER 5.10.2
[101] AEMO, 2022 ISP (June 2022), page 7, at 2022-integrated-system-plan-isp.pdf (aemo.com.au)
[102] AEMC, Electricity Network Economic Regulatory Framework 2020 Review – Final Report (October 2020), at EPR0085 - ENERF 2020 final report - 1 October 2020 (aemc.gov.au)
[103] Ibid, page 14

outside the TEM. The most recent review (July 2022) informed the development of the CBA Methodology.

## AEMC's Wholesale Demand Response Mechanism rule change (rule change status – completed)[104]

***Overview***

Implements a (WDRM) under which consumers are able to sell demand response in the wholesale market either directly or through specialist aggregators.

While the WDRM focuses on customers with loads that are large, controllable, and predictable, it is an important step in demonstrating effectively what a two-sided market would facilitate, i.e. a market informed by both quantity and price information from the both the supply and demand sides.

While a two-sided market may have broader scope, particularly in relation to the level of market participation, the implementation and use of the mechanism will inform market design choices in the development of a two-sided market.[105]

***Relevance to Project EDGE***

Although participation in the WDRM is not within the scope of Project EDGE, the market's broader implementation and use of this mechanism may inform market design choices.

## Access, pricing and incentive arrangements for distributed energy resources (rule change status – completed)[106]

***Overview***

The rule change package seeks to integrate DER more efficiently into the electricity grid through a range of mechanisms.

Key aspects of the final rules include:

- Clear obligations on distribution businesses to support more DER connecting to the grid:
    - Clarification that export services are part of the core services to be provided by distribution businesses
    - Removing complete export bans: customers seeking an export connection must be provided a non-static zero export limit, unless exemptions apply
    - Requiring distribution businesses to plan for the provision of export services and explicitly explain their approach to DER integration in their regulatory proposals
    - Extending the existing planning and investment arrangements to exports, giving the AER the ability review distribution businesses' expenditure plans
- Enabling distribution businesses to offer a range of options to encourage solar owners to limit solar waste, save money and benefit the grid:
    - Removing the existing prohibition on distribution businesses from developing export pricing options, which can help get more out of the network infrastructure
    - Requiring all distribution businesses to offer a basic export level in all their tariffs without charge for 10 years
    - Introducing new customer safeguards to help the transition to export pricing

[104] AEMC. Wholesale demand response mechanism, final determination and rule (June 2020), at Wholesale demand response mechanism | AEMC
[105] AEMC, Wholesale demand response mechanism, final rule determination (June 2020), page iii, at Final determination (aemc.gov.au)
[106] AEMC, Access. Pricing and incentive arrangements for distributed energy resources (August 2021), at Access, pricing and incentive arrangements for distributed energy resources | AEMC

- Strengthening customer protections and regulatory oversight by the AER:
    - Distribution businesses will be required to consult widely and test and trial the options they put forward using Export Tariff Guidelines to be developed by the AER
    - The AER will:
        - undertake a review considering incentive arrangements for distribution businesses to deliver efficient levels of export service and performance
        - report annually on the performance of distribution businesses in providing export services to customers
        - develop CECVs to help guide efficient levels of investment for exports and support other regulatory processes
        - update its connection charge guideline to reflect the restrictions imposed on static zero export limits.

***Relevance to Project EDGE***

Consideration will be given to the timing of the introductions of reforms, including between DNSPs.

## Integrating Energy Storage Systems into the NEM rule change (rule change status – completed)[107]

***Overview***

The IESS rule change considered integration of bi-directional units to support movement towards a two-sided market, including consideration of Flexible Trader Model 1 proposed by the ESB under its ESB's electricity market redesign final advice (refer below).

The rule change introduces a new technology neutral participant category, the Integrated Resource Provider (IRP), that accommodates participants with bi-directional energy flows that may offer and consume energy and ancillary services. This includes grid-scale storage, hybrids and aggregators of small generation and storage units.

IRPs participate in the market with a single Dispatchable Unit ID (DUID) and a single bid to reflect the IRP's desire to charge or discharge for market prices. IRPs will receive a single dispatch target for their portfolio.

***Relevance to Project EDGE***

The consideration of bi-directional bids and offers being progressed through Project EDGE have contributed to AEMO's high-level design for implementing single DUIDs for wholesale IESS, and vice versa, with efforts being made to align the two projects. Project EDGE will also provide an opportunity to test the implementation approach (including, for example, validation of bid files) prior to the wider implementation of IESS.[108]

## Flexible Trading Arrangements for Consumer Energy Resources (rule change status – pending)[109]

***Overview***

The ESB's electricity market redesign final advice (August 2021) included recommendations for the implementation of flexible trading arrangements.

Flexible trading arrangements separate controllable load (for example solar PV, batteries, EVs, pool pumps) from uncontrollable resources (the primary source of electricity to a customer's home or business), through a single shared smart meter. This would allow customers to engage with

[107] AEMC, Integrating energy storage systems into the NEM, at Integrating energy storage systems into the NEM | AEMC
[108] Project EDGE Public Interim Report (June 2022), page 15, at Public Interim Report (aemo.com.au)
[109] AEMC, Flexible trading arrangements for consumer energy resources, at Flexible trading arrangements for consumer energy resources | AEMC

multiple service providers, access additional services, and be rewarded for flexible demand and generation, while not making significant changes to behaviours for conventional energy usage.

The ESB proposed two models to enable flexible trading, both based on amendments to the existing regulatory framework, both of which can co-exist in the NER:[110]

- Flexible Trader Model 1 (FTM1) – FTM1 extends the existing Small Generator Aggregator framework. The main change moves the SGA design from generation only to cater for bi-directional energy flows and participation in the ancillary services market. Doing this will enable SGAs to provide new products and services to customers. Model 1 was considered as part of the IESS rule change (refer above)
- Flexible Trader Model 2 (FTM2) – FTM2 provides a specific category of connection arrangement that enables a National Meter Identifier (NMI) to be established within a customer's electrical installation. This would enable customers to separate their controllable electrical resources and have them managed independently, without the need to establish a second connection point to the distribution network. The pending rule change proposes to establish FTM2.

***Relevance to Project EDGE***

The operational and customer insights from Project EDGE relating to the integration and control of DER devices can inform the development of FTM2 through the rule change process.

For the purposes of the CBA, flexible trading arrangements are assumed under all scenarios.

## Scheduled Lite rule change (rule change status – yet to be lodged)[111]

***Overview***

The concept of 'Scheduled Lite' was developed by the ESB to refer to resources that are not currently scheduled in the market, with the aim of encouraging the 'opt-in' of these resource to:[112]

- Provide greater visibility to AEMO about their intentions in the market (visibility model)
- Participate in dispatch with lighter telemetry (dispatchability model).

The ultimate intent is to provide greater visibility of these resources to support increased market certainty through more accurate scheduling and enable AEMO to operate the market more efficiently and facilitate broader participation in dispatch.

AEMO was tasked with the high-level design of this mechanism.

Flexible trading models (refer above) could provide a framework for participation in Scheduled Lite, noting that AEMO does not propose that the separation of resources (via establishment of FTM1 or FTM2 arrangements) will be required for participation in Scheduled Lite. Three participation models have therefore been proposed for consultation:  Standard connection point arrangements, FTM1 and FTM2.

***Relevance to Project EDGE***

The trialling of scheduling frameworks and processes through Project EDGE will inform Scheduled Lite regulations and detailed implementation arrangements.

The lessons derived from Project EDGE trials are expected to inform AEMO's understanding of the participation capability (e.g., visibility, forecastability and dispatchability) of each of the models

[110] ESB, Post-2025 Market Design Final Advice to Energy Ministers (Part B), page 85, at 1629945809-post-2025-market-design-final-advice-to-energy-ministers-part-b.pdf (datocms-assets.com)
[111] AEMO, Scheduled Lite: Draft High Level Design Draft Consultation Paper (June 2022), at Microsoft Word - Draft Scheduled Lite Consultation Paper v6.0 (aemo.com.au)
[112] ESB, Post-2025 Market Design Final Advice to Energy Ministers (Part B), page 87, at 1629945809-post-2025-market-design-final-advice-to-energy-ministers-part-b.pdf (datocms-assets.com)

proposed in Scheduled Lite, including the participation capability of flexible resources managed independently via establishment of FTM1 or FTM2.

It is also anticipated that enhancements to network visibility as contemplated by the DER Data Hub being trialled in Project EDGE, could sit alongside Scheduled Lite's visibility model.

## C.3 Studies and market trials

### AEMO and ENA's Open Energy Networks Project[113]

***Overview***

AEMO, in collaboration with ENA, sought to identify framework options for the most appropriate framework for building a two-sided marketplace to enable DER to provide both wholesale market and local network services. Work included:

- Initial consultation to explore the proposed frameworks required to integrate DER, including a more active DSO and the advent of distribution markets. Multiple frameworks were considered including:
    - Hybrid Model – featuring a single central market platform comprised of wholesale and ancillary services markets. AEMO organises and operate the central dispatch to achieve a whole system optimisation which takes account of distribution network constraints. DER can participate in the central market via an aggregator and/or energy retailer. DSOs calculate and provide operating envelopes to assist in market bid development
    - Independent DSO model – featuring a single central market platform and a number of local market platforms. IDSOs organise and operate local market platforms to procure distribution network support and control ancillary services to solve distribution network constraints. DNSPs build, maintain and operate and network and actively exchange information with IDSOs. AEMO operates the central market platform comprising the wholesale energy and select ancillary markets. DER participate in the central or local markets via and aggregator and/or energy retailer, with bids prequalified to take account of distribution network constraints
    - Single Integrated Platform model – featuring a single central market platform comprised of wholesale and ancillary service markets. AEMO organises and operate the central market to achieve a whole system optimisation which takes account of distribution network constraints. DER can participate in the central market via an aggregator and/or energy retailer

[113] AEMO, Open Energy Networks Project, at AEMO | Open Energy Networks Project

    - Two-Step Tiered Platform model – featuring a single central market platform and a number of local market platforms. DSOs organise and operate local market platforms to procure distribution network support and control ancillary services to sole distribution network constraints. AEMO operates the central market platform comprising the wholesale energy and select ancillary markets. DER participate in the central or local markets via and aggregator and/or energy retailer, with bids prequalified to take account of distribution network constraints

- An international review to identify system operators that have begun considering system architecture frameworks and defining the roles, responsibilities and control coordination for real-time operation of DER[114]
- A Smart Grid Architecture Model developed to represent possible models for DSO architecture[115]
- A CBA to determine the total net benefit of optimising DER for Australia by 2030. The key benefits were assumed to arise from minimising costs associated with electricity generation, transmission and distribution, given increasing levels of DER penetration in the electricity grid. [116] [117]

***Relevance to Project EDGE***

Project EDGE will further consider the Hybrid Model proposed by the Open Energy Networks Project.

For the purposes of the CBA, we will also be informed by and also seek to build upon the following key inputs:

- The CSIRO review of CBA frameworks and results of DER integration, which was a global review of cost-benefit analysis of distribution coordination and optimisation of DER
- Baringa Partner's CBA of open energy networks frameworks, which provided a high level quantitative assessment of the costs and benefits of the frameworks.

## AEMO's VPP Demonstration[118]

***Overview***

AEMO's VPP Demonstration was a collaboration between AEMO, AEMC, AER and members of the Distributed Energy Integration Program, with funding from ARENA.

The demonstrations were a first step in a broad program of work designed to inform changes to regulatory frameworks and operational processes to integration DER into the NEM.

The trial framework allowed VPPs to demonstrate their capability to deliver services in contingency FCAS (through a trial specification) and respond to energy market price signals. By trialling VPP operations while aggregated fleets remain of a small scale, the VPP Demonstration was able to provide information regarding the effective integration of VPPs into the NEM before they reach large scale.

Throughout this trial, AEMO observed the behaviour and capabilities of VPPs and developed a series of knowledge sharing reports.

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[114] Newport Consortium, Coordination of Distributed Energy Resources; International System Architecture Insights for Future Market Design (May 2018), at newport-intl-review-of-der-coordination-for-aemo-final-report.pdf
[115] EA Tech, Modelling the Modelling the DSO transition using the Smart Grid Architecture Model (July 2018), at Microsoft Word - Modelling-DSO-Transition-Using-SGAM_V02.1_19Jul2018 - Copy (energynetworks.org)
[116] CSIRO, Review of cost-benefit analysis frameworks and results for DER integration (April 2019), at Microsoft Word - CSIRO_CBAReviewReport_13-05-2019.docx (aemo.com.au)
[117] Baringa Partners, Assessment of Open Energy Networks Frameworks (May 2020), at Assessment of Open Energy Networks Frameworks (aemo.com.au)
[118] AEMO, VPP Demonstrations, at AEMO | Virtual Power Plant (VPP) Demonstrations

***Relevance to Project EDGE***

Project EDGE will draw upon the insights and learnings from the AEMO VPP Demonstration to further inform development and design.

## Western Australia's Distributed Energy Resources Orchestration Pilot (Project Symphony) [119]

***Overview***

Project Symphony is a pilot project in Western Australia to orchestrated DER as a VPP participate in an energy market, with the aim of unlocking greater economic and environmental benefits for customers and the wider community. It is a collaboration between Western Power as the DSO, Synergy, as the aggregator and AEMO as the WEM Market and System Operator, with funding from ARENA.

The overall objective of Project Symphony is that it will help better understand how DER can be integrated to provide a safe, reliable and efficient electricity system, where the full capabilities of DER can provide sustainable benefits and value to all customers.

Project Symphony will 'orchestrate' approximately 900 DERs such as rooftop solar, batteries and large appliances across 500 homes and businesses into a VPP. Located in one of Perth's most prevalent solar districts of Southern River, with almost 50 per cent of households having rooftop solar, it will aggregate and then dispatch electricity generated by the DER assets to the network in the same way as a traditional power plant.

To facilitate this DER integration, the project team will design, procure, develop, implement and test software based 'platforms' capable of registering, aggregating and orchestrating customer DER to provide both on-market and off-market services. All this will be via a simulated market, separate to the market operating in the WEM.

***Relevance to Project EDGE***

Engagement is occurring with Project Symphony to share insights and learnings across programs and further inform development and design.

## South Australia's Flexible Exports for Solar PV Trial[120]

***Overview***

To protect the network for all customers, DNSPs must set static export limits at each customer connection point. Some DNSPs have had to impose zero or near-zero export limits for new solar PV systems in constrained parts of the network.

The trial, funded by ARENA, developed an approach to integrating rooftop solar with the grid, using smart inverters, by aiming to produce a flexible connection option for solar PV systems, so customers don't have to limit electricity export to permanent zero or near-zero in congested areas.

Flexible exports will remove the potential need for permanent zero-export settings, increasing value to the c customer and increasing low-cost renewable energy available to the market.

***Relevance to Project EDGE***

Engagement is occurring with SA Power Networks to share insights and learnings across programs and further inform development and design.

[119] AEMO, Project Symphony, at AEMO | Project Symphony
[120] ARENA, Projects, at Projects - Australian Renewable Energy Agency (ARENA)

# Appendix D – Frequently Asked Questions (FAQs)

The table below addresses the most common questions from stakeholders on the CBA draft methodology during the consultation process.

Table D-1: Questions for consultation

| # | Theme | Question | Answer |
|---|---|---|---|
| **1** | Base Case | What does the assumed base case consumer look like for the purposes of the CBA? | Participating in a VPP with some combination of active DER (solar and batteries, stand-alone batteries, heat pump water heaters or EVs). It is assumed all consumers participating in the DER marketplace will have a smart meter. |
| **2** | Base Case | What is the base case? | The base case is captured by Scenario 1 and Scenario 6 (see Table 3-2).<br>• Scenario 1 represents a conceivable yet conservative outcome where future DER integration does not include a singular DER marketplace that provides the services requested by AEMO or DNSPs. It also represents a datum of rudimentary operating envelopes from which we can capture the changes in market expenditure as a result of increased sophistication in operating envelopes and trading arrangements.<br>• Scenario 6 has the same assumptions as Scenario 1, except load and DER penetration levels. The purpose of these scenario variations is to avoid inaccurate comparisons from using Scenario 1 as the base case for comparing Scenarios 7, 8, 9 and 10, that incorporate a higher load and DER uptake assumptions. |
| **3** | Base Case | Are tariff reforms being considered in the base case? | The DER uptake under each scenario is pre-determined and therefore does not explicitly model or reflect tariff reforms. |

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| **4** | Active DER | What are the assumptions being used for the amount of DER consumers that are assumed to actively participate (e.g. active DER)? | The two co-optimisation models (covering the proportion of active DER that participates in the DOEs and marketplace arrangements) that have been incorporated into different scenarios are:<br>• VPP Only: Only DER that is participating in a VPP would be participating in the DOEs and any DER marketplaces, meaning dynamic signals on the safe upper and lower bounds for both imports and exports are only sent to those DER, the behaviour of other DER will be uncertain. All other active DER (solar and batteries, stand-alone batteries, heat pump water heaters or EVs) and all passive DER (solar PV that does not have an associated battery storage system) as non-participating DER would not be subject to the dynamic envelope, and would therefore be able to export and import under static limits unless their inverter trips them off automatically to protect the distribution network from adverse outcomes or DNSPs remotely disconnect customer DER, which can occur in South Australia, Western Australia and is proposed in a recent Queensland rule change.<br>• 100%: All new DER connected to the distribution network would be participating in the DOEs and any DER marketplaces through enforcing or updating standards to ensure interconnectivity. Existing DER will gradually phase out, leading to 100% participation in DOEs. Before that occurs, non-participating DER would not be subject to the dynamic envelope, and would therefore be able to export to the grid under static limits unless their inverter trips them off automatically to protect the distribution network from adverse outcomes or DNSPs remotely disconnect customer DER. |
| **5** | Scope of CBA | Will the CBA take into account other jurisdictions? | Yes. The CBA will consider the whole-of-system (NEM region) impact. Specifically, the TEM will extrapolate AusNet topology data across the NEM. For impact on the transmission and distribution networks this will occur via:<br>• Estimating the average impact by asset category e.g., feeder type (e.g., CBD, urban, short rural and long rural), substation type (e.g., HV/STS zone substation categories), customer mix (accounting for DER penetration levels and also smart meter levels) and expanding by multiplying out based on counts of other DNSPs and unit price differentials (e.g., 11kV vs. 22kV)<br>In addition, the impact on the wholesale market will be expanded based on AEMO's 2022 ISP forecast new generator entry and exit, unit price relativities and fuel. |
| **6** | Scope of the CBA | Why was the Hybrid model used as the boundary for comparing alternative roles and responsibilities? | The Hybrid Model of the Open Energy Networks Project reflects what is understood to be a broadly agreed industry view based on previous industry consultation. |

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| **7** | Techno Economic Modelling (TEM) | What does the TEM output mean in relation to the costs and benefits quantification? Do the TEM outputs reflect the trial itself? | The TEM outputs (as detailed in Table 3-8) will be used as inputs into the broader CBA.<br><br>The field trial will be used to parameterise the modelling of DOE impacts by considering how they have worked in real application under a variety of conditions, as opposed to what the modelling forecasts under perfect information. For example, if on a given feeder, 200 kW of network capacity was predicted by the DOE algorithm to be available for the day ahead, but in reality, there was 220 kW available, the TEM would need to account for this forecasting error to be credible.<br><br>This data will be used to develop an estimate of forecasting error under a wide variety of conditions such as forecasting horizon and frequency, network type, time of day, DER penetration and will be applied to the DOE impact on the TEM. |
| **8** | Scenarios | Why use the ISP Step Change for the CBA's base case load and DER uptake scenario? | A wide range of informed industry stakeholders viewed the most likely scenario in the AEMO's ISP 2022 to be the relatively fast Step Change Scenario. The Step Change Scenario reflects a rapid consumer-led transformation of the energy sector and co-ordinated economy-wide action, involving a consistently fast-paced transition from fossil fuels to renewable energy resources in the NEM.<br><br>AEMO has noted that since then, momentum towards decarbonisation has accelerated, confirming the Step Change scenario as a solid foundation for planning NEM investment.[121] |
| **9** | Scenarios | Why are the Renew/ECA high DER scenario assumptions being used to underpin the High DER Scenario. | The Renew/ECA assumption are taken from Energeia's 2021 Renew DER Optimisation (Stage II) final report. The engagement received funding from ECA.<br><br>While the ISP also provided a scenario with higher DER adoption than the AEMO Step Change Scenario (i.e. Hydrogen Superpower) the Renew/ECA Consumer high DER assumptions were ultimately selected given greater alignment with the Project EDGE thesis. This was based on:<br><br>• Stakeholder endorsement: The Renew/ECA Consumer high DER assumptions were accepted by Renew, the ECA and other consumer advocates, retailers and DNSPs on the project consultation committee, as being representative of a credible consumer-focused scenario. Consumer-focus is more aligned with Project EDGE strategic project objectives than hydrogen market development.<br>• Commercial applicability: the Renew/ECA Consumer high DER assumptions will likely better showcase the pathway to a high DER future. As it is underpinned by commercial factors |

[121] AEMO, 2022 ISP (June 2022), page 7, at 2022-integrated-system-plan-isp.pdf (aemo.com.au)

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| | | | relating directly to DER uptake, it would enable a fuller understanding of the potential long-term implementation and policy pathways. Whereas the Hydrogen Superpower scenario (the only ISP scenario consistent with limiting global warming to 1.5°C while also largely replacing natural gas with hydrogen for domestic use and building a hydrogen export industry) is predicated on a substantial shift in energy demand by hydrogen electrolysers and material anticipated policy change, rather than commercial factors relating directly to DER. |
| **10** | Data Hub | How would the data hub approaches scale up? Is the Centralised data hub standardised and consistent across states? | The Centralised solution can scale by AEMO (or application service provider that built the hub) building applications that extend the solution. Under the Decentralised solution market participants can extend the solution (as aligned with the shared governance requirements). The drivers for scale will vary however DER penetration levels are expected to be key. |
| **11** | Other Projects | Have other similar projects been considered (e.g., Project Edith)? | Yes.<br><br>A key difference of Project Edith's investigation, relative to Project EDGE, is in its exploration of the use of dynamic network pricing to incentivise efficient use of available network capacity for energy market services. Project EDGE does not seek to test the use of dynamic network pricing to influence the use of available network capacity by aggregated DER, but rather tests how local network services (e.g., demand management and voltage management) and energy market services can be delivered by aggregated DER through a common data exchange hub.<br><br>Both Project Edith and Project EDGE calculate the Dynamic Operating Envelopes (DOE) in a distributed manner for each customer connection point for the provision of both energy market and local network services. In contrast to Project Edith though, Project EDGE tests multiple network capacity allocation methods (varying objective functions) within the DOEs to analyse what approach might best enable efficient DER access to the available network capacity. |

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