Deloitte.

ENERGEIA

Project EDGE

Cost Benefit Analysis (CBA)
Final Report - Webinar
19 October 2023

Deloitte
Access Economics

We acknowledge the Traditional Owners of country throughout Australia and recognise their continuing connection to land, waters and culture.

We pay respect to their Elders past, present and emerging.

General Use Restriction

The Project EDGE CBA is prepared for AEMO, AusNet and Mondo. It is not intended to and should not be relied upon by anyone else and we accept 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. You should not refer to or use our name or the advice for any other purpose.

Acknowledgements

Project EDGE received funding from the Australian Renewable Energy Agency (ARENA) as part of ARENA's Advancing Renewables Program. The views expressed herein are not necessarily the views of the Australian Government. The Australian Government does not accept responsibility for any information or advice contained within this document.

Role within Project EDGE

As part of Project EDGE, Deloitte Access Economics and Energeia conducted an independent cost benefit analysis (CBA) **to provide policy makers and industry leaders with an assessment of the costs and benefits associated with NEM-wide implementation of the demonstrated DER integration model.**

The CBA utilises where practical the most recent data and forecasts. Exploring a range of scenarios under which DER integration within the NEM could deliver the long-term interests of electricity consumers across a **20-year time horizon (FY23-FY42).**

CBA Publications within Project EDGE

- **CBA 'as-built' methodology** – detail on how the CBA was undertaken and the assumptions used
- **CBA Final Report Executive Summary** – summary of key takeaways
- **CBA Final Report** – detailed findings
- **CBA Webinar** – summary of key takeaways

The CBA is not intended to act as a business or investment case for individual market participants.

Further, the applicability of its findings is limited to an understanding of the NEM as of March 2023, and through the voluntary contributions of the Project EDGE participants (AEMO, AusNet and Mondo), DER Aggregators participating in Project EDGE, non-participating DER Aggregators and technology vendors.

Agenda

Project EDGE CBA Overview	15 mins
CBA Methodology	10 mins
CBA Findings	15 mins
Implementing the CBA Insights	10 mins
Conclusion and Questions	10 mins

This webinar is focused only on the CBA as opposed to other workstreams or activities (e.g. Project EDGE field trial) completed within Project EDGE.

This webinar will be recorded for the benefit of those who are unable to attend. The recording and presentation will be available on the AEMO website.

Project EDGE CBA Overview

Key CBA Findings

The CBA findings quantitively show that greater coordination of active DER in the NEM via the Project EDGE arrangement can result in incremental value to all consumers of up to $6.04b.

The Project EDGE arrangement was found to avoid 50.1TWh of customer rooftop solar curtailment to 2030 and up to 257.1TWh across the 20-year time horizon to 2042.

The CBA also found that greater DER export capacity and VPP uptake can lower electricity sector emissions in the NEM (up to $2.60b).

There is an immediate opportunity to further unlock the value of DER by:

- **removing consumer constraints** on solar exports for as many customers as possible so more consumers can benefit from VPPs coordinating DER
- **setting the rules** for efficient DER coordination with a clear set of roles and responsibilities for market participants
- **laying the foundations** for DER market-enablement with an efficient and scalable data exchange approach to reduce costs and expand consumer choice.

CBA Summary: Integration of DER into the NEM

Australia is a global leader in rooftop solar installation, while broader DER uptake is accelerating...

...however a number of barriers prevent the realisation of a large portion of DER value in the NEM.

The CBA found key drivers, to unlock the value from DER...

...which can provide $6.04b of benefits to all electricity consumers within the NEM.

- Static export limits
- Fragmented market frameworks
- Lack of standardisation
- Limited visibility of DER
- Social License

These barriers have the potential to impact all consumers by impeding the secure and reliable operation of the NEM as we move towards a higher DER future.

CBA drivers

- Customer coverage of DOEs
- The presence of a scalable data exchange hub
- LSE
- Visibility of DER

These drivers are critical to unlocking value from DER coordination via VPPs.

Outcomes

- Greater affordability
- Greater reliability
- Cleaner electricity

CBA Stakeholder Engagement

The development of the CBA involved extensive engagement with key stakeholders across the NEM. It was essential that the inputs and assumptions that underpin the CBA were refined in line with stakeholder views and reflected where possible the latest information available.

Broad industry stakeholder engagement via Project EDGE Industry Forums*

Deep stakeholder engagement via 1:1s

Market Institutions

AEMC

AUSTRALIAN ENERGY REGULATOR

ENERGY SECURITY BOARD

AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

Peak Bodies

Energy Networks Australia

ENERGY CONSUMERS AUSTRALIA

DNSPs

western power

AusNet

Ausgrid

SA Power Networks

DER Aggregators

mondo

agl

DISCOVER ENERGY

Rheem

Project EDGE Forums: https://aemo.com.au/initiatives/major-programs/nem-distributed-energy-resources-der-program/der-demonstrations/project-edge/project-edge-industry-forums

* DER Market Integration Consultative Forum, DER Demonstrations Industry Forum, Network Advisory Group and Consumer Advisory Group

CBA Methodology

CBA Scenarios

The CBA considered two scenario sets, the first of which reflects DER uptake assumptions based on AEMO ISP 2022 forecasts (Scenarios 1-5) and the second of which represents a more rapid rate of DER uptake (Scenarios 6-10)[1].

The scenarios[2] reflect a gradual increase in maturity against the base cases in terms of the selected configurations of DER participation.

		Scenario 1 Base case	Scenario 2 Simple DOE, Moderate Coverage	Scenario 3 Simple DOE, Moderate Coverage with Data Hub	Scenario 4 Advanced DOE, High Coverage	Scenario 5 Advanced DOE, High Coverage with Data Hub
Based on AEMO ISP Step Change forecast load and DER uptake assumptions						
Dynamic Operating Envelope (DOE) configurations	Constraint Optimisation Frequency	Annual	Daily	Daily	Intra-day	Intra-day
	DOE Customer Coverage	VPP only	VPP only	VPP only	100%	100%
	DOE Optimisation Methodology	Approximation	Approximation	Approximation	LV impedance model	LV impedance model
	DOE Objective Function	Nameplate	Maximise service	Maximise service	Maximise service	Maximise service
Market configurations	Scalable Data Exchange	Point-to-point data exchange approach	Point-to-point data exchange approach and LSE	Data Hub & LSE	Point-to-point data exchange approach and LSE	Data Hub & LSE
	Local Services Exchange (LSE)					

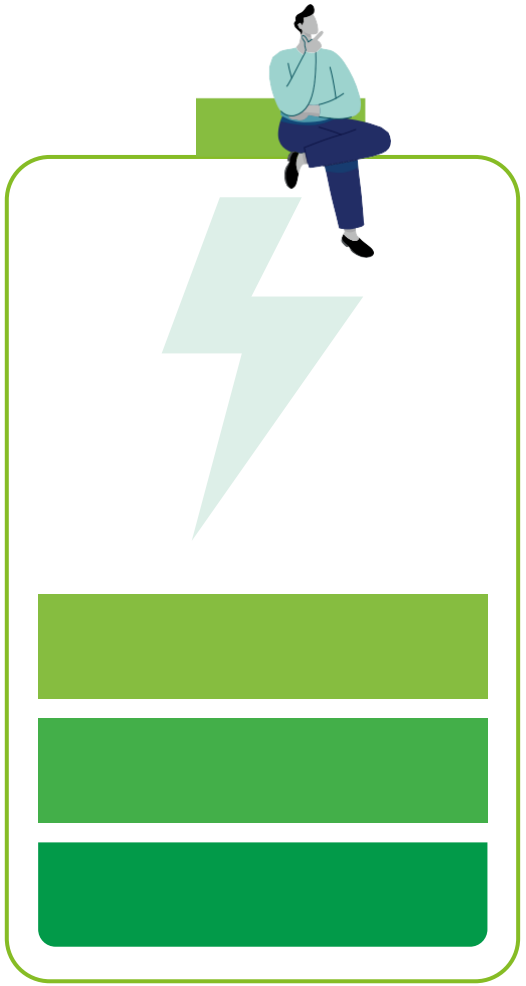
		Scenario 6 Base case	Scenario 7 Simple DOE, Moderate Coverage	Scenario 8 Simple DOE, Moderate Coverage with Data Hub	Scenario 9 Advanced DOE, High Coverage	Scenario 10 Advanced DOE, High Coverage with Data Hub
Based on High DER forecast load and DER uptake assumptions						
Dynamic Operating Envelope (DOE) configurations	Constraint Optimisation Frequency	Annual	Daily	Daily	Intra-day	Intra-day
	DOE Customer Coverage	VPP only	VPP only	VPP only	100%	100%
	DOE Optimisation Methodology	Approximation	Approximation	Approximation	LV impedance model	LV impedance model
	DOE Objective Function	Nameplate	Maximise service	Maximise service	Maximise service	Maximise service
Market configurations	Scalable Data Exchange	Point-to-point data exchange approach	Point-to-point data exchange approach and LSE	Data Hub & LSE	Point-to-point data exchange approach and LSE	Data Hub & LSE
	Local Services Exchange (LSE)					

Maturity of DOE and market configurations

[1]The load and DER uptake assumptions for Scenarios 1-5 are based on AEMO, 2022 ISP (June 2022). The load and DER uptake assumptions for Scenarios 6-10 are based on Energeia (2020), Renew DER Optimisation (Stage II): Final report.

[2]All scenarios assume 41% VPP participation as a % of storage by 2030 (8.9GWh for Scenarios 1-5 and 16.2GWh for Scenarios 6-10) and 52% VPP participation as a % of storage by 2042 (34.2GWh for Scenarios 1-5 and 58.2GWh for Scenarios 6-10). Under Scenarios 1-5 36,178 MWs of Solar PV and 21,785MWhs of Battery Storage is assumed in 2030 and 57,374 MWs of Solar PV and 64,111 MWhs of Battery Storage is assumed in 2042. Under Scenarios 6-10 47,428 MWs of Solar PV and 39,334MWhs of Battery Storage is assumed in 2030 and 103,860 MWs of Solar PV and 108,959 MWhs of Battery Storage is assumed in 2042.

The DOE and market configurations considered in the CBA



Dynamic Operating Envelope Configurations[3]

Constraint Optimisation Frequency

The frequency **(Annual, Daily or Intra-day)** of updating the constraint optimisation settings that govern the safe operating distribution network limits.

DOE Optimisation Methodology

Approximation option involves analytical approximation of the network capacity using mainly historical network and Advanced Metering Infrastructure (AMI) data.

LV impedance model option involves a load flow calculation using low voltage network impedance models, customer data and operational forecasts.

DOE Customer Coverage

VPP only means only DER that is participating in a VPP would be receiving DOEs.

100%[4] means all new DER connected to the distribution network is active and would be receiving DOEs.

Objective Function for Network Capacity Allocation

Nameplate involves allocating DER capacity in a way where the optimal outcome is a pro-rata split of distribution network capacity based on the nameplate rating of the DER.

Maxmise Service involves allocating DER capacity, 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 constraints.

Market Configurations

Scalable Data Exchange

Point-to-point

Data Hub

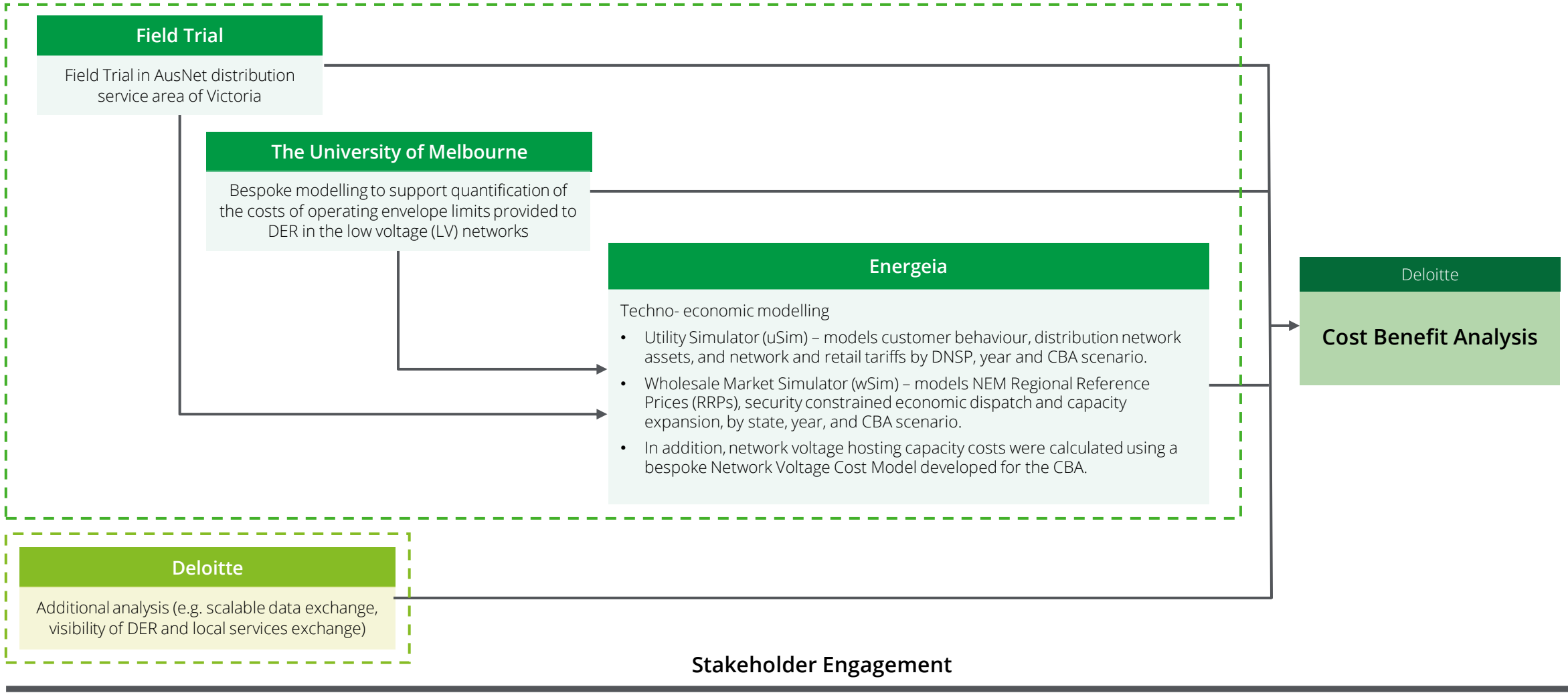
Local Services Exchange (LSE)

LSE is the interface to facilitate visible, scalable and competitive trade of DER-based network support services for local network constraint management. The data exchange for the LSE can be via point-to-point or a data hub.

[3]Currently, in most cases, operating envelopes are fixed at conservative levels regardless of the capacity of the network because they are static and need to account for 'worst case scenario' conditions. Dynamic rather than fixed export limits can enable higher levels of exports from DER by allowing higher export limits when there is more hosting capacity on the local network.

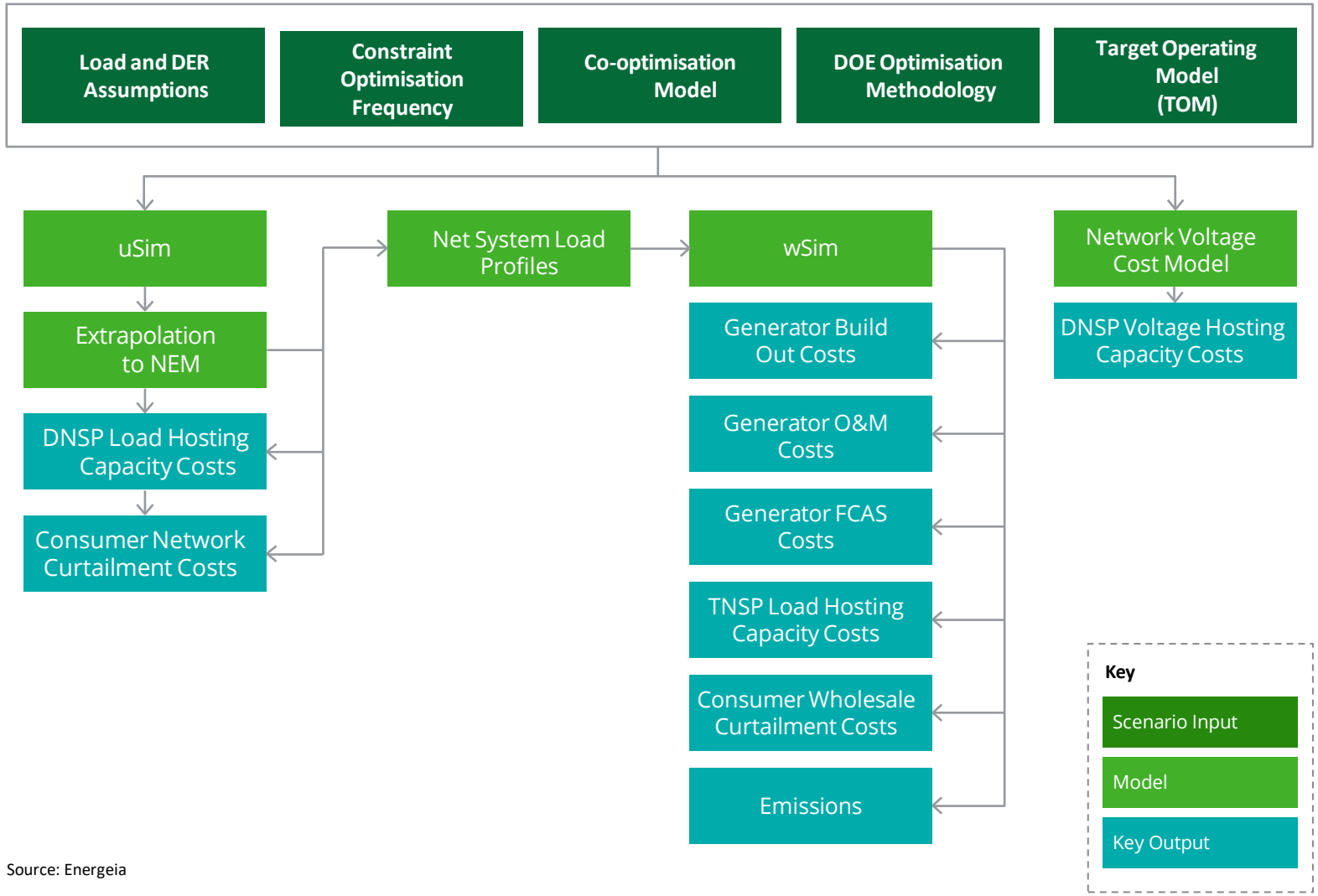
[4]100% DOE Customer Coverage is intended to represent a 'bookend'.

CBA workflow overview



Techno-economic modelling – Energeia

TEM output relationships



Source: Energeia

Techno-economic modelling was undertaken to enhance the granularity of CBA findings, specifically.

Distribution Impacts

- Agent-based modelling of AusNet network capex and opex
- Bespoke LV network model for customer curtailment and LV costs
- Results then extrapolated to NEM-wide outcomes.

Wholesale Impacts

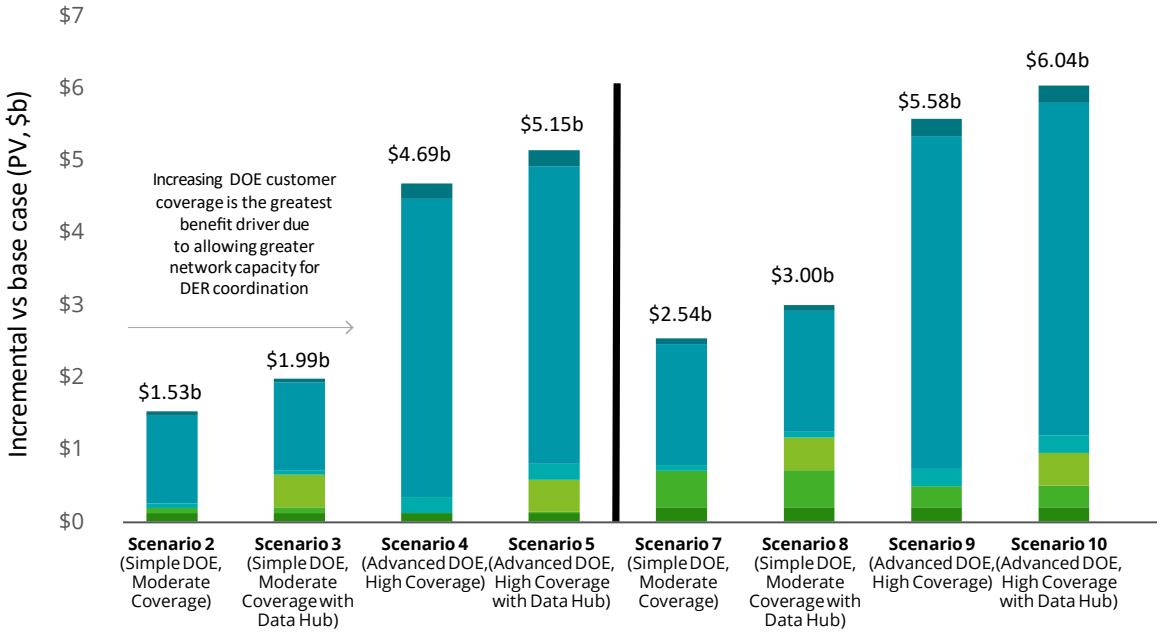
- Security Constrained Economic Dispatch modelling of opex
- Capacity expansion model of entry/exit and associated capex.

Data from the Project EDGE field trial was used when validating Energeia's TEM 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 (e.g., ensuring that an appropriate forecasting error was considered).

CBA Findings

All consumers stand to benefit from the accelerated and optimised integration of DER via Virtual Power Plants (VPPs) in the NEM

CBA findings – key enablers of value incremental to the base cases (20-year time horizon, $FY23, 4.83% discount rate)[5]



Key enablers of value across the CBA Scenarios

- DOE Constraint Optimisation Frequency (more total network capacity unlocked for DER coordination)
- DOE Customer Coverage (more total network capacity unlocked for DER coordination)
- DOE Objective Function (more network capacity allocated to DER)
- Data Hub (reduced costs and enables additional DER services)
- LSE (reduced DER curtailment)
- Visibility of DER (enhanced power system operations)

Note: Total power system cost in Scenario 1 is $192.7b and in Scenario 6 is $190.2b. This total cost is the cost that forms the basis of the incremental present value impact shown across the scenarios.

The findings show quantitatively that greater coordination of active DER in the NEM via the Project EDGE arrangement can result in incremental value to all consumers of up to $5.15b under the AEMO ISP Step Change DER uptake assumptions and up to $6.04b under the High DER uptake assumptions.

Based on the capabilities tested within the CBA scenarios, the value of coordinated DER is enabled by:

- **DOE configurations** that enable high customer coverage and target maximum utilisation of the distribution network by DER and VPPs
- **Data hub** approach to a scalable DER data exchange that reduces integration costs for participants and allows access to a greater scope of service opportunities for DER Aggregators serving customers
- **LSE** providing a scalable and standardised arrangement for DNSPs to procure network support services from DER Aggregators, who co-optimise network support services and wholesale services within their DER portfolio
- **Visibility of DER** for the Market Operator and DNSPs to improve their awareness of where DER are installed on the network and how they behave to enhance situational awareness, operational forecasting, and network planning functions. Ultimately, reducing costs via enabling more accurate (and less conservative) operations across the network.

Active DER participation in VPPs is critical to realise the value associated with the capabilities assessed within the CBA scenarios. This will enable DER to make a coordinated response at scale to market prices and system security events.

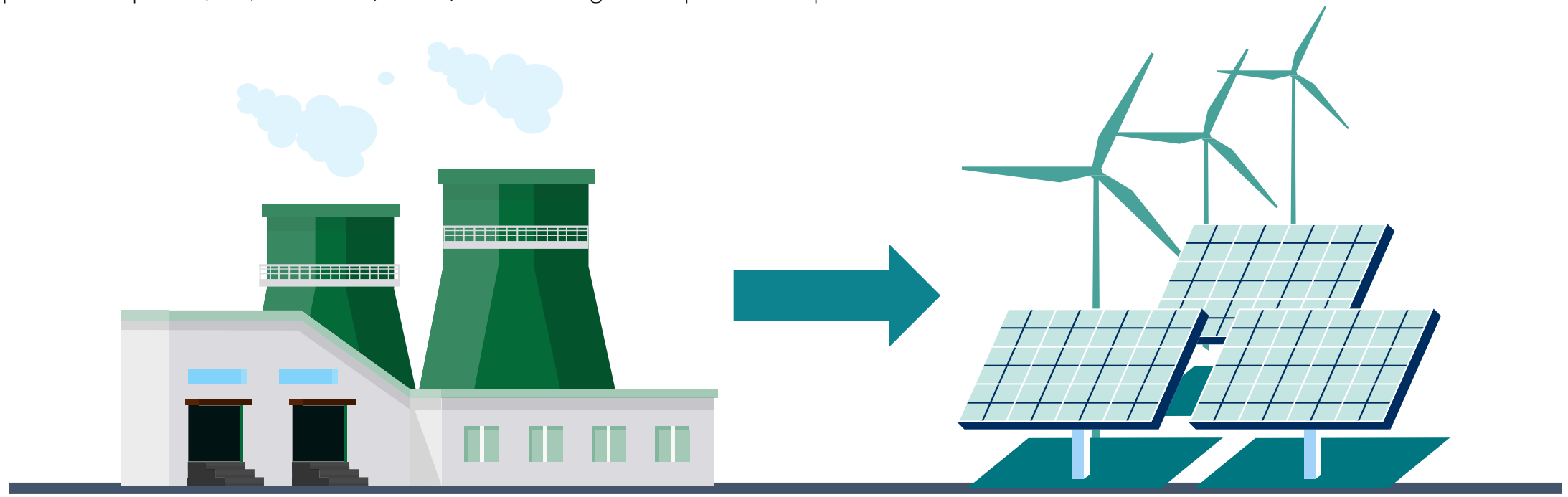
[5]Scenarios 2-5 are compared to Scenario 1, while Scenarios 7-10 are compared to Scenario 6.

The CBA configurations highlight opportunity for lower electricity sector emissions in the NEM

Emissions reduction is driven by DER displacing fossil fuel generators. This is enabled primarily by greater DOE customer coverage that allows for more network capacity to be unlocked and utilised by DER and VPPs.

A social cost of carbon was applied to value the avoided emissions (tCO2e). In FY23 (CBA base year) the assumed social cost of carbon[6] is ~$101 (per tCO2e) and in FY42 the assumed social cost of carbon is ~$147 (per tCO2e).

The CBA found that across the 20-year time horizon total emissions avoided can be up to 18,859,157 tCO2e ($1.54b) under the AEMO ISP Step Change DER uptake assumptions and up to 32,871,522 tCO2e ($2.60b) under the High DER uptake assumptions.



[6]Environmental Protection Agency (2017), *The Social Cost of Carbon.*

Scalable DER data exchange and local services can unlock value for DER Customers

Data Exchange Hub

A data hub approach to scalable DER data exchange would reduce costs and facilitate additional DER service opportunities more effectively compared with a point-to-point approach

- A centralised data hub could reduce costs by up to $0.44b and a decentralised data hub could reduce costs by up to $0.45b
- A data hub could deliver further upside through facilitating new DER-based service innovations more easily and at lower cost as it simplifies integration, identity verification and reporting between participants.

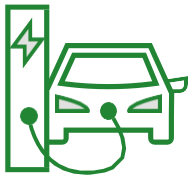
LSE

A Local Services Exchange (LSE) can provide cost-effective alternatives for DNSPs seeking network support services

- The implementation of an LSE (with data exchange between participants facilitated via a data exchange hub) can result in an incremental benefit of up to $0.08b under the AEMO ISP Step Change assumptions and up to $0.51b under the High DER uptake assumptions based only on the use of an LSE to reduce DER export curtailment.
- The CBA found that the costs to implement an LSE via a data hub arrangement, as compared to the alternative point-to-point arrangement, would be $9m lower. This is due to the reduced number of integrations required, as each participant would integrate with the data hub once.
- The value of network support services is directly linked to its ability to relive network constraints, which are locational and temporal. The CBA has adopted a conservative approach to valuing the benefits of an LSE, based only on its use to reduce DER export curtailment.

Additional emerging customer benefits

The CBA provides a **conservative estimate** of the benefits as there are several additional qualitative benefits linked to the capabilities tested in the CBA (e.g. expanding customer coverage of DOEs and a scalable DER data exchange) not accounted for in the CBA due to limitations in data availability. These include:



Vehicle to Grid (V2G) coordination – given the increasing uptake of electric vehicles (EVs) in Australia, V2G (EV charging and discharging into the grid) is expected to increase the opportunity and value associated with coordinated DER participating in a VPP (due to more DER capacity to coordinate).

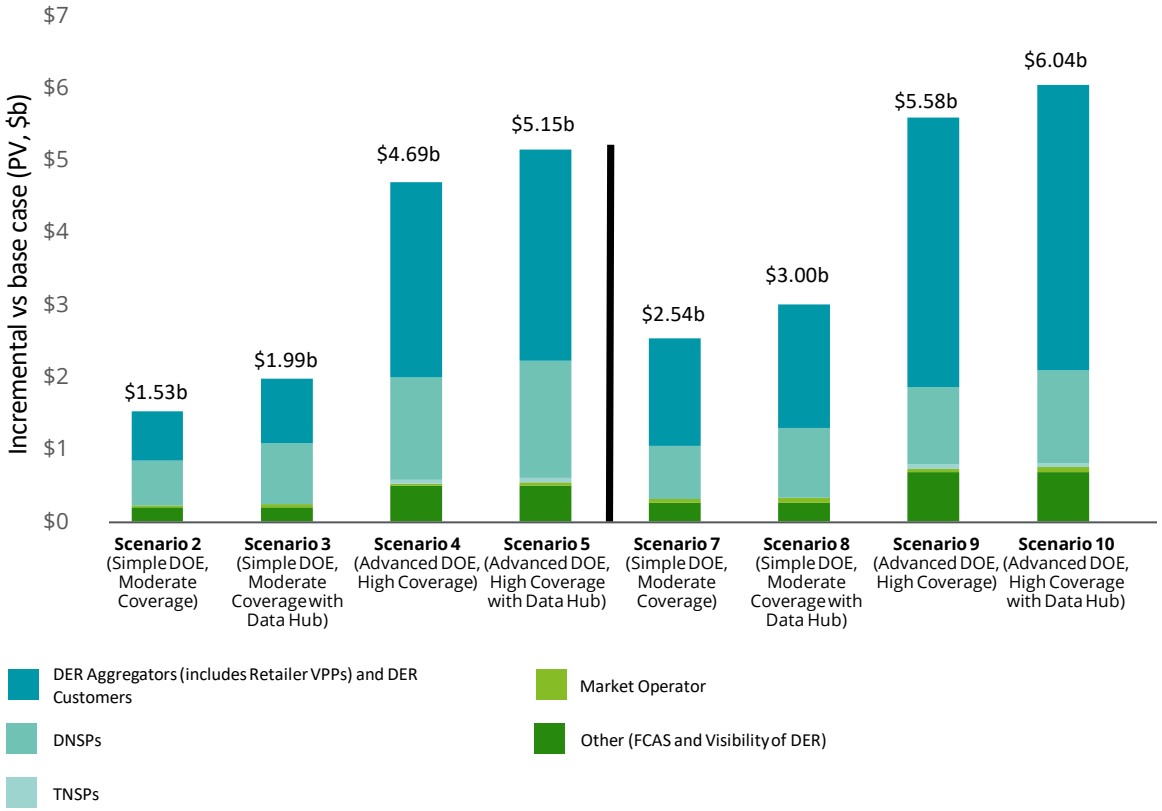
Compounding effect of market configurations on DER uptake – the effective integration of DER into the NEM via market configurations (e.g., scalable DER data exchange and LSE) that enable cost reductions or access to a greater scope of service opportunities for DER Aggregators could result in direct or indirect incentives to install more DER and increase VPP uptake.

Additional DER services – effective market configurations have the potential to facilitate further value from DER as industry maturity and needs evolve by enabling new DER-based service innovations to be more easily adopted. For example, a data hub could support additional transactions as the industry evolves and innovates such as Retailers requesting DER Aggregators to manage DER exports and hedge their exposure during periods of negative prices.

Coordinated DER provides value across market participants

In practice it is expected that much of this value would ultimately flow through to electricity customers in the NEM.

CBA findings across market participants (20-year time horizon, $FY23, 4.83% Discount rate)[7],[8]



The CBA findings across market participants show:

- Increased opportunities for **DER Aggregators** and, as a consequence, DER Customers, due to:
  - a reduction in DER export curtailment,
  - partial displacement of large generators enabled via wholesale integration of active DER,
  - the provision of contingency Frequency Control Ancillary Services (FCAS) and local network support services
  - reduced data exchange costs
- Lower **DNSP** costs in maintaining and increasing the capacity of the distribution network and reduced data exchange costs
- Lower **TNSP** costs in maintaining and increasing the capacity of the transmission network
- Lower **Market Operator** costs through reduced data exchange costs and enhanced management of power system security issues due to greater visibility of active DER.

[7]This assumes that DER Aggregators capture all the value of displacing large generators enabled by more advanced DOEs and greater active participation of DER in VPPs and all value associated with the delivery of local network support services. In reality, DER Aggregators would likely capture a significant portion but not all of this value.

[8]'Other' relates to broader 'whole of system' impacts as compared to a specific market participant.

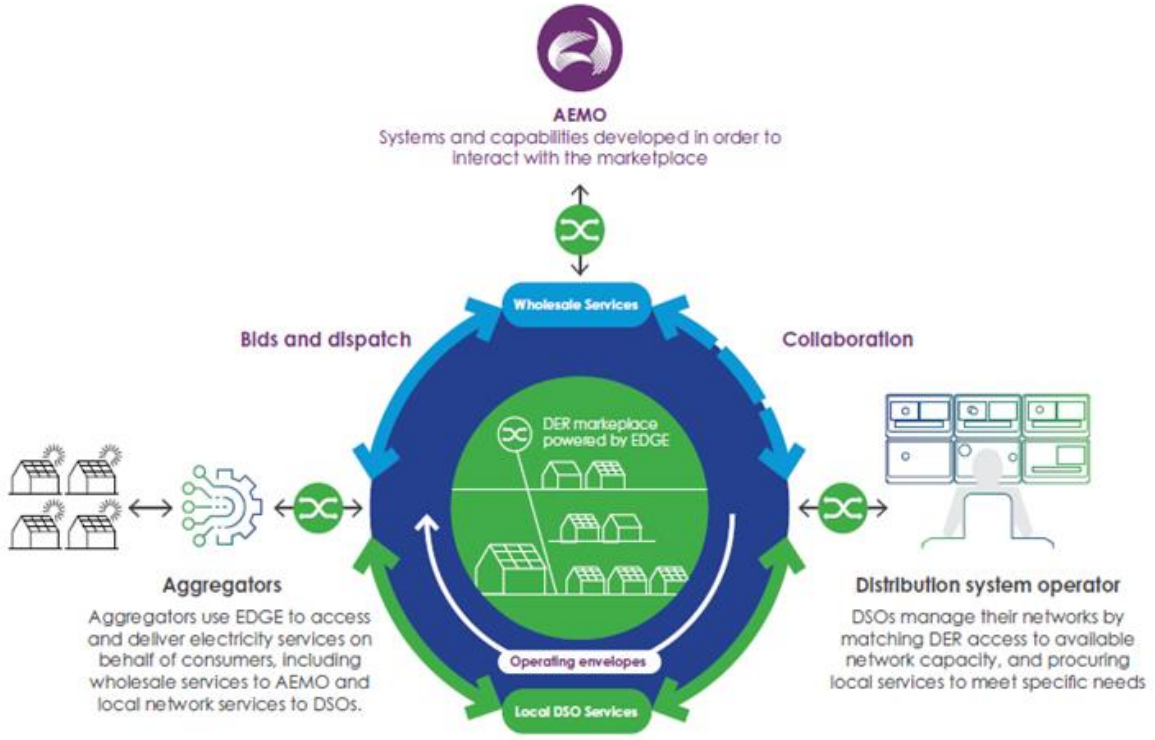
Set clear roles and responsibilities where DER Aggregators optimise DER on customers' behalf

The Project EDGE arrangement of roles and responsibilities (based on the Hybrid Model[9] for integrating DER) underpins the realisation of value identified in the CBA

The key feature of the Project EDGE arrangement of roles and responsibilities involves DER Aggregators, on behalf of DER customers, receiving the necessary external signals (such as prices and constraints) and co-optimising DER portfolios across wholesale and business-to-business (B2B) opportunities (e.g., network support services). This allows:

- Prioritisation of the interests of DER customers in how their DER is utilised – this is particularly important in a voluntary, market-based arrangement where customers who have invested in DER need to perceive clear value in participating in the NEM through a DER Aggregator
- Streamlined visibility with all service capacity (for market and B2B services) of a portfolio represented in a common portfolio level bid to the Market Operator
- Opportunities for value-stacking which can allow for greater value customer products and cost efficiencies to be realised by DER Aggregators
- An appropriate allocation of risks and incentives as DER Aggregators are responsible for optimising DER resources while acting in compliance with market rules and connection agreements.

Summary of Project EDGE roles and responsibilities



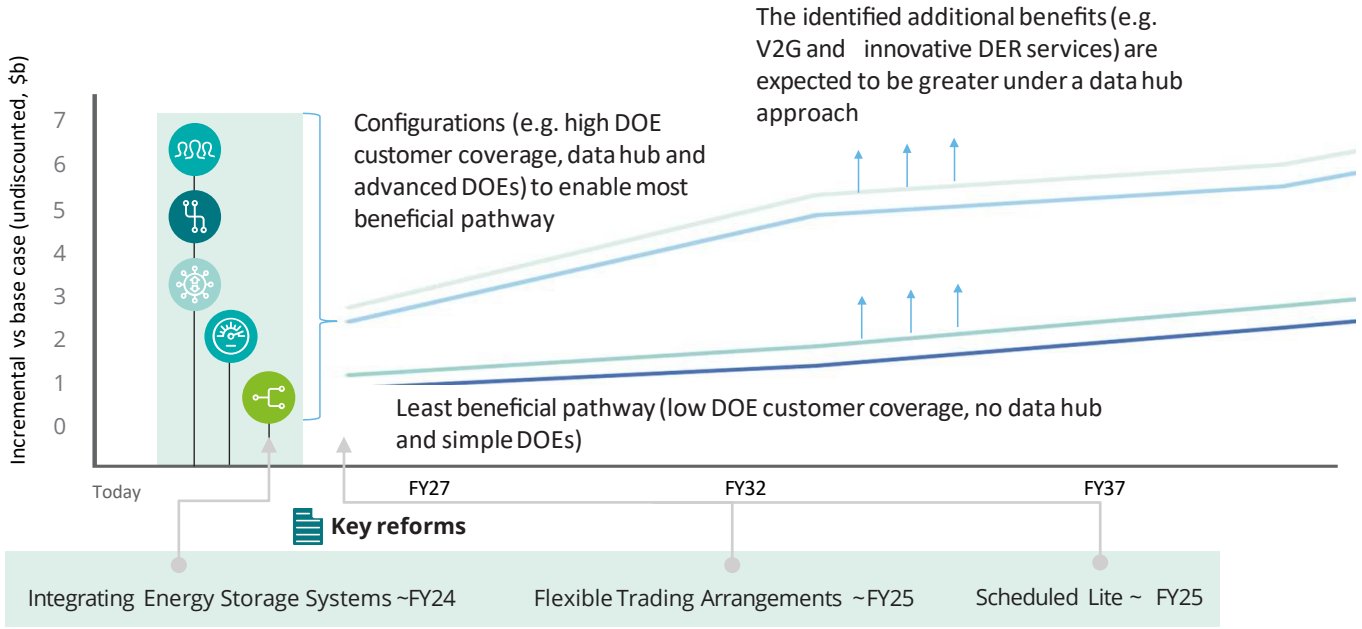
Source: Project EDGE participants (AEMO, AusNet and Mondo).

[9]AEMO and Energy Networks Australia (2019), at http://www.energynetworks.com.au/assets/uploads/open_energy_networks_-_required_capabilities_and_recommended_actions_report_22_july_2019.pdf

Implementing the CBA Insights

A Roadmap for Implementation – the DER Optimal Investment Pathway

The CBA found that the broad deployment of DOEs for many DER Customers and the establishment of a scalable data exchange hub are short-term priorities necessary for the longer-term delivery of value from DER.



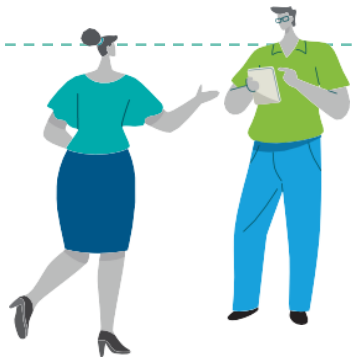
DNSP Regulatory Resets

FY25-FY30 FY26-FY31 FY27-FY32

Regulatory submissions are submitted by DNSPs ~18 months in advance of the upcoming Regulatory Reset Period and therefore proposed expenditure decisions will need to be outlined at this time.

The time for action is now

CBA Functions	Lead Times
DOE Customer Coverage	1-3 years
Visibility of DER	1-5 years
Scalable data hub	1-2 years
DOE Optimisation Methodology and Constraint Frequency[10]	2-5 years
Local Services Exchange	Staged according to network constraints



- **Scenario 2**[11] (Simple DOE, Moderate Coverage)
- **Scenario 3** (Simple DOE, Moderate Coverage with Data Hub)
- **Scenario 4** (Advanced DOE, High Coverage)
- **Scenario 5** (Advanced DOE, High Coverage with Data Hub)

[10] LV impedance model optimisation methodology and a maxmise service DOE objective function

[11] Scenarios 6-10 using High DER uptake assumptions follow the same trend whereby the base case (Scenario 6) has the lowest cumulative benefit from the initial year.

Insights across capabilities tested in the CBA

Acknowledging cross industry reform efforts to date, unlocking value from DER coordination via VPP participation requires coordinated action. The CBA identified immediate foundational priorities to progress towards this outcome.

	Immediate foundational priorities	Insight	Implication
	**DOEs – customer coverage**	DOE customer coverage is the key driver for delivering benefits by unlocking network capacity so that more DER can be coordinated via VPPs.	**The enablement of flexible export limits** must be prioritised To promote DOE customer coverage, further work is required to inform consumers of the benefits of DER integration and to build social licence with consumers.
	**Visibility of DER**	The Market Operator and DNSPs having sufficient visibility of DER is critical to ongoing secure and reliable electricity supply.	The Market Operator should be focused on **building capabilities to know how and in what volumes DER generation/load will respond to prices and the impact this will have on the market and the ability to forecast effectively.** DNSPs should be focused on **investment to uplift monitoring and management of their LV networks and connected DER.** This will require DNSPs to invest in monitoring systems and digital platforms to increase visibility and control.
	**Scalable Data Hub**	A data hub approach to scalable DER data exchange will reduce costs and allow new DER-based service innovations to be more easily adopted compared to a point-to-point approach.	**Implementation of a scalable data hub** that provides standardised data services such as DER registration, identity verification and reporting should be prioritised.

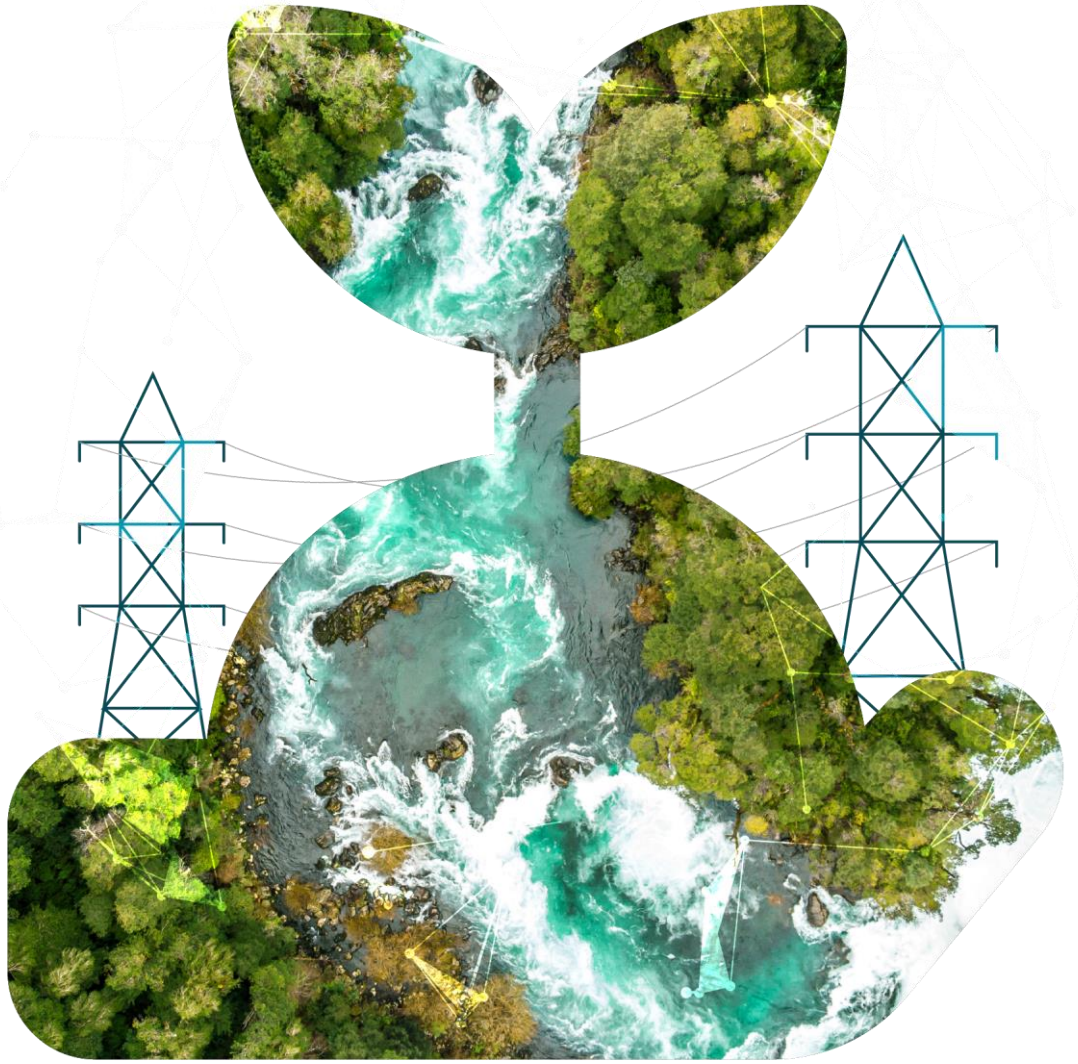
The Project EDGE arrangement of roles and responsibilities underpins the realisation of benefits associated with the capabilities tested in the CBA.

Insights across capabilities tested in the CBA

The CBA identified the following as secondary priorities to be introduced more gradually.

	Secondary priorities	Insight	Implication
	DOEs – optimisation methodology and constraint optimisation frequency	There is merit in gradually introducing more advanced DOE configurations (e.g., LV impedance model optimisation methodology and a maximise service DOE objective function).	**DNSPs will need to target implementation of DOEs that are optimised** for a given network segment and DER penetration level.
	LSE	The value of a local service is realised in the presence of network constraints which are locational and temporal.	A **targeted approach should be taken to implementing an LSE** based on network needs.

Conclusion



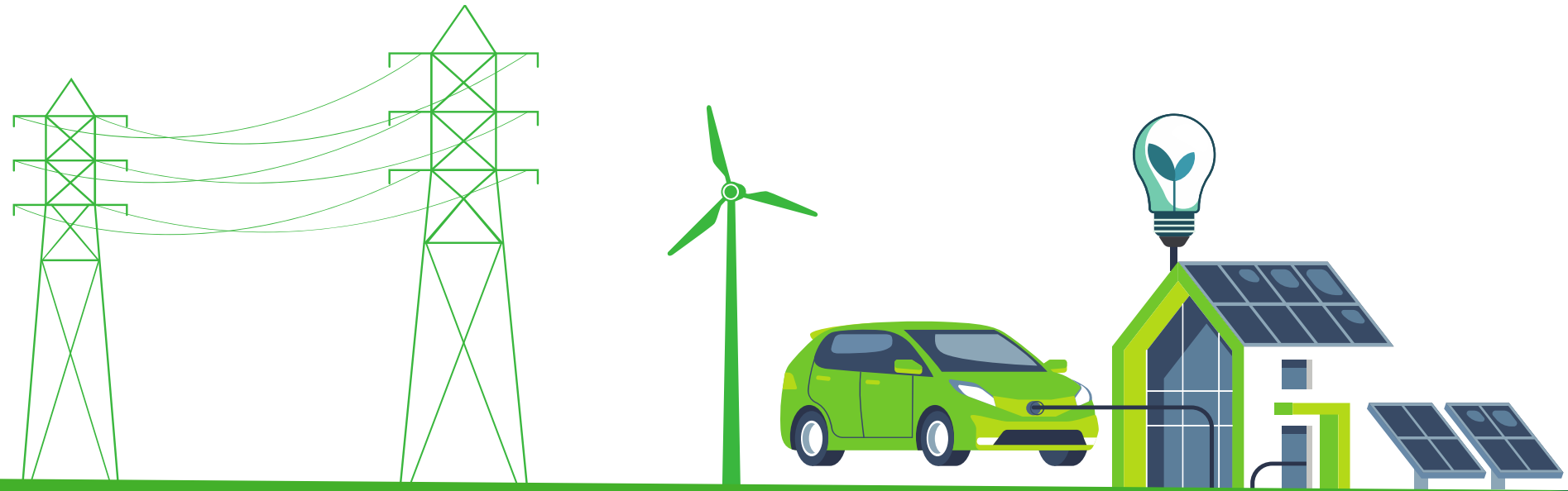
Conclusion

Building on the immediate foundational priorities for unlocking the benefits of DER, this CBA found that a coordinated market-based approach to DER integration within the NEM whereby DER Aggregators and Retailers represent DER Customer needs is economically feasible and can deliver value to all electricity consumers.

There is an immediate opportunity to unlock the benefits of DER by:

- **removing consumer constraints** on solar exports for as many customers as possible so more consumers can benefit from VPPs coordinating DER
- **setting the rules** for efficient DER coordination with a clear set of roles and responsibilities for market participants
- **laying the foundations** for DER market-enablement with an efficient and scalable data exchange approach to reduce costs and expand consumer choice.

Timely action in implementing the capabilities identified in this CBA will help realise considerable consumer value, drive emissions reduction and help secure, reliable operation of the NEM as we move towards a higher DER future.



Further Information - CBA Publications with Project EDGE

CBA 'as-built' Methodology

Detail on how the CBA was undertaken and the assumptions used

CBA Final Report Executive Summary

Summary of key takeaways

CBA Final Report

Detailed findings

Questions

Deloitte.

Designed by CoRe Creative Services RITM1539347