Project Edith

Project Overview Report

Unlocking more value for and from distributed energy resources by evolving the services that distribution networks offer

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Authors & acknowledgements

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ABOUT THIS REPORT

Project Edith is a demonstration project currently taking place in New South Wales, Australia. It is led by electricity distributor Ausgrid and technology provider and aggregator Reposit Power, in collaboration with the Australian National University and energy software developer Zeppelin Bend.

Stage 1 of the project is expected to run until early 2023 and aims to demonstrate a fully functioning, end-to-end, dynamic approach to the decentralised allocation of distribution network capacity.

This report provides an overview of what Project Edith is, the concepts it is testing and the value this new approach could create for and from distributed energy resources. The findings of Project Edith are intended to inform the evolution of the energy system in Australia.

PREPARED ON BEHALF OF

Ausgrid | reposit

And the Project Edith partners.

Contents

Glossary

Aggregator | An aggregator is a company that operates a VPP, coordinating customers' resources to provide services to the electricity system.

Market equilibrium price | A price that results in a balanced supply and demand of electricity, for a given time and location.

Connection point | The agreed point of electricity supply established between a customer and distribution network.

DER | Distributed energy resources. Energy resources connected to the distribution network such as generation, storage, flexible load and/or management hardware and software. Common examples include rooftop solar, home batteries, electric vehicles and controllable hot water systems.

DNSP | Distribution network service provider. DNSPs operate and maintain the distribution network, including infrastructure such as power poles, wires, transformers and substations. They are responsible for the transportation of electricity.

DOE | Dynamic operating envelope. DOEs are flexible upper and lower limits placed on customers' electricity loads and generation – specifically the share that is taken from or injected to the electricity grid. These vary over time and location, based on the hosting capacity of the distribution network.

DSO | Distribution system operator. A DSO is an uplift in the capabilities of the DNSP to provide a dynamic network service that supports more value for and from DER.

Dynamic network pricing | Network tariffs that change in response to real-time conditions. Dynamic prices can reflect the long-run cost of providing electricity in those conditions or the market equilibrium price for the available network capacity.

Network tariffs | The transport component of a customer's electricity bill, which covers the cost of transmitting and distributing electricity between generators and customers. The other components of a customer's bill are competitive generation and retail components. Retailers are not required to pass network tariffs on to end-use customers and can choose to package these up into simple retail tariff offerings.

Peak load or peak demand | Terms that are used interchangeably to denote the maximum power requirement of a system at a given time; or the amount of power required to supply customers at times when need is greatest. They can refer either to the load at a given moment or averaged over a given period.

VPP | Virtual power plant. VPPs are a network of distributed resources that are coordinated to deliver power system and energy market services.

1

How are price-responsive distributed energy resources (DER) changing the current paradigm?

Australia's energy system is becoming increasingly decentralised, as we change how we generate, consume and share electricity. These changes are in part driven by the scale and pace at which customers are investing in distributed energy resources (DER), such as rooftop solar, home batteries and electric vehicles.

In parallel to this rapid uptake, DER are becoming increasingly sophisticated, which gives households and businesses the opportunity to actively manage their energy consumption and bills. The software embedded in DER now often features a range of 'smart' capabilities and functions, including the ability to receive and respond to external signals such as prices – known as 'price-responsive' DER. With these new capabilities, new possibilities for DER to participate in commercial constructs, such as energy markets, are emerging and presenting new opportunities for customers, distribution network operators and the energy system.

When it comes to DER uptake, there are two overarching questions currently facing the system:

1. How can we **maximise the opportunities and value** for and from DER?
2. How can we integrate **more DER?**

Maximising the opportunities for and from DER will require changes to the existing market design. Australia's Energy Security Board, the ESB, is overseeing this transition through its post-2025 electricity market design reforms.

1.1

Towards an increasingly two-sided market

Parts of the reforms proposed by the ESB seek to unlock the full potential of distributed energy, through arrangements that reward customers with flexible demand for responding to market conditions [1].

The ESB proposes an increasingly two-sided market to manage network capacity to incorporate rising DER uptake, and to share value with customers. Two-sided markets commonly refer to a construct where buyers and sellers meet to exchange a product or service – in this case, energy. In the context of the ESB's reforms, a two-sided market could support an efficient balance of electricity supply and demand whilst enabling all consumers to realise the value of their DER and demand flexibility [2]. In addition to this, more efficient use of the network by DER can also reduce electricity prices for all customers.

A program of work to implement the DER focused reforms is being delivered through the ESB's DER Implementation Plan and informed by the broader energy industry. This includes demonstrations already underway, such as Project Edith in New South Wales, Project Symphony in Western Australia, and Project EDGE in Victoria.

1.2

Aggregating price-responsive DER as virtual power plants (VPPs)

New business models and services are emerging to facilitate value from customers' price-responsive DER. One example is a virtual power plant, or VPP – a network of resources, coordinated by an aggregator to deliver power system and energy market services as shown in **Figure 1.** Aggregators orchestrate the behaviour of multiple customers' DER to better harness the generated and stored energy and demand response. To maximise the value obtained from DER, aggregators will stack several value streams. This includes participating in the wholesale markets for energy arbitrage and frequency control ancillary services (FCAS),[1] and providing network support [3].

1 Ancillary services are used to manage the security and stability of the electricity system. System frequency is managed through FCAS.

A simple VPP customer offering

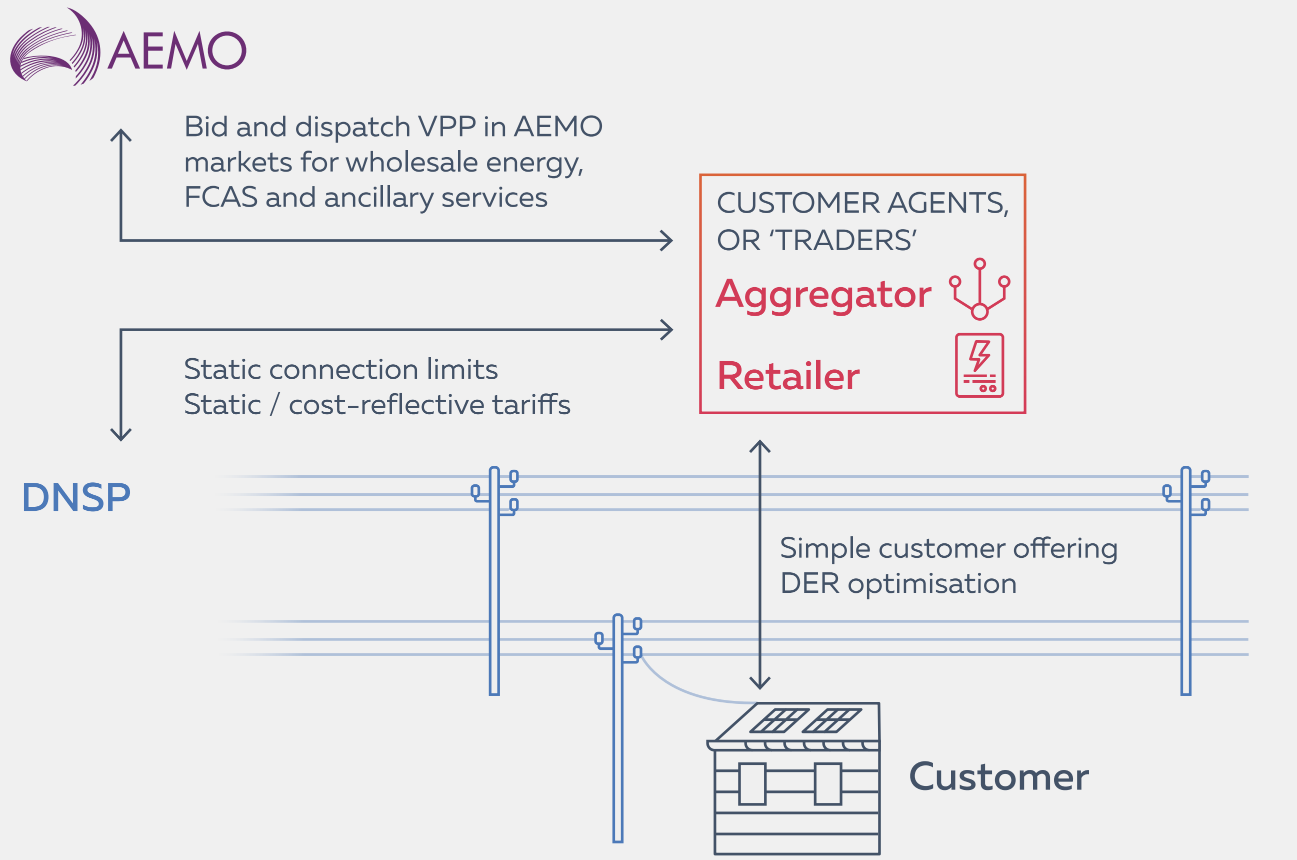
Customers who choose to enrol in a VPP will typically have an ongoing relationship with their aggregator. These relationships can vary in complexity, depending on the aggregator's product offering and business model.

Reposit is a technology provider and aggregator that offers a 'No Bill' product – residential customers purchase a solar and battery system in return for a guarantee of no electricity bills for five years.

Under this arrangement, the customer is abstracted from all complexity and benefits from renewable power generation. Reposit in turn incurs the cost of the customer's bill and is exposed to market risks. However, Reposit also retains the net financial gains from DER aggregation and optimisation.

Figure 1

The emergence of more sophisticated 'customer agents'



1.3

A need for evolving approaches to network management

Distribution network service providers (DNSPs) are evolving to optimise the use of local resources and flexibility on their networks. To do this, DNSPs need to develop new knowledge and capabilities, and trial new approaches to network management. This includes how they procure demand-side services from customer DER, such as voltage support.

More DER on the network means more customers are now generating their own power – typically through rooftop solar – and exporting the surplus back to the electricity grid. This is coming up against network capacity[2] constraints. Most rooftop solar generation feeds back into the grid from late morning to early afternoon. However, demand does not follow the same pattern and rather rapidly increases in the late afternoon.

CURRENT NETWORK PRICING

Networks currently offer a range of tariffs[3], including static, seasonal, and controlled-load tariffs. Network tariffs today typically vary by time and aim to incentivise certain customer behaviours. Examples include:

- Time-of-Use tariffs, which include different prices for electricity use during three different time periods – peak, shoulder, and off-peak. Prices are cheaper in off-peak and shoulder periods, incentivising customers to shift their load away from peak periods [4], and
- Demand tariffs, which are charged on each customer's peak use of the electricity network. For residential customers, this is based on the level of household demand on the network during a specified peak time window. Demand pricing incentivises customers to consistently lower their demand during peak times [5].

Whilst a distribution network will naturally have differences across the total area it covers – for example, due to the weather and customer characteristics – network prices today are averaged across regions. This is known as 'postage stamp pricing'. This means that customers are charged an average price, regardless of their location and real-time conditions.

CURRENT APPROACH TO MANAGING CUSTOMER GENERATION

Customer electricity generation is typically managed by placing a limit on the size of the system, for example rooftop solar or a battery, that a customer can connect to the network at the time of connection. Thus far in Australia, these limits have largely been static, set at 5 or 10 kilowatts per residential customer connection. This aims to manage the available capacity during minimum and maximum demand conditions, which normally only occur between 1 to 5 per cent of the year. Most of the time, DER are therefore unnecessarily constrained in size or in the amount of electricity customers can export to the grid [6].

The changing patterns to load and generation can lead to network congestion in some places at some times. Because of the differences in DER uptake, network congestion and stability can vary across different times and locations. While the current system allows DNSPs to operate distribution networks safely, it does not maximise the value for and from price-responsive and flexible DER. In particular:

- current network tariffs may inefficiently inhibit the use of price-responsive DER because they do not always reflect network constraints, and
- network limits may be too restrictive during normal operation and do not consider the value that flexible loads could offer to the network or the system as a whole.

2 Network capacity refers to the maximum electricity generation, or supply, and demand that can be supported without exceeding the physical limits of the distribution network.
3 The pricing signals embedded in network tariffs do not have to be passed on to customers, through the retail tariffs that customers are charged by their electricity retailers. Network tariffs are paid by retailers and retailers may charge customers using a different structure if they wish.

2

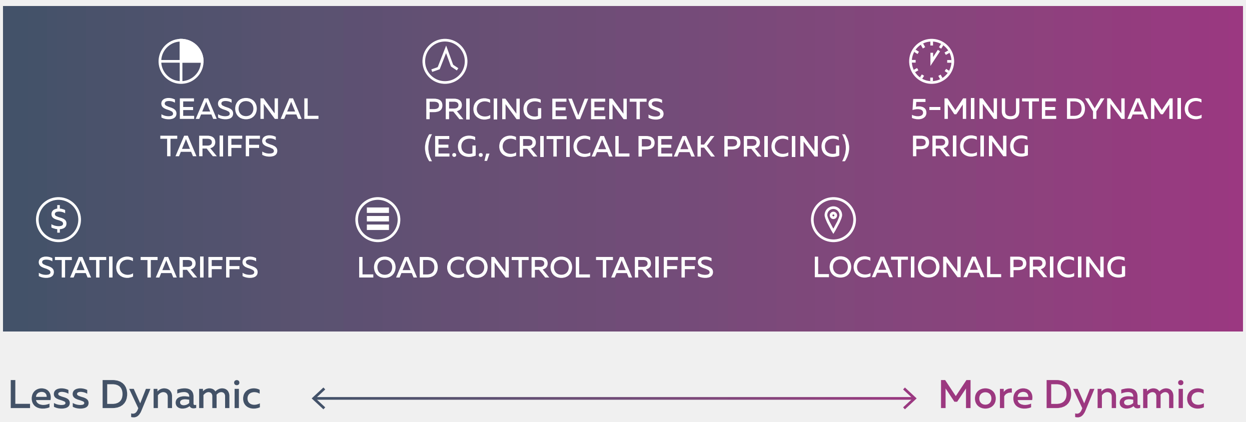
How to unlock more value for and from DER?

DNSPs are now exploring ways of developing time and location-specific, rather than network-wide, incentives, to make unused network capacity available to DER while managing local constraints. Two key approaches being explored are:

- dynamic, real-time network pricing, and
- dynamic operating envelopes – or DOEs.

Figure 2

Network tariffs, from less dynamic to more dynamic



2.1

Dynamic network pricing

Current network prices tend not to adequately reflect what is happening 'on the ground' (as shown in **Figure 3**), in that the tariff structures are set in advance and changed infrequently (for example, every few years). These tariffs typically fall on the less dynamic end of the spectrum shown in **Figure 2.** Dynamic prices instead change in response to the actual cost to serve customers[4], based on real or near-real-time conditions.

4 Network tariffs are set based on the long-term costs to serve customers. This is known as long-run marginal cost pricing and is a requirement of the National Electricity Rules – the NER.

By using time and location-specific incentives, two-way dynamic prices seek to make unused network capacity available to DER as well as reward behaviours that support the local network. Factors that can be considered when calculating dynamic prices include:

- typical demand and generation for each customer,
- weather,
- DER penetration in each area, and
- local area network characteristics.

Using this information, dynamic prices are then calculated and refreshed at a set interval, such as once a day. Dynamic pricing components for both imports (load) and exports (generation) are published for each defined sub-section of a distribution network.

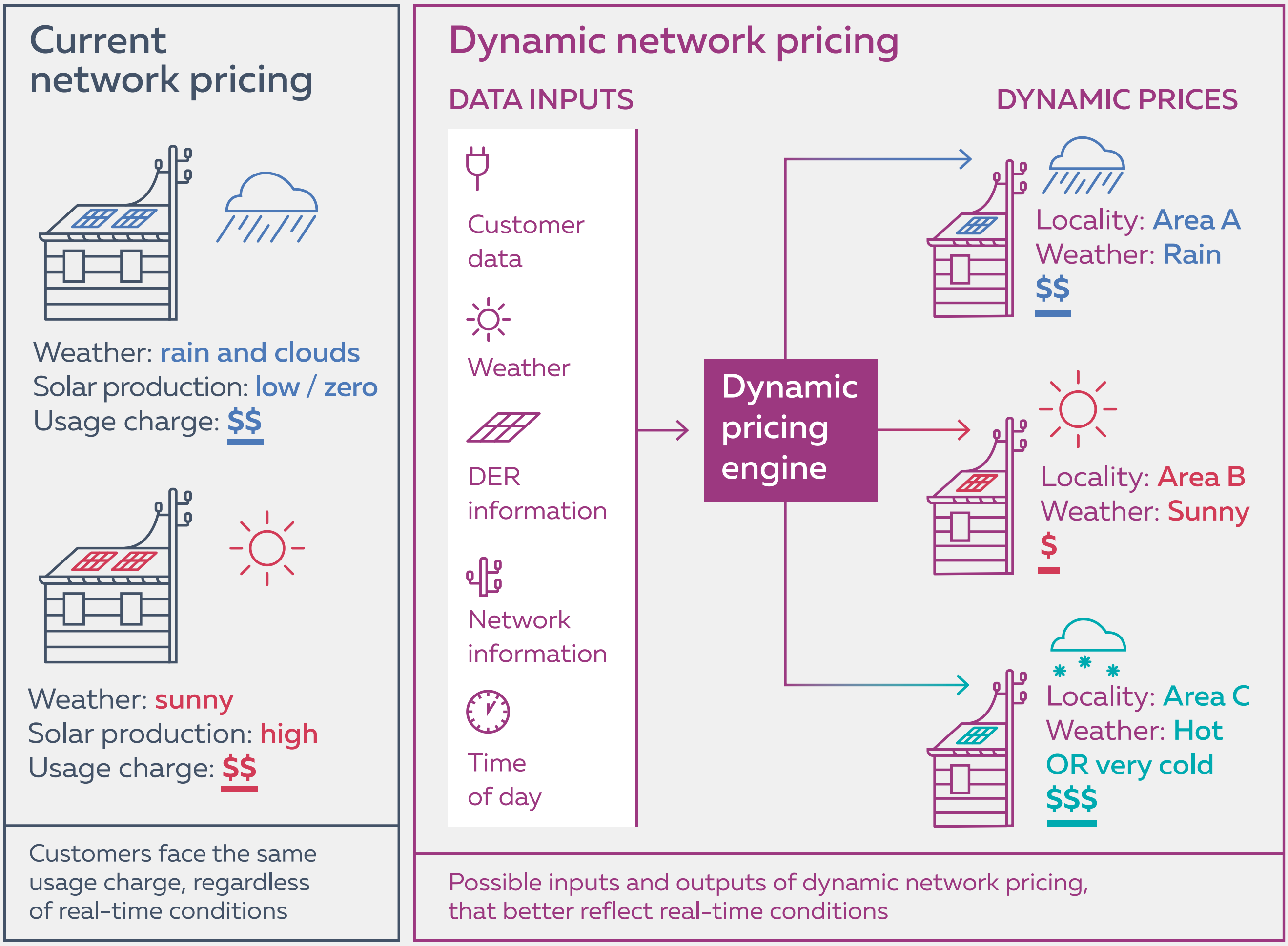
A simplified visualisation of a dynamic network pricing model is shown in **Figure 3.**

As dynamic prices mature, they can be used to find the short-run equilibrium of demand and supply to calculate market equilibrium prices. An equilibrium price results in a balanced supply and demand of electricity, for a given time and location. In the near term, incremental improvements in efficiency can still be achieved by using simpler approaches to dynamic prices. Dynamic prices enable DNSPs to better target and group times and locations with similar costs to serve customers, improving the efficiency of network pricing.

The frequent signalling of where there is value available (including through negative tariffs that ‘pay’ for the provision of services) enables aggregators to optimise across their portfolio and maximise their value stack.

Figure 3

Outputs of current network pricing compared to dynamic network pricing



2.2

Dynamic operating envelopes

Dynamic operating envelopes change the upper and lower limits on customers' load and generation.[5] These flexible limits can vary over time – as shown in **Figure 4** – and location, depending on the available capacity in each area of the network. These could be refreshed and published at five-minute intervals, with day-ahead forecasts, to match energy market settlement periods.

DOEs provide an option to broaden the network capacity that is available to customers during off-peak consumption times to allow for more import from and export to the electricity grid.

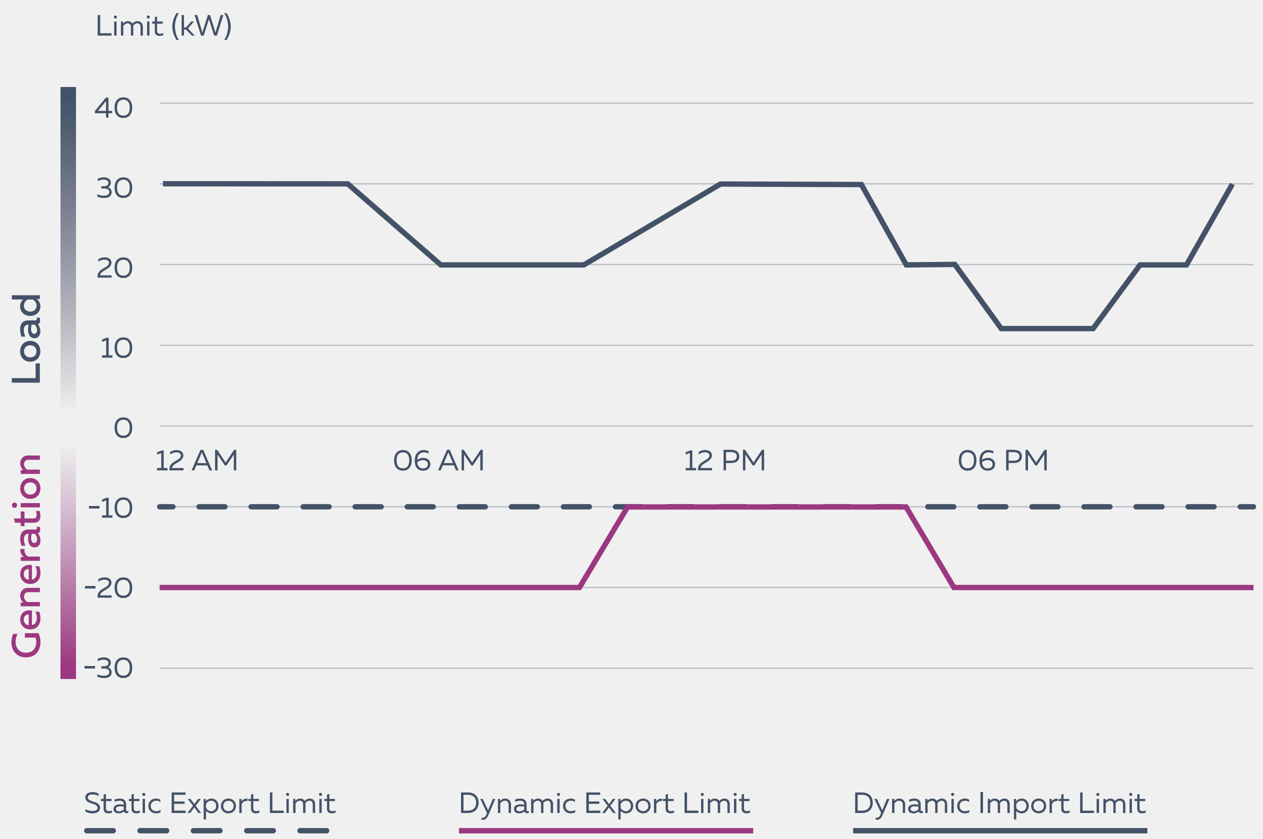
DOEs can also provide guardrails during peak load or generation periods to manage local network congestion [7]. As the rollout of DOEs progresses, the dynamic aspect should improve the use of underutilised network capacity and enable more renewable energy onto the grid.

Moving forward, it is also envisioned that DOEs could facilitate more electric vehicle charging and faster charging by allowing for higher loads during off-peak times. This could improve the service of the network to customers while putting downward pressure on network costs.

5 More precisely, DOEs are placed on the share of load or generation that is drawn from or injected to the electricity grid – customers' imports and exports of energy.

Figure 4

Comparison of static export limits versus dynamic operating envelopes



3

What is Project Edith?

Project Edith is a demonstration project led by Ausgrid and Reposit, in collaboration with the Australian National University (ANU) and Zeppelin Bend. The project is one of several initiatives underway that explore the possibilities for DER to further participate in energy and services markets, and inform the ESB's post-2025 implementation.

Project Edith is supporting more value for and from DER by testing the extent to which dynamic pricing can be used to:

- allocate distribution network capacity in a decentralised manner, and
- reward network support, such as voltage support.

In the decentralised model in Project Edith, the DNSP does not explicitly allocate distribution network capacity to connection points but rather provides signals that are used by the customer or the 'customer agent' to decide and optimise on the capacity used. In contrast, in a centralised model, the decision on capacity allocation is optimised centrally. The project is testing the use of DOEs as 'guardrails' for DER to operate within, rather than explicitly optimising capacity allocation. This provides DER with the maximum access to use the network to participate in markets while ensuring the network is used safely.

3.1

Project partners and roles

Ausgrid is the distribution network for Sydney, the Central Coast and the Hunter Valley supplying electricity to 1.8 million customers. Through Project Edith, Ausgrid aims to:

- show how the services DNSPs offer to customers could evolve to support DER and therefore VPPs participating in markets,
- explore new processes for setting network tariffs, and
- extend capabilities, such as publishing dynamic pricing through the same platform used for publishing DOEs.

"We are using existing systems, identifying what needs to change and changing only the components that need to be changed."

Dean Spaccavento,
CEO and Co-Founder, Reposit Power

Reposit is a technology provider and DER aggregator seeking to operate within fluctuating network capacity and deliver maximum value to its customers. Reposit will leverage its existing DER optimisation software and algorithm, and customer base, within Ausgrid's network during the project. Through the project, Reposit aims to:

- adapt its DER optimisation software and algorithm to respond to the dynamic approach tested in Project Edith, and
- develop simple customer offers that adequately provides customers with transparency and shares value.

Project Edith is building on the Evolve Project[6], leveraging the software ANU developed for calculating and publishing DOEs. As part of Project Edith, the Evolve platform will be enhanced to include a dynamic pricing engine. Zeppelin Bend is working with project partners to host the DOE and dynamic pricing engines.

3.2

Using dynamic pricing and DOEs in Project Edith

DYNAMIC NETWORK PRICING

Dynamic network pricing for each connection point is at the core of Project Edith. The proposed prices are made up of three elements:

1. a **fixed charge,**
2. a **subscription charge** based on the minimum DOE a customer can comply with, and
3. a **dynamic** five-minute price component with prices for imports, exports and voltage support.

These prices will effectively replace existing network tariffs for the duration of the demonstration project.

The fixed charge will be comparable to the network access charge that customers pay under the current network tariff structure. For Project Edith, this will most likely be a daily charge.

The subscription charge is based on the minimum import and export limit each customer can comply with. For example, a customer who wishes to maintain an allowance for at least 10 kilowatts (kW) of peak-time passive load and a 5kW solar system would pay a charge for 10kW of imports and 5kW of exports. This customer's DOE would always be at or above these values. On the other hand, a customer who is willing and able to optimise or curtail their load or generation to reduce imports and exports can save by opting for a lower subscription.

The subscription charge is designed to incentivise customers and aggregators to actively manage the DER under their control. It rewards customers for being more flexible and owning more flexible assets – the more flexible customers are, the narrower their minimum band is and therefore the lower their subscription charge.

The subscription charge is forward looking, based on the subscription nominated by a customer or their agent. This means that if a customer pays for 10kW and does not use the full amount, they are still charged the full subscription fee.

The dynamic pricing component will be calculated and published by Ausgrid's pricing engine, considering the spare network capacity – that is, the capacity that customers have not already purchased through a subscription – among other factors. Prices are set for every five minutes, to match the intervals used in the wholesale market. Aggregators then use this information to optimise DER imports and exports for each customer.

6 The Evolve DER Project is led by Zeppelin Bend and is a collaboration between industry, academia and government. The project is partly funded by the Australian Renewable Energy Agency (ARENA) [11].

These dynamic prices can be positive or negative. When there is spare capacity in the network, disincentives are removed. Similarly, when DER can help the network, such as during peak times, rewards are offered.

The project will also explore a negative dynamic price for voltage support (based on reactive power) in addition to imports and exports. This configuration is used to demonstrate that rewards for network support, such as reactive power, can be priced and signalled through a single, extensible dynamic pricing platform.

While the dynamic pricing structure offers greater flexibility to DNSPs and supports value for aggregators, there is diversity in customer participation. Customers are likely to range from those that are extremely involved, or 'active' in the market to those that are content with a static tariff structure. If dynamic prices do become a standard network offering, this would be on an opt-in basis for customers who choose to engage with the market through an aggregator.

"Technology offers the opportunity to move beyond static and average network prices and account for differences in location and time. That is creating new opportunities for how to think about network pricing."

Justin Robinson, Pricing Innovation Manager, Ausgrid

DYNAMIC OPERATING ENVELOPES

While testing the use of dynamic prices to allocate network capacity and to reward network support are the primary focuses of Project Edith, the use of DOEs as 'guardrails' will also be tested. This ensures that DER operate in a way that maintains the network's safety and stability.

To address the possibility that capped maximum dynamic prices[7] alone do not provide sufficient certainty against breaching the network's operational limits, a safeguard is needed to maintain the network within these limits. In Project Edith, this is DOEs. The use of dynamic prices creates diversity in when, where, and how much customers use the network, making spare capacity available. This makes it possible for Ausgrid to publish larger DOEs that are only used as 'guardrails'.

Having these 'guardrails' is especially important during network events, such as peak consumption, and energy market events. Having larger DOEs also allows for greater market access for DER and VPPs, whilst ensuring sufficient capacity is available for inflexible loads and DER that cannot be controlled.

The project partners expect that throughout the demonstration project, the DOEs published for each customer will evolve, as more is understood about the behaviour and responsiveness to changes in prices of the customers participating in the demonstration.

7 To ensure that customers are adequately protected from unreasonably high prices, it is likely that the maximum dynamic prices will be capped.

3.3

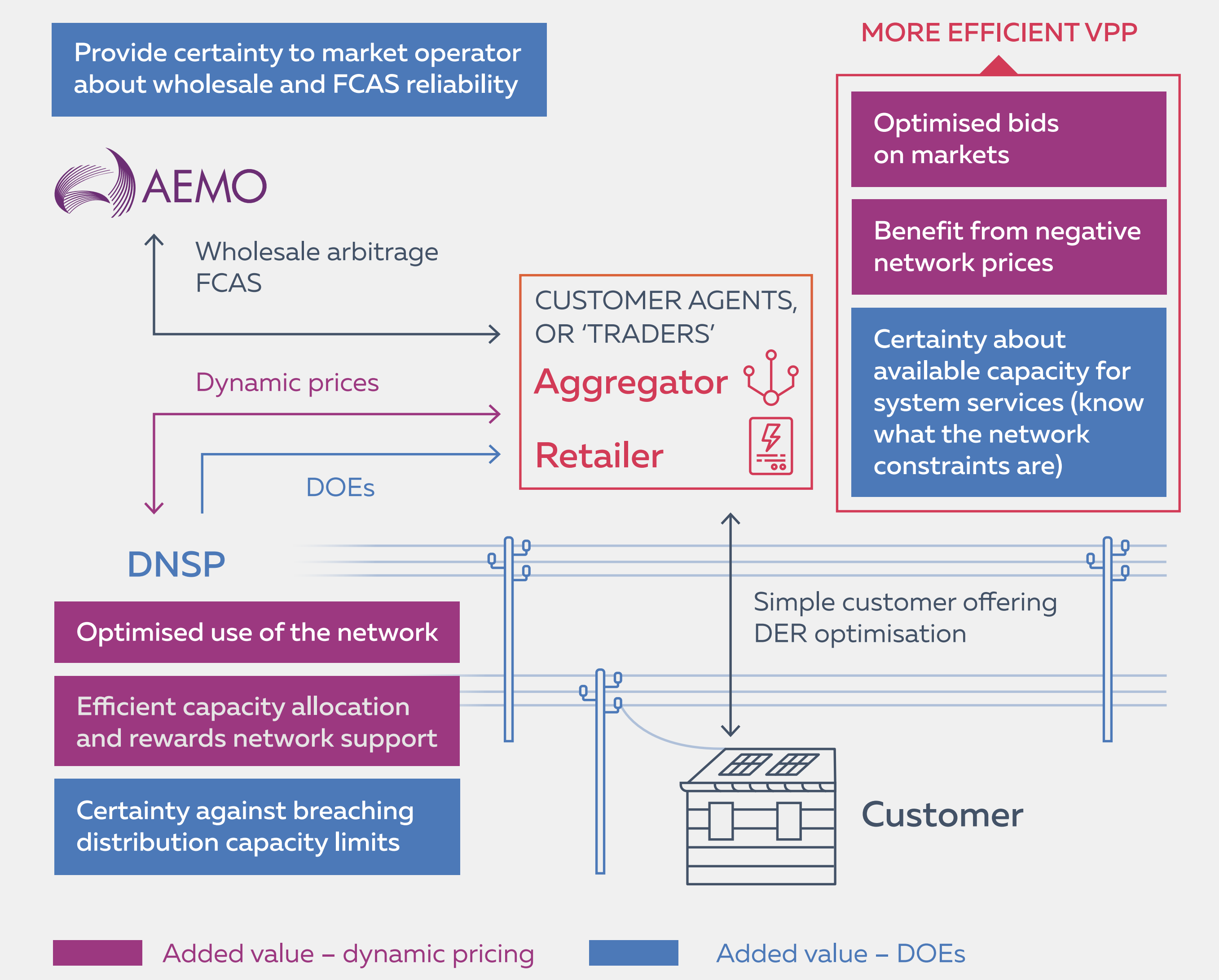
Demonstrating core concepts of Project Edith

The objective of the initial demonstration phase – Stage 1 – of Project Edith is to validate that the services DNSPs offer can evolve to support the increased participation of DER, through VPPs, in markets, by using dynamic network prices and DOEs. In this way, additional value can be unlocked for and from DER within the bounds of existing energy markets and systems. The main value streams that the decentralised approach unlocks are shown in **Figure 5.**

Initial testing conducted with a subset of two residential solar and battery storage systems validated that DER respond to price signals sent to them from the DNSP. This test sought to substitute the customers' retail tariffs with tariffs that were modified to synthesise the signals that will be sent as part of a dynamic network price mechanism. The outcome of this test validated that when given a price signal, DER systems will respond.

The next step of testing is to validate the proposition that DER can be optimised using dynamic network prices and DOEs. This step will see the scope of testing expanded to include five-minute pricing intervals and the application of dynamic network prices to tariffs on customers' imports and exports of electricity.

Figure 5 Maximising value through a decentralised approach



Centralised optimisation platforms

Another approach to managing DER is through a centralised optimisation platform. In this approach, wholesale market participation, ancillary service provision and network service provision are managed and co-optimised via a centralised platform.

Currently, the wholesale and ancillary markets are operated in this manner. In the future under a centralised operating model, network services would also be included in this model.

An example of this approach that is currently being tested is Project EDGE [10]. The differences in decentralised versus centralised approaches are shown in **Figure 6.**

Figure 6

Comparison of a centralised versus decentralised approach to managing DER

EDGE approach

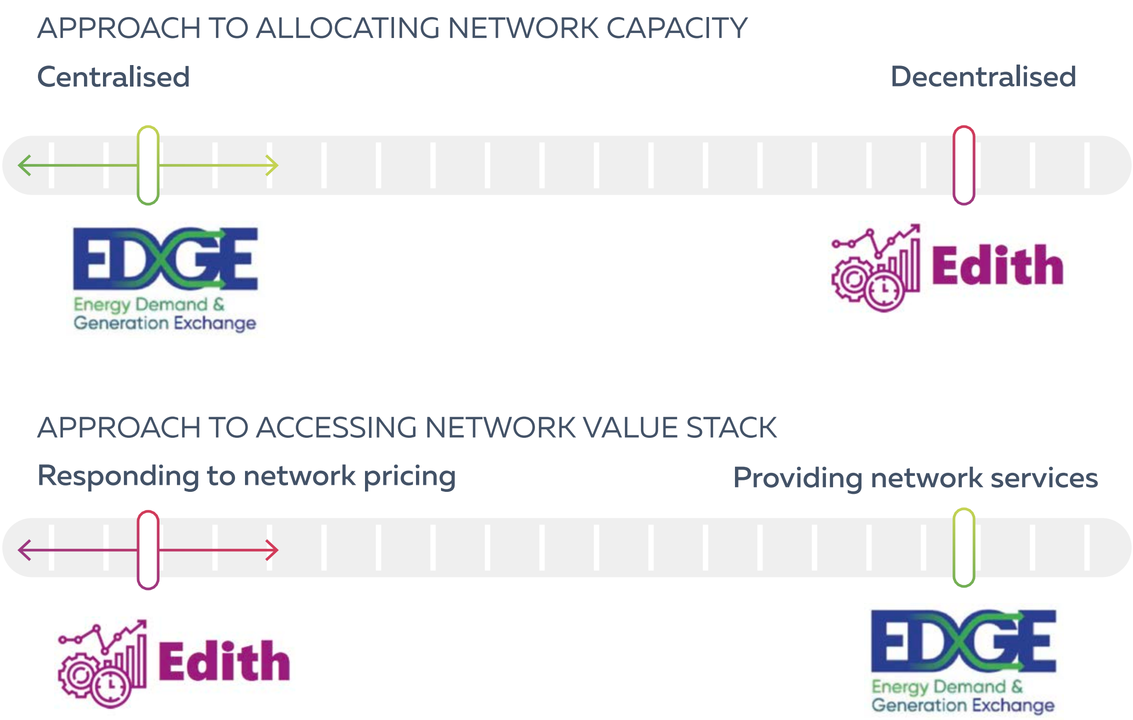
manage distribution limits by co-optimising capacity allocation in a centralised DER Market Place.

Edith approach

manage distribution limits by incentivising efficient use of the network through pricing.

Both use dynamic operating envelopes (DOEs) but with different objectives:

- EDGE – optimised capacity allocation, considering VPP bids.
- Edith – absolute capacity limit, using network pricing to optimise VPP bids.



4

What does a successful demonstration of Project Edith mean?

4.1

Outcomes Project Edith seeks to demonstrate

Project Edith is seeking to demonstrate a proof of concept for the decentralised approach – that dynamic pricing signals and DOEs can be implemented and work with existing systems.

Successful outcomes from Project Edith would:

- validate an approach to improve the efficiency in how capacity is allocated and support market participation through dynamic pricing (in comparison to static tariffs and limits),
- inform the development of a market equilibrium price that takes into consideration customers' responses to changing prices, and
- highlight the ways that this approach can comply with existing regulations, and the spaces where regulatory updates may be required to enable better optimisation.

Ultimately Project Edith aims to demonstrate that the decentralised approach can be rolled out incrementally, with minimal upfront investment, leading to reduced costs to customers while unlocking more value for and from DER. The project partners anticipate that investments by aggregators to develop more complex optimisation algorithms and manage larger numbers of customers will be required over time.

> **"Project Edith is bringing in economic tools to complement the engineering tools currently used to manage network capacity"**
>
> Alida Jansen van Vuuren,
> Head of DSO, Ausgrid

4.2

Creating new opportunities for DNSPs, aggregators and customers

ENABLING GREATER MARKET PARTICIPATION FOR CUSTOMERS WITH DER

Project Edith allows Ausgrid to bring to life a paradigm shift in the role DNSPs play. As more dynamic capabilities and services are enabled by DNSPs, they shift from only operating a network that provides electricity to customers to innovating services and enabling customers and aggregators to participate in the wholesale and ancillary services markets and provide local network support. This transition is commonly referred to as DNSPs becoming distribution system operators (DSOs).

While Reposit customers who have rooftop solar and batteries are enrolled in Project Edith, the concepts being tested could be applied to unlock value from other sources of flexible demand – including electric vehicles and 'smart' household appliances such as hot water systems and pool pumps. In undertaking a proof of concept, Project Edith seeks to provide a toolkit that other DNSPs as well as aggregators managing increasingly price-responsive DER can pick up and implement.

SMARTER MANAGEMENT OF NETWORK CAPACITY

Dynamic pricing moves towards locational equity rather than equality; in other words, accounting for the future costs of providing electricity at each connection point. For customers, the Project Edith model could create opportunities to use the electricity network at a lower price than what is currently available most of the time. Conversely though, customers will be exposed to higher costs if they choose to use the network during congested periods.

Responses to dynamic pricing can also help identify sections of the network where capacity is highly valued. The data gathered from DER creates opportunities for DNSPs to gain better awareness of the differences across customers, DER and network constraints at a more granular level and so better manage and plan for the network. Dynamic prices and customers' valuation of capacity also help signal to Ausgrid, customers, and other third parties where opportunities exist to build more capacity.

GREATER ACCESS TO INFORMATION TO STIMULATE COMPETITION AMONG AGGREGATORS AND MORE EFFICIENTLY REWARD NETWORK SUPPORT

The dynamic pricing approach provides aggregators access to information about network costs and enables a share in network benefits. Through this, Ausgrid aims to foster more opportunities for competition between aggregators. However, aggregators' optimisation algorithms will have to evolve to harness greater value from their portfolio of DER.

Through the approach tested in Project Edith, DNSPs will be able to price network support and create a more efficient process for rewarding support from aggregators. Contracts may still be developed for specific network requirements, but variable support for different locations and times may be rewarded through dynamic pricing.

5

What comes next?

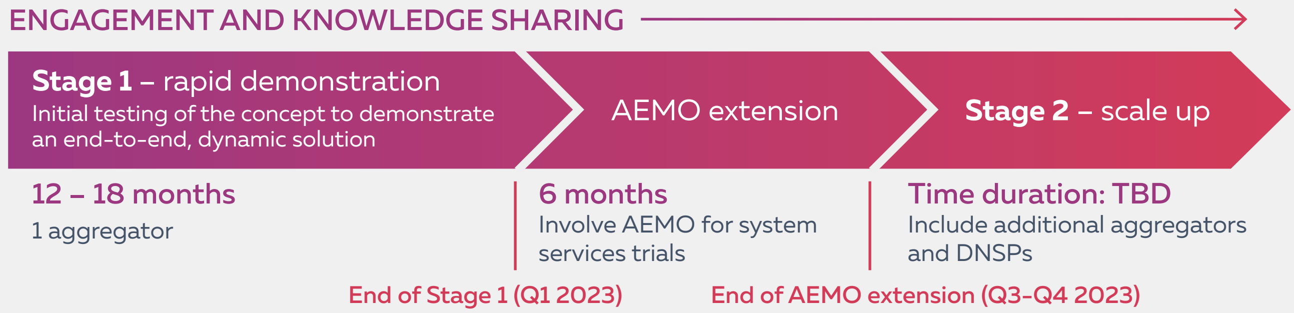
5.1
Expanding Project Edith

Stage 1 of Project Edith, which is the initial testing of the concept with a single aggregator (Reposit) and single DNSP (Ausgrid), aims to demonstrate a fully functioning, end-to-end, dynamic solution. Following a successful completion of Stage 1, the project partners anticipate a possible extension with AEMO to further integrate VPPs into markets and expansion to include other aggregators and DNSPs. The workplan for Project Edith has been structured such that findings from each stage inform the next steps. As such, the demonstration timeline may change. The proposed timeline for Project Edith is shown in **Figure 7.**

5.2
Beyond Project Edith

The rapid evolution of DER is changing Australia's energy landscape. As DER continues to evolve, changes to the policies and regulations that govern the energy system are needed as well. Several initiatives are underway that seek to address the opportunities DER presents for two-sided markets and distribution networks, and to inform policy changes. The initial findings of these initiatives – such as Project Edith, Symphony, and EDGE – are expected in the next eighteen months. Findings are intended to inform the evolution of the energy system in Australia, including through the ESB's post-2025 electricity market design reforms and DER Implementation Plan. Findings could also inform AEMO's engineering framework and Integrated System Plan (ISP). Regulatory changes to network pricing may also be needed in the future, to implement dynamic pricing at scale and ensure that customers are priced fairly. Project Edith will continue to engage with the broader energy industry and share findings to support a low-cost transition to net zero that unlocks value for and from customers' investments in DER.

Figure 7 **Project Edith timeline**



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