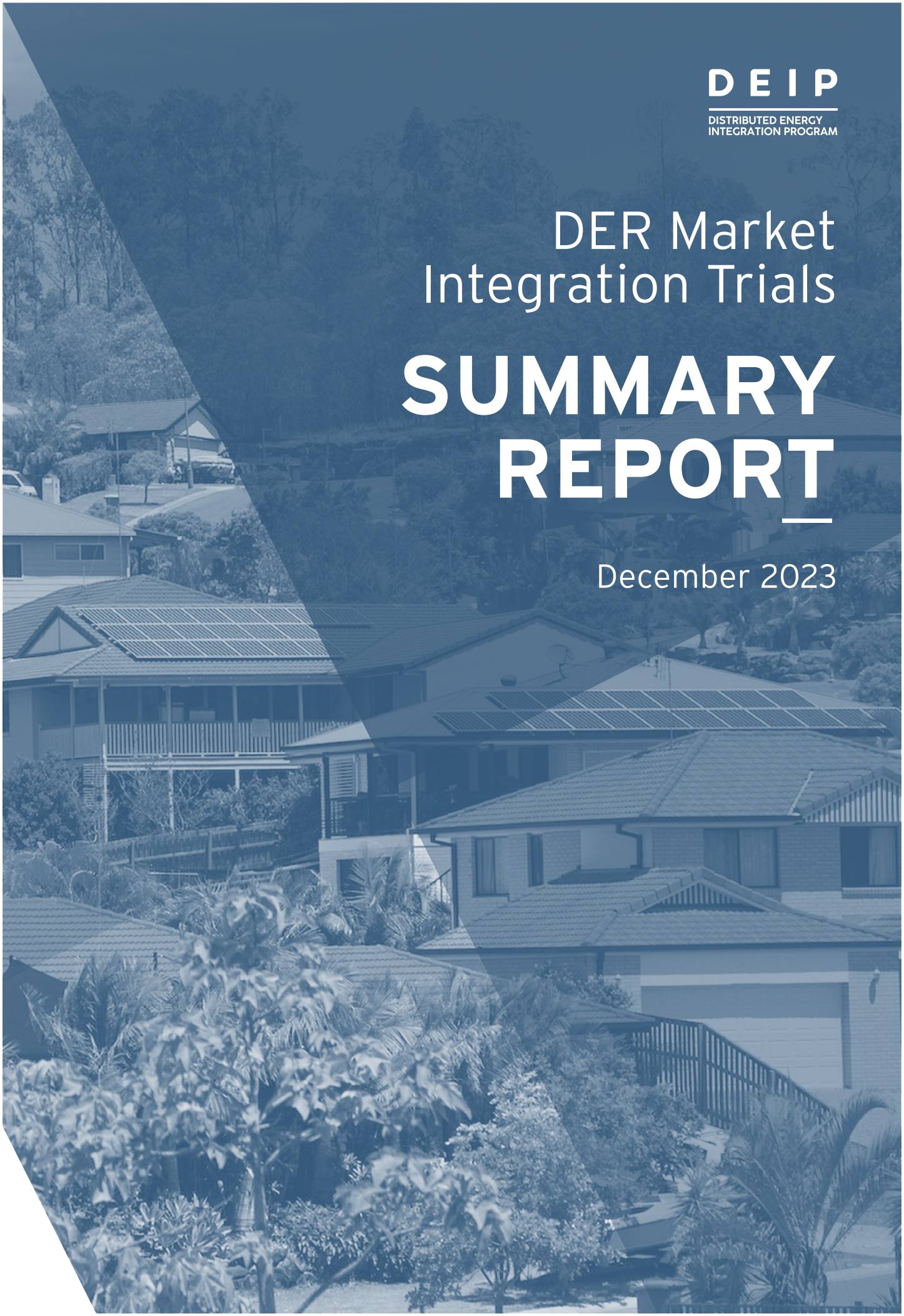

DEIP

DISTRIBUTED ENERGY INTEGRATION PROGRAM

DER Market Integration Trials

SUMMARY REPORT

December 2023

ABOUT DEIP

The Distributed Energy Integration Program (DEIP) is a collaboration of government agencies, market bodies, peak industry bodies and consumer associations aimed at maximising the value of distributed energy resources (DER) for all energy users. DEIP is not an organisation, it is a collaborative forum where organisations come together to share knowledge and work together towards a common goal. DEIP is driven by the premise that collaborating on shared issues and mutual goals will more efficiently identify knowledge gaps and priorities, as well as accelerate DER integrated in the interest of all consumers. For more information on DEIP, visit the DEIP website.

DISCLAIMER

This report was commissioned by the Australian Renewable Energy Agency (ARENA), on behalf of the Distributed Energy Integration Program (DEIP). This report has been written by Grids Energy Pty Ltd with input from the DEIP and DER markets integration trials (AEMO Project EDGE, Ausgrid Project Edith, and Evoenergy Project Converge, and Western Power Project Symphony). The report presents the findings of Grids Energy Pty Ltd, which was prepared to provide a high-level summary of the DER market integration trials. ARENA, the DEIP and the DER markets integration trials have not endorsed the contents of this report, nor does the report necessarily represent the views or opinions of ARENA, the DEIP, or the DER market integration trials. The views expressed herein are also not necessarily the views of the Australian Government, and the Australian Government does not accept responsibility for any information or advice contained herein.

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To the best of ARENA and Grids Energy Pty Ltd knowledge, no conflict of interest arose during the course of preparing this report. Grids Energy Pty Ltd has not received any grant funding from ARENA.

EXECUTIVE SUMMARY

As uptake of consumer energy resources (CER) continues to increase in Australia, we see growth in new energy products such as virtual power plants (VPP), electric vehicle smart charging offers, integrated hardware and retail bundles, and the early participation of CER in energy markets.

Novel policies and frameworks are being developed in which CER can operate safely and efficiently within the limits of the system, such as flexible exports, in addition to new ways to incentivise efficient usage of the network through various tariff trials[1].

At higher levels of CER uptake, numerous existing and emerging methods of operating end-to-end energy solutions will need to improve:

- Trustworthy entities must provide consumers with compelling and clear offerings for new energy products and services.
- On behalf of customers, traders will need to integrate a range of data sources and operate or signal CER in increasingly sophisticated ways. Networks as Distribution System Operators (DSOs) will require greater visibility of real-time network energy flows, along with more sophisticated tools and incentives for the efficient, secure, and reliable management of energy flows. Methods of exchanging data between a large and diverse set of actors will need to be iteratively rolled out as CER infrastructure grows and integration offerings mature

Three trials, Project EDGE, Project Converge, and Project Edith and one pilot, Project Symphony, examines how the end-to-end market integration of CER may look with high levels of CER uptake in the mid-to-late 2020's and beyond.

Part 1 of the DER Market Integration Trials Summary Report[2] was published in 2022. The report describes several challenges in CER market integration, outlining the various approaches each of the trials are undertaking to overcome these challenges. This report examines findings from the trials over the past 12 months, and other relevant studies and processes as it relates to consumers, traders, network limits and network support, and approaches to data exchange.

Consumers tend to be satisfied with their VPP program, but are unsure how much they are benefiting

Surveys and interviews carried out by Deakin University's Better Consumption Lab suggests that the average consumer is lukewarm about joining a VPP. However, providing consumers with more control, transparency, safeguards, and appropriate information are approaches service providers can utilise to develop trust with consumers.

Surveys conducted on participating VPP consumers generally reported to have a positive experience. However, many participants were unsure how competitive their VPP plan was compared to alternative plans, or how much their energy bill was reduced. Furthermore, many consumers were uncertain whether aggregators took into consideration their long-term needs and whether aggregators were benefitting more than themselves.

The Better Consumption Lab illustrates a snapshot of community and consumer sentiment. Repeated surveys over time with broader groups may further these insights and allow us to see trends and changes in the data. Energy consumers are currently surveyed through processes such as the Energy Consumer Sentiment Surveys[3], whilst energy markets are reviewed through the AER's State of the Energy Market Reports[4]. Over time, either these processes or others could be extended to collect

1 https://www.aer.gov.au/networks-pipelines/network-tariff-reform/tariff-trials
2 https://arena.gov.au/knowledge-bank/deip-der-market-integration-trials-summary-report/
3 https://ecss.energyconsumersaustralia.com.au/
4 https://www.aer.gov.au/publications/state-of-the-energy-market-reports/state-of-the-energy-market-2023

more information around VPP programs and price responsive CER, as the uptake of these participation models increase.

Traders will play a key digital role connecting consumer assets and market systems

Traders, sometimes referred to as retailers and aggregators, are the intermediaries that help consumers offer their CER into the market. There are many new roles traders will have to play when designing and operationalising energy offers that involve VPPs.

It is important that traders, and other key actors in the energy supply chain, such as OEMs and installers, develop a strong understanding of these emerging energy services and offerings.

Furthermore, traders will need to increase their ability to connect and interact with AEMO, DNSPs, and technology provider systems in simple and cost-effective ways, while being the intermediatory with a wide range of consumer assets through increased interoperability. This will contribute to healthy competition and consumer choice in new energy products.

Advanced ways of managing flows on the local network will be required as CER uptake continues to grow

Emerging flexible export programs currently have quite simple allocation methods, such as giving all customers on a segment of a network the same export limit. Although this current approach is sufficient, more refined methods of allocating flexible exports will become necessary to maximise the total amount of energy exported, resulting in significantly better outcomes overall. However, more sophisticated methods of allocating flexible export limits often results in differing customer export limits and outcomes. The social impacts and acceptability of allocation inequalities will require further exploration.

Project Edith found that dynamic network prices, which are locational network tariffs updated on a 5-minute basis based on the congestion in that part of the network, can overcome many of the traditional barriers to demand response:

- Customers retain choice on whether to respond to the price signal, or even participate in the program.
- There is no need to develop baselines
- It leverages existing DSO systems such as billing, Low Voltage forecasting and DOE.

One drawback of dynamic network pricing is that it possesses a lower level of firmness than more typical network support procurement processes. This is due to the voluntary nature of responding to the incentives of dynamic network prices, compared to other forms of network support that place obligations on households or business to respond when needed. Edith suggests that multiple forms of network support could be implemented, such as utilising direct procurement during constraints requiring a high level of firm service delivery, and dynamic network pricing for other circumstances.

Data standards and architectures must evolve over time to support CER market integration

As CER plays an increasingly pivotal role in the energy system, considerations must be made of how data is sent between relevant parties. This data could include asset registration data, dynamic operating envelopes, market bids and other information relevant to the operation of CER.

While data exchange is currently done in relatively bespoke ways, standardising an industry-wide methodology will play an increasingly significant role. To achieve this goal, the trials and other processes are examining areas such as:

- Standards: this includes protocols, testing regimes and compliance for consistent ways to communicate data, and expected operational responses from assets. Standards and protocols should be developed in a flexible manner for various architectures and extended for new use cases. An example of this is CSIP-AUS, which all four of the market trials and pilot have used in various architectures (point-to-point and data hub) and Project Edith has extended CSIP-AUS to support the inclusion of network prices.
- Architecture: Many initial data integrations will be between technology providers, traders and DNSPs in point-to-point integrations. Over time a datahub may be required as more actors become involved and exchanging data becomes more complex. It's essential that simpler point-to-point architectures are designed with the flexibility to transition to datahub architecture to avoid future compatibility issues.
- Cyber Security: As fleets of aggregated CER and data exchange grow, adequate cyber security requirements and controls for parties involved in the operations of CER will become essential.

GLOSSARY

AEMC	Australian Energy Market Commission
AER	Australian Energy Regulator
ANU	Australian National University
API	Application programming interface
ARENA	Australian Renewable Energy Agency
BSGIP	Battery Storage Grid Integration Program
CER	Consumer energy resources
CSIP-AUS	Common Smart Inverter Protocol Australia
DCOA	Distribution constraint optimisation algorithm
DEIP	Distributed Energy Integration Program
DER	Distributed energy resources
DERIAPITWG	DER Integration API Technical Working Group
DNSP	Distribution Network Service Provider
DOE	Dynamic operating envelope
DSO	Distribution System Operator
ESB	Energy Security Board
FCAS	Frequency control ancillary services
ISC	Interoperability Steering Committee
NECF	National energy customer framework
NEM	National Electricity Market
OEM	Original equipment manufacturer
RERT	Reliability and emergency reserve trader
SOE	Shaped operating envelope
VPP	Virtual power plant

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INTRODUCTION

In Australia there are three trials, Project EDGE[5], Project Converge[6], and Project Edith[7] and one pilot, Project Symphony[8], that are examining the end-to-end integration of price responsive consumer energy resources (CER) into the energy system.

The end-to-end integration of CER includes meeting four core functions:

- Market Services: providing system-level market services for participation in current wholesale energy, FCAS, or RERT markets.
- Network Services: providing capacity to local networks to defer or avoid costly network upgrades.
- Local Constraints: adhering to the local network capacity available to CER.
- Consumer Needs & Preferences: providing compelling products with appropriate value, information and protections that give consumers the opportunity and choice to participate in the above three functions.

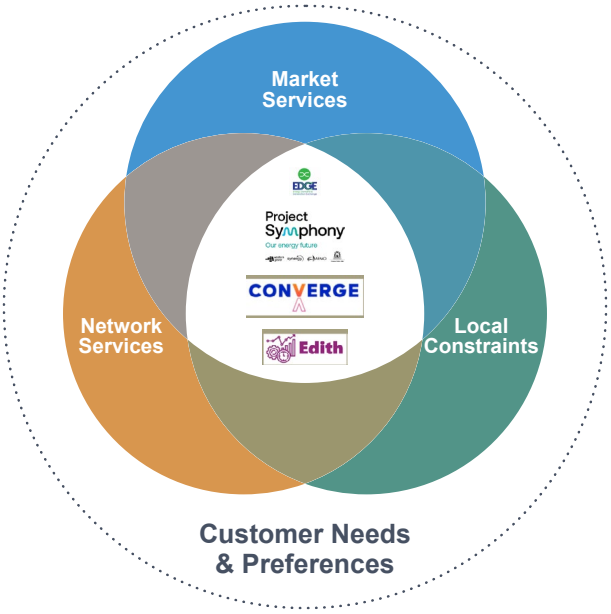


Figure 1 Core functions met in end-to-end DER market integration trials, Source: Deip[9]

Part 1 of this report[10] was published in 2022 at a prior stage in the trials. It describes several challenges in the market integration of CER and outlines the various approaches each of the trials are taking to solve these challenges. It is highly recommended to refer to the previous report as a reference to this report as it illustrates and makes a comparison to the features of the different market integration trials.

5 https://arena.gov.au/projects/project-edge-energy-demand-and-generation-exchange/
6 https://arena.gov.au/projects/project-converge-act-distributed-energy-resources-demonstration-pilot/
7 https://www.ausgrid.com.au/About-Us/Future-Grid/Project-Edith
8 https://arena.gov.au/projects/western-australia-distributed-energy-resources-orchestration-pilot/
9 https://arena.gov.au/knowledge-bank/deip-der-market-integration-trials-summary-report/
10 https://arena.gov.au/knowledge-bank/deip-der-market-integration-trials-summary-report/

	AEMO PROJECT EDGE	WESTERN POWER PROJECT SYMPHONY	AUSGRID PROJECT EDITH	EVOENERGY PROJECT CONVERGE
METERING POINT	Connection Point or **Sub-metering**	Connection Point	Connection Point	Connection Point
ENERGY MARKET BIDDING	**Model consistent with scheduled BDU from IESS**	Bids into balancing and **contingency reserve raise** markets	Current bidding process for FCAS	**Bids first sent to DSO**
DOE ALLOCATION	Various	Various	**Subscription model**	**Bid-optimised**
LOCAL CONSTRAINTS	DOE	DOE	DOE	DOE
NETWORK SUPPORT	**Local services exchange**	**Contracted network services**	**Dynamic network price**	**Real-time RIT-D**
DATA TRANSFER	**Data-hub**	**Platform integrations**	**Point-to-point**	Point-to-point
LOCAL CONSTRAINTS COMMUNICATION PROTOCOL	CSIP-AUS (only using schema)	CSIP-AUS	**CSIP-AUS extended with pricing)**	CSIP-AUS

Figure 2 Technical settings of the market integration trials. Bold denotes a novel approach, Source: DEIP[11]

The purpose of this new report is to summarise and contextualise information and findings from these trials over the past 12 months. This includes linking areas of investigations from the trials to broader industry trials, initiatives, and reforms.

Over the past 12 months, the trials have yielded additional insights, such as:

- further insight about the approaches,
- desktop research,
- in-depth technical modelling, and
- experiences from operational implementation

These new findings from the trials can be grouped into four key areas, which are individual chapters in this report:

Consumers: What are the current perceptions towards CER and VPPs from the community and customers who have signed up to VPP programs? What efforts are being made to ensure adequate consumers protections for these new energy products, and how can similar trials, pilots and reform programs incorporate the consumer voice in energy system decisions?

Traders: How can traders cost effectively and simply integrate into upstream AEMO and DNSP systems, and downstream to signal prices or actions to consumer CER, to simplify and increase the cost effectiveness of virtual power plant products?

Network Limits and Network Support: With higher participation of CER in the future, how does CER operate within network limits, and provide local value when there is a need?

Data Exchange: As CER and the networks become more digitised, larger amounts of data will be sent between an increasing number of parties. How can parties efficiently, reliably, and safely exchange data with each other through various stages of CER growth?

Each chapter of the report contains summaries and references to the relevant studies and reports. This report serves as a starting point to many of these issues, but readers can delve deeper into the referenced source material for further information.

11 https://arena.gov.au/knowledge-bank/deip-der-market-integration-trials-summary-report/

CONSUMER

Consumers are paramount to the integration of CER into the energy system and markets. As Consumers own these assets and produce value for the grid, consumers must reap benefits to ensure participation. This is a new concept in energy. Until recently, consumers have had more limited choice in the way they interacted in the energy system. Often the choices available were to compare amongst retailer options and make behavioural changes to shift electricity to off-peak hours.

With the adoption of rooftop solar and home batteries, development of innovative network tariffs, access to energy market revenue through virtual power plants (VPPs), and other new retail offerings, consumers now have an opportunity to provide value back to the system and be compensated.

However, a trade-off occurs in exchange for greater risk. These new energy offerings and products are highly complex, requiring a greater level of knowledge from consumers or trust towards service providers. There are also equity and fairness considerations, ensuring that these new energy offerings are designed with customers in mind to avoid unfair distribution of rewards.

This section includes:

- social science research from Project EDGE, which examines the community perceptions of VPPs and experiences of consumers in VPP programs,
- work from the AER on consumer protections for new energy services, and
- a study from ANU's Battery Storage Grid Integration Program (BSGIP) on how consumers can be better consulted at an earlier stage during decision making processes in the energy industry.

CONSUMER PERCEPTIONS OF VPPS

Deakin University's Better Consumption Lab published a series of reports "to examine how potential and current residential VPP customers perceive VPPs with a view to understanding how to:

- Accelerate the adoption of VPPs
- Increase VPP customer satisfaction and retention
- Build the trust of the aggregators who are managing customers' DER
- Encourage additional VPP exports
- Develop policies that fairly facilitate DER exports."

This research was communicated through four main reports, and a final summary report[12].

12 https://aemo.com.au/-/media/files/initiatives/der/2023/project-edge---customer-insights-study-summary-report.pdf

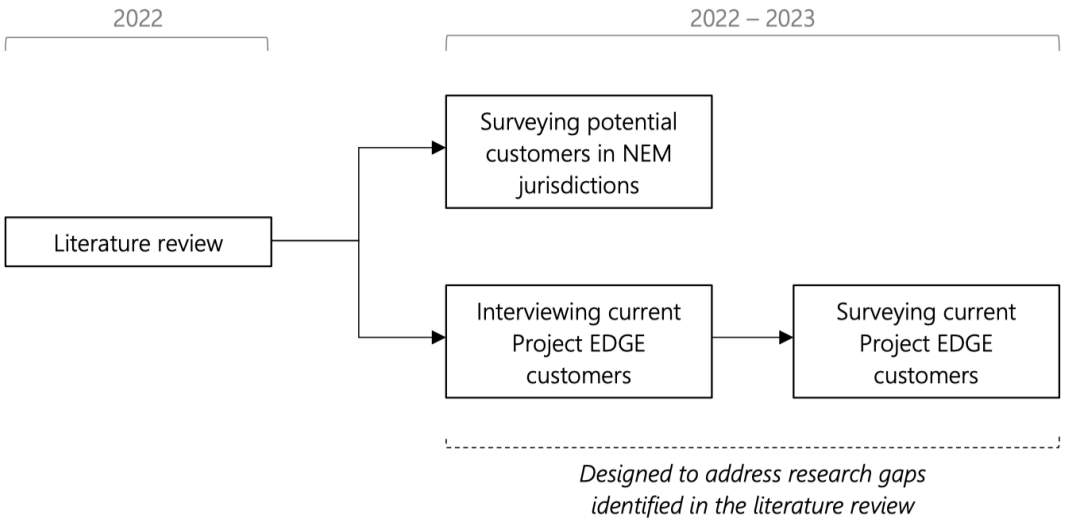


Figure 3 Program of Research, Source: Deakin University, Project EDGE

The Gaps in Existing DER Customer Insight Research[13] identified under-examined areas in consumer research related to DER. Twenty-one gaps were identified and these gaps should be considered for future research. This includes:

- Further quantitative analysis. This includes statistical analysis and eliciting quantitative information from customers (e.g. understanding a monetary threshold of financial return that would motivate a customer) to better understand trades-offs, thresholds, and what customers refer to as "fair" or "good value".
- Previously, research emphasis was focused on adoption-related issues (as opposed to long-term customer experience), early adopters, and trial benefits which may not generalise to non-trial contexts. This can be expected due to the immature nature of VPPs, and research carried out within the timeframe and scope of a trial. However, as adoption increases, a deeper understanding of customer types and researching deeper into the product life cycle will be more viable.
- Further research into how companies can improve the acquisition, installation, servicing, and processes for customers.
- The Lab also conducted a survey of 898 residents throughout New South Wales, Queensland, South Australia, and Tasmania to evaluate community perceptions on DER and aggregators[14].
- Analysis found that customers tend to be unsure and lukewarm about joining an aggregator or VPP. However, providing more control, transparency, safeguards, and appropriate information are ways to increase trust in aggregators. The report provides detailed breakdowns of survey analysis of consumer sentiment useful to a wide range of industry stakeholders (example below).

13 https://aemo.com.au/-/media/files/initiatives/der/2022/project-edge-lit-review-der-customer-insights-research.pdf
14 https://aemo.com.au/-/media/files/initiatives/der/2022/community-perceptions-of-der-and-aggregation-services.pdf

Potential ways to enhance trust in an aggregator	Solar panels: No	Solar panels: Yes
Aggregator owned by community group	31.4%	29.1%
Aggregator owned by commercial company	14.2%	14.7%
Aggregator guarantees earnings	61.4%	68.7%
Consumer controls how much stored power aggregator can export	64.3%	67.9%
Consumer controls when aggregator can export stored power	63.1%	62.7%
Consumer notified before every export takes place	61.5%	57.1%
Consumer notified after every export has taken place	53.0%	55.3%
Friends/family have joined aggregator	42.2%	38.3%
People in community have joined aggregator	38.6%	40.0%
Aggregator endorsed by trusted community group	43.4%	38.7%
Aggregator endorsed by government agency	50.6%	50.0%
Aggregator has a lock-in contract	26.1%	30.0%

Trust was recoded from three categories (increase trust; neutral; decrease trust) to two categories (increase trust; not increase trust) to ensure sufficient minimum cell sizes were present to run chi-square analyses. Only the 'increase trust' proportions are reported here. Red and green highlighting is used to indicate if solar panel status is over-represented (green; standardised residual ≥ 1.96) or under-represented (red; standardised residual ≥ -1.96) in their preference for trust-enhancing strategies.

Figure 4 Strategies for Enhancing Trust in an Aggregators,
Source: General Community Perceptions of Distributed Energy Resources[15]

CONSUMER EXPERIENCE WITH VPPS

In Project EDGE, Deakin University's Better Consumption Lab surveyed 63 customers participating in the EDGE trial for primarily quantitative insights and conducted semi-structured interviews with 35 customers for qualitative insights[16].

Analysis of the survey results from Deakin University reveals:

The Good: Overall, consumers skewed towards satisfaction with their CER and VPP experience, and particularly valued and understood their CER.

- Consumers were overall satisfied with both their CER (88% reported they were satisfied) and VPP (79% reported they were satisfied).
- Almost all customers (insert percentage) considered that the installation of the CER and joining the VPP was easy.

The Bad: Consumers are wary of aggregators.

- Consumers overall believed aggregators benefited more than them (29% believed aggregators benefited more than them vs 11% who thought the opposite).
- Only 57% of consumers believed aggregators looked after the long-term needs of their household.
- Only 51% of consumers were satisfied with the messages received from VPP providers.

The Unknown: Some consumers had difficulty understanding how their current VPP offer compared to offers from different aggregators, or how their energy bill was impacted from participating in a VPP.

- "The overwhelming majority of customers were not able to evaluate how their VPP stacked up against those of other aggregators." This may be in part due to the limited selection of aggregators to choose from, and the variety of ways the financial value of VPPs are communicated and distributed to customers (e.g. It is difficult to compare a $300/year offer, a $20/event offer, and a $1/kWh offer).

15 community-perceptions-of-der-and-aggregation-services.pdf (aemo.com.au)
16 https://aemo.com.au/-/media/files/initiatives/der/2023/project-edge---survey-insights-for-customers-in-the-edge-vpp.pdf

- While 71% of customers were satisfied with the financial rewards for participating in a VPP program, 30% of customers did not know the impact participating in a VPP had on their energy bill.

The qualitative analysis from semi-structured interviews with customers provided more detail:

- Customers were "generally open" to increasing the amount of energy they traded through a VPP if it passed a 'better off overall test'. This suggests that aggregators can improve their relationship with customers and build trust by developing better ways to communicate the financial impacts of VPP operations.
- Some customers had "heightened or unrealistic expectations about what DERs or VPPs could achieve"[17]. This was also found during the broader Deakin University survey (General Community Perceptions of Distributed Energy Resources) in which participants on average considered $970/year in value from the aggregator as reasonable.

CONSUMER PROTECTIONS FOR NEW ENERGY SERVICES

The AER in its Review of consumer protections for future energy services[18] are determining whether and how new energy products and services, such as virtual power plant products, should be regulated.

The National Energy Customer Framework (NECF), which covers the sale and supply of electricity, may not apply to many new energy products and services which are not directly involved in the supply of electricity. While Australian Consumer Law (ACL) "will provide some protections, these are not tailored specifically to energy products and services which are likely to have a high degree of complexity". This means there may be a current or future gap in regulation and consumer protections with respect to many new energy products and services such as virtual powerplant programs.

The Review is looking to answer questions such as:

- What protections do consumers need to effectively engage with the future energy market?
- Who should be regulated in the future energy market?
- How and when are energy providers regulated.

The AER is examining 3 different models, which ranges from updating and extending the existing NECF to cover these new energy services (Model 1) to designing an entirely new outcomes-based frameworks where a service provider 'must act in the best interests of the customer' (Model 3).

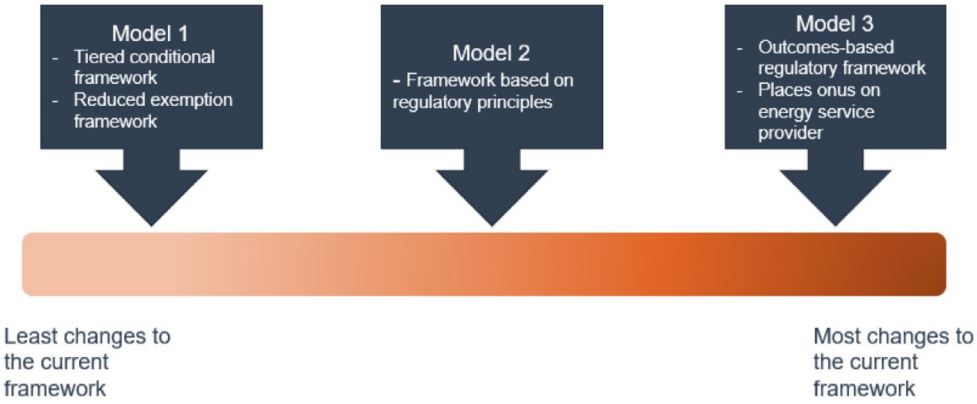


Figure 5 Range of reform model options, Source: AER[19]

17 https://aemo.com.au/-/media/files/initiatives/der/2023/project-edge-qualitative-insights-for-customers-in-a-vpp.pdf
18 https://www.aer.gov.au/retail-markets/guidelines-reviews/review-of-consumer-protections-for-future-energy-services
19 https://www.aer.gov.au/system/files/AER%20-%20Review%20of%20consumer%20protections%20for%20future%20energy%20services%20options%20paper%20-%20October%202022%2814535486.1%29.pdf

When determining the regulations of new energy products and services, consideration of trade-offs must be made. Examples include regulations introduced too early or inappropriate regulations stifling innovation as well as regulation complexity.

CONSUMER INVOLVEMENT DURING ENERGY SYSTEM DECISION MAKING PROCESSES

Decisions and reforms in the energy system increasingly have a direct impact on consumers. An example of this is the Access, Pricing and Incentive Arrangements for Distributed Energy Resources rule change[20] which examined how rooftop solar and other distributed generation can be better integrated into the electricity grid.

A group of ANU researchers from the Battery Storage and Grid Integration Program (BSGIP) examined how these processes could better involve and serve consumers[21]. This includes questions such as:

- What are appropriate consumer engagement models during energy system decision making processes?
- How would consumers like the energy system to respond to their needs?

The ANU team proposed a decision-making model that consults and involves customers and consumers earlier:

"Consumers should be consulted earlier, using tools such as "neutral spaces" to explore what is important to consumers. This creates a space which focusses on consumers' expectations rather than proposed solutions to industry defined problems."[22]

BSGIP also demonstrated how this model can fit into existing regulatory processes such as rule changes (Figure 6) and DNSP regulatory reset processes.

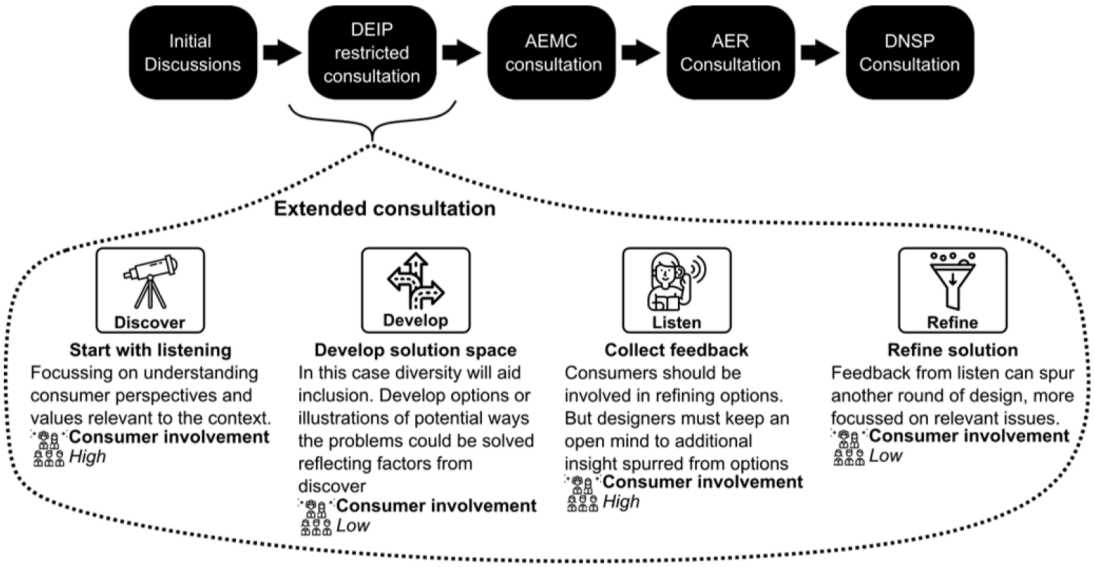


Figure 6 Proposed decision-making model, Source: ANU BSGIP[23]

While rule change and DNSP processes are being adapted and improved to more effectively incorporate consumers in the processes, BSGIP identified areas for improvement. To improve the way decisions impacting consumers are made in the energy industry, early consumer involvement should be implemented to hear their perspectives.

20 https://www.aemc.gov.au/rule-changes/access-pricing-and-incentive-arrangements-distributed-energy-resources
21 https://bsgip.com/wp-content/uploads/2023/06/Final-report.pdf
22 https://bsgip.com/wp-content/uploads/2023/06/Final-report.pdf
23 https://bsgip.com/wp-content/uploads/2023/06/Final-report.pdf

TRADERS

Traders, sometimes referred to as retailers and aggregators, are the intermediaries that help consumers offer their CER into the market. While retailers have primarily served billing and hedging roles, their scope of functions increase when facilitating the operation of CER.

For instance, the Customer Insights Summary Report from Project EDGE[24] highlights some additional and more sophisticated functions required when offering VPP products over typical energy plans, such as:

- Developing clear value propositions to communicate the advantages of joining VPPs programs.
- Ongoing communications about how customer assets are utilised and informing the outcomes to the customer. This involves balancing the consumer's desire for information, without overloading them with too much or unsuitable information.
- Bundling VPP products into integrated energy offerings, such as selling batteries or EV chargers which are compatible and suitable for retail electricity plans.

There are new digital functions traders must perform, such as interacting with the digital systems of DNSPs, AEMO and technology providers for operational purposes.

For healthy competition and innovation in the new energy space, it is important that:

- Traders develop the skills to create, explain and operate compelling new energy products, and
- Traders can effectively communicate with the customer's CER in day-to-day operations.

UPLIFT IN UNDERSTANDING

As new energy services and opportunities emerge, consumer and energy system intermediaries, such as traders, OEMs, and installers will need to understand these new services to provide information and tailored offerings to consumers.

This can involve new roles and functions that these intermediaries typically did not play in the past, such as providing information on a flexible export or VPP plan. While some intermediaries have taken a proactive stance in understanding these new energy services and functions by, for instance, participating in trials and working groups, many have not. It is therefore important to acknowledge the ongoing education and training needed for the successful uptake and implementation of new energy services and offerings.

When the Converge team interviewed various intermediaries in industry regarding dynamic operating envelopes[25], the team noted that DOE knowledge is concentrated to a small group and that this knowledge and specialisation will need to reach a broader group:

> ***"DOEs and SOEs require specialised understanding and the intermediaries working in this space are currently a relatively small group of people. The roles, knowledge and skills needed in Australia as DOEs (and perhaps later SOEs) are applied and scaled are greatly varied. All intermediaries involved will need to have specialist understanding of DOEs. Targeted support looks necessary to support the growth of DOE specialised intermediaries at scale, so that DOEs can then be scaled."*** – Converge

24 https://aemo.com.au/-/media/files/initiatives/der/2023/project-edge---customer-insights-study-summary-report.pdf
25 https://arena.gov.au/knowledge-bank/social-science-report-1-intermediary-insights-on-dynamic-and-shaped-operating-envelopes/

IT INTEGRATIONS

To date, Traders have not had to integrate with AEMO and DNSP systems in respect to the operation of the fleets of CER they represent, except in niche scenarios such as trials or contingency FCAS participation.

As flexible export programs and CER market integration increases, traders will need to build up the capability in supporting these integrations. While some traders will naturally excel at this, some may be required to develop or enhance that capability over time.

The Project EDGE lessons learnt reports[26] provide real-world feedback into the experience that traders may experience using new data exchange platforms, with some potential solutions:

- Clear documentation is important to reduce the human resources needed to deploy solutions. This includes centralising documentation and developing step-by-step guides.
- Multiple ways to integrate, such as APIs, cloud-native applications, and web applications may provide flexibility and benefits to participants. Of note, EDGE used a container-based[27] application that participants could download and run.
- A phased roll-out of a data exchange may be beneficial as systems and capabilities can be progressively implemented. This would mean initially implementing some high priority use cases through a data exchange and increasing the number of use cases and functionality of the data exchange over time.

These insights and considerations are not only important for an industry wide data hub, but also important when considering shorter term point-to-point integrations, such as individual DNSPs beginning to offer integrations into their 'utility server', which publishes flexible export limits. An example of this is SA Power Networks' flexible export program, where aggregators and devices communicate directly with SA Power Networks.

INTEROPERABILITY

Traders in some cases need to communicate with consumer devices and technology providers to provide new energy services. When traders are unable to do this, due to interoperability barriers, consumers will have limited options as to which VPP programs their CER are compatible with.

The Energy Security Board (ESB) identified five domains that CER interoperability throughout the energy system could be expressed[28]. With regards to the position of traders, the domains of interest are:

- Domain 1, CER-market interoperability: How traders can communicate with technology providers or CER directly.
- Domain 2, Behind-the-meter interoperability: How CER in a consumer's home can communicate between each other, such as a home energy management system (HEMS) controlling a battery.

26 https://aemo.com.au/-/media/files/initiatives/der/2023/project-edge-der-data-hub-lessons-learnt-final-june-2023.pdf
27 https://www.docker.com/resources/what-container/
28 https://www.datocms-assets.com/32572/1665556228-interoperability-policy-directions-paper-final.pdf

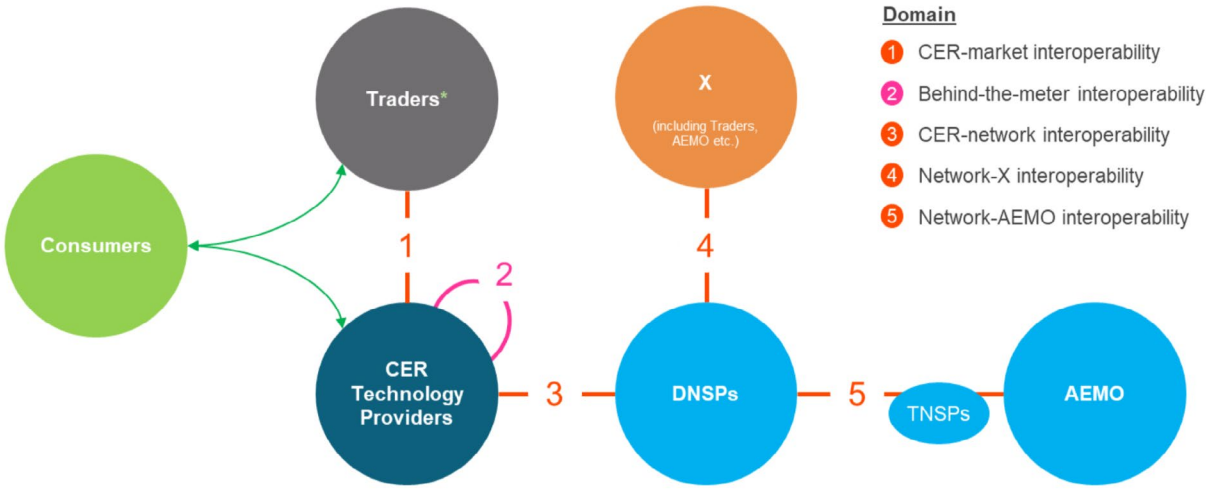


Figure 7 Consumer energy resource interoperability domains, Source: ESB[29]

Interoperability efforts to date have focused on "domain 3: CER-network interoperability" due to the pressing need for the integration of flexible export limits where the network communicates with technology providers and consumer assets.

Recently, there has been work from the ESB, DEIP's Interoperability Steering Committee, and in trials to address domains 1 and 2. For instance, SA Power Networks, AGL, and Simply Energy, through the Market Active Solar Trial[30], are testing how traders can manage the output of a customer's solar inverter in response to market signals (such as reducing output during negative wholesale prices and rewarding a customer for this behaviour), while continuing to adhere to the flexible export limits communicated by the DNSP.

There are other ways of categorising these different interoperability domains too. In Project Edge a three-domain categorisation was used:

- Domain 1, Actor to actor: Traders communicating with DNSPs, AEMO, and other technology providers.
- Domain 2, Customer to VPP: Customers can churn to any aggregator with their CER.
- Domain 3, Device to device: CER in a consumer's home can communicate between each other, such as a home energy management system (HEMS) controlling a battery.

Under this categorisation the four market trials are primarily addressing Domain 1, actor to actor.

29 https://www.datocms-assets.com/32572/1665556228-interoperability-policy-directions-paper-final.pdf
30 https://arena.gov.au/projects/sa-power-networks-market-active-solar-trial/

HOW CER CAN OPERATE WITHIN THE LIMITS AND SUPPORT THE LOCAL NETWORK

As CER and distribution networks become increasingly digitised and energy usage patterns change, there is a growing opportunity to enhance how network capacity is shared between consumers. This includes:

- How energy flows on the network are maintained within safe limits and how those limits are communicated.
- How managed loads and generation are used to support the network in times of stress, alleviating the need to augment and upgrade the network.
- How new and discretionary loads and generation are incentivised to shift their operation into times where the network is underutilised.

In the National Electricity Market (NEM), there is an uptake and scaling of "emerging solutions", such as simple flexible export limits and tariff trials[31], under the purview of the Australia Energy Regulator (AER). The four market integration trials look further down the road with a "future focus" on how these mechanisms can be enhanced and extended over time.

For instance, the SAPN Flexible Exports[32] offer (an emerging solution) is a widely available and relatively simple implementation of flexible exports that is suitable for current flexible export technology. Project Converge extends this concept by examining how market bids of aggregators can be considered when constructing flexible exports. Projects EDGE and Symphony also examine more sophisticated, future focused ways of allocating flexible export capacity[33].

Table 1 Ways of managing flows on the network now, soon, and further into the future.

	CURRENT	EMERGING SOLUTIONS (AER)	FUTURE FOCUS (MARKET TRIALS)
CALCULATING NETWORK AND SITE LIMITS	Static Limits	Simple Flexible Export Limits	Sophisticated Flexible Export Limits, Shaped Operating Envelopes, Flexible Import Limits
MANAGING FLOWS WITHIN LIMITS	TOU tariffs, RIT-D non-network solutions	Tariff trials	Local Services Exchange, Real-time RIT-D, Dynamic Network Prices

A theme from the four market trials and pilot is that increasing the sophistication of tools used to manage flows on the network, such as more accurate DOEs or targeted network pricing, become more valuable at higher levels of CER penetration and network constraints. While there is time to consider if or how these enhancements can be implemented, that time should be used thoughtfully. Two ways that can help this sophistication grow over time are:

31 https://www.aer.gov.au/networks-pipelines/network-tariff-reform/tariff-trials
32 https://www.sapowernetworks.com.au/industry/flexible-exports/
33 Reviewed in section 4.1: Network Capacity Allocations Through DOEs

- Emerging solutions such as mass-market, flexible-export programs and tariff trials collaborate where possible with future-focused solutions (such as ARENA trials) to share learnings and spot barriers or inconsistencies early which may impact or change the implementation plans of future solutions.
- Early identification of regulatory barriers or issues that may need to be overcome in promising future solutions. Many solutions in the trials require fundamental changes in the ways customers interact with the electricity network and tough trade-offs to be decided upon. It is important risks are identified and worked through at the right time to ensure these barriers do not create impediments or delays to the rollout.

NETWORK CAPACITY ALLOCATIONS THROUGH DOEs

Dynamic operating envelopes (DOEs) emerged from early ARENA funded trials[34] as a tool to ensure the local network can stay within safe operating limits. Currently, households are given fixed export and import limits such as a 5kW export limit for a household installing rooftop solar. DOEs allow those limits to vary based on how much spare capacity there is on the local network. For instance, instead of a 5kW export limit, the customer could elect to be on a flexible export limit, where they are given a 10kW export limit majority of the time and limited to lower export values when many local customers want to export at the same time.

There are three primary benefits of dynamic operating envelopes:

1. More energy can flow through the distribution network compared to static limits, which improves the financial outcomes for customers and increases utilisation of the network.
2. Customers and traders can rely on network capacity being available and so can offer firm services into the market such as demand response and ancillary services.
3. Customers, regulators, traders, and networks can better understand the true network capacity that is accessible to customers.

In flexible export programs, DNSPs calculate the level of export capacity in different segments of the network, and then distributes to individual sites, such as households and businesses. There are many ways this total amount of capacity can be distributed, such as:

- **Equal allocation:** where all sites on that part of the network get the same export limit – e.g. all sites get a 7kW export limit.
- **Proportional to asset size:** where sites get a limit proportional to the size of their exporting asset – e.g. a house with a 10kW system would get twice the export limit of a house with a 5kW system.
- **Maximising total generation:** where limits are distributed to sites in a way that maximises the total amount of energy exported on that segment of the network – e.g. a site that is expected to have more energy to export or is in a part of the network where voltage is less sensitive to additional exports may get a larger export limit than other sites in that part of the network.

Modelling studies in Projects EDGE and Symphony examined various DOE allocation methods in respect to flexible exports and assessed the outcomes based on metrics such as network utilisation, CER utilisation and fairness.

Findings from both studies suggest that equal allocation methods can result in poor overall outcomes for consumers and the electricity system, relative to some methods which allocate capacity in "unequal ways". This difference in outcomes between different DOE allocation methods become more pronounced in high penetration CER scenarios where networks become constrained more often. From the University of Melbourne's Fairness in Dynamic Operating Envelope Objective Functions report[35]:

> ***"In general, the results show that imposing fairness requirements into the DOE objective function calculation on the division of capacity allocated to customers participating in the DER marketplace has a detrimental impact on the technical and economic performance of the DOEs.***

34 https://arena.gov.au/knowledge-bank/on-the-calculation-and-use-of-dynamic-operating-envelopes/
35 https://aemo.com.au/-/media/files/initiatives/der/2023/the-fairness-in-dynamic-operating-envelope-objectives-report.pdf

Additionally, this negative impact can become worse with higher DER penetration rates as networks become more constrained."

A report from Project Symphony, Distribution Constraints Optimisation Algorithm (DCOA) Report[36], also highlights this effect:

"The evaluation showed the DCOA methods consistently outperformed both the baseline SOE [static operating envelopes] and the DOE equal allocation methods on key metrics in scenarios where there is inadequate network capacity to support forecast import or export of energy."

While early flexible export implementations are expected to use simpler methods such as equal allocation, over time there is a need to consider implementing more sophisticated methods that place a greater emphasis on optimising the total benefits to a group of consumers on the network. These more sophisticated methods may improve overall outcomes but will result in winners and losers on an individual basis.

Further exploration of the technical and economics outcomes of DOE allocation methodologies is needed, as well as consideration of the social impact and acceptability in how these more sophisticated methods are implemented. Section 2.4 Consumer Involvement During Energy System Decision Making Processes of this report includes a report from ANU BSGIP[37], which gives some direction in how consumers can be included early in energy system decision making processes.

DOE ALLOCATIONS BASED ON ENERGY MARKET BIDS

Project Converge is testing a mechanism to consider energy market bids and network support when calculating DOEs. Where there is a scarcity of network capacity (for example, where local rooftop solar exports would exceed the network capacity), that capacity will be preferentially allocated to traders or aggregators that bid lower prices to export (and higher prices to import) into energy markets. This improves utilisation of the local network and cost outcomes of the total electricity system as capacity is allocated to sites with low-cost energy that are most likely to be dispatched in the energy market.

As an example scenario (Figure 8), there are two customers sharing 12kW of export capacity. Both sites would like 10kW of export capacity to provide frequency control ancillary services (FCAS). Site A bids 10kW of FCAS capacity at 30c/kW and Site B bids 10kW of FCAS raise at 10c/kW. Under this scenario, there is 20kW of requested export capacity but only 12kW to allocate. By taking the bid prices into account, the DSO could allocate a 10kW export limit to Site B and a 2kW export limit to Site A. This would maximise the amount of cheaper energy offered into the energy market and increase the amount of network capacity that will be utilised as Site B is more likely to be dispatched (due to its lower bid price) than Site A.

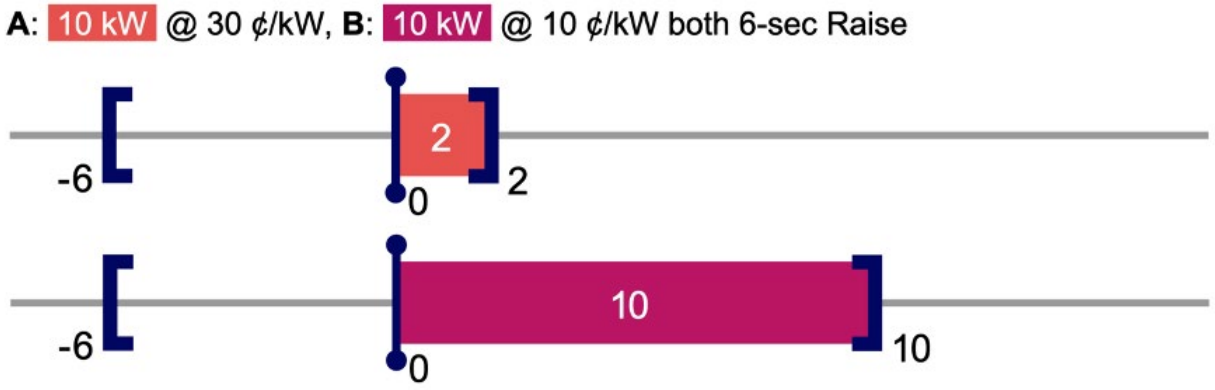


Figure 8 An example of SOE allocation based on market bids, Source: ANU[38]

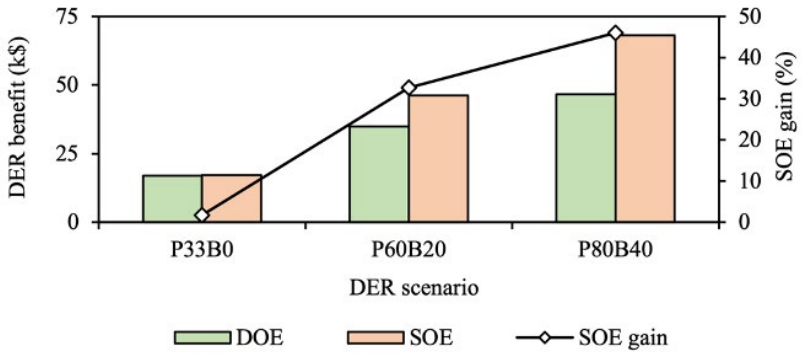
36 https://arena.gov.au/knowledge-bank/project-symphony-distribution-constraints-optimisation-algorithm-report/
37 https://bsgip.com/wp-content/uploads/2023/06/Final-report.pdf
38 https://arena.gov.au/knowledge-bank/shaped-operating-envelopes-technical-design-and-implementation-report/

While the SOE calculation has an objective to maximise the value of energy market bids when constructing the envelopes, it can also consider fairness objectives such as making envelopes similar across households or businesses. These two objectives are often in conflict and so weightings or thresholds can be set. For example:

- when energy market bids are similar, allocate similar SOEs,
- when energy market bids are sufficiently differentiated such as in the above example, allocate SOEs in a way that maximises the use of the network for cheaper energy.

The Converge trial will further explore the trade-off between efficiency and fairness, and how equity and fairness can be defined or measured in relation to SOEs.

Simulations of SOEs in a range of CER uptake scenarios suggest that SOEs can provide more benefits than DOEs at high levels of CER penetration.



DER SCENARIO	CUSTOMERS WITH PV	CUSTOMERS WITH BATTERY SYSTEMS
P33B0	33%	-
P60B20	60%	20%
P80B40	80%	40%

Figure 9 SOE and DOE benefits modelling, Source: ANU[39]

To achieve these gains, SOEs may introduce increased complexity and costs, such as:

- Increased complexity for aggregators as they must supply bidding information at the site level and explicitly communicate reserve requirements to the DSO (e.g. an aggregator may require 1.2MW of network capacity to bid 1MW into FCAS due to having a capacity buffer).
- Introducing perverse incentives such as aggregators bidding in ways to maximise the network capacity they receive. This is known as disorderly bidding (Box 1) and occurs at the transmission level.

Further, many aggregators do not bid with the expected richness of some of the examples in the Technical Design and Implementation Report[40]. For instance, some traders currently bid into FCAS markets at $0/MWh and often only participate in one market. This creates difficulties in valuing that capacity and deciding how to allocate capacity between markets (e.g. when should the DSO curtail energy exports to create export capacity for FCAS?).

These challenges will be explored during final stages of the trials, with simulations used to supplement live results to give richer context.

39 https://arena.gov.au/knowledge-bank/shaped-operating-envelopes-technical-design-and-implementation-report/
40 https://arena.gov.au/knowledge-bank/shaped-operating-envelopes-technical-design-and-implementation-report/

Box 1 – Disorderly Bidding

At the transmission level, constrained network capacity is allocated to the lowest price bidders in a similar manner to shaped operating envelopes (SOE).

For example, if there are two generators on a constrained part of the network, the generator that bids the lowest will preferentially be given network capacity, whereas the other generator will be limited to what it can export to the network.

The efficiency of this network capacity allocation mechanism relies on generators with cheaper fuel or short run marginal costs to bid lower than other generators, such as a solar farm bidding a lower amount than a peaking gas generator.

Due to the market structure, the price you bid is rarely the price you receive, as the price everyone receives is based on the highest priced generator dispatched in the region. This creates a perverse incentive, particularly when high wholesale prices are expected, where generators on constrained parts of the network could bid in at lower and lower prices in order to secure network capacity yet still receive high wholesale prices for the energy the export. A 'race to the bottom' can ensue where generators on those constrained parts of the network bid at the market floor (currently -$1,000/MWh) in order to maximise the network capacity they receive.

More details are available at the "AEMC Fact Sheet – disorderly bidding" from 2019[41]and an in-depth "Special report – The impact of congestion on bidding and inter-regional trade in the NEM"[42] by the AER from 2012.

DOE UPDATE FREQUENCIES

While the protocol for sending and receiving DOEs, Institute of Electrical and Electronics Engineers (IEEE) 2030.5 and the Common Smart Inverter Profile – Australia[43], has been adopted broadly in the industry, there are still details of its implementation to determine. The CutlerMerz[44] finds that there is a high level of consistency between DNSPs in the technical implementation of sending and receiving DOE information, but there are some technical features where different options are being considered. Two examples of this are the forecasting period of DOEs and fall-back procedures where sites lose connectivity with the DNSP or aggregator.

One technical feature that has been examined by the University of Melbourne through Project EDGE is determining the impact of update frequency on operating envelope efficacy[45]. The study investigated the accuracy of DOE forecasts when created at different time intervals, e.g. comparing a DOE created 24 hours ago to a DOE created 30-minutes ago. Inaccuracies in DOE forecasts can result in either:

- under allocating network capacity and over constraining export capacity at sites, or
- over allocating network capacity leading to network limits being breached or rooftop solar unexpectedly reducing output due to electrical safety requirements.

The study modelled three different DOE update frequencies:

- Day ahead forecasts: publishing DOEs at 10am that begin at 4am the next day.
- Intra-day forecasts: publishing DOEs at for the next 6 hours that begin in 30 minutes (i.e. the forecast generated at 4am will begin at 4:30am).
- Close-to-real-time/persistent forecasts: adapting forecasts in each 30-minute time step, in a similar way to how AEMO runs dispatch and pre-dispatch processes in the electricity market.

41 https://www.aemc.gov.au/sites/default/files/2019-03/Fact%20Sheet%20disorderly%20bidding.pdf
42 https://www.aer.gov.au/wholesale-markets/performance-reporting/special-report-the-impact-of-congestion-on-bidding-and-inter-regional-trade-in-the-nem
43 https://arena.gov.au/knowledge-bank/common-smart-inverter-profile-australia/
44 https://arena.gov.au/knowledge-bank/review-of-dynamic-operating-envelope-adoption-by-dnsps/
45 https://aemo.com.au/-/media/files/initiatives/der/2023/project-edge-determining-the-impact-of-update-frequency-on-operating-envelope-efficacy--workstream-3.pdf

These different update frequencies were applied to a range of networks (city, suburban, regional) with a range of DER penetration scenarios.

The modelling found, unsurprisingly, that real-time forecasts were more accurate than intra-day and day ahead forecasts. The real-time forecasts are particularly advantageous in higher DER penetration scenarios and where there are a large number of constraints on the network. This follows the general theme that more sophisticated methods will become needed over time, such as close to real-time updates to DOE forecasts, but simpler methods can be sufficient in the beginning, such as slower update rates to the limits.

INCENTIVISING CER TO SUPPORT THE NETWORK

DOEs defines the outer limit of what energy flows the network can support, but how can networks better manage flows within that limit? Historically, this has been done through 'time of use tariffs', and 'critical peak pricing' in some networks. The four market trials and pilot have tested more sophisticated and targeted methods to procure or incentivise CER to support the network.

Project Edith is testing dynamic network pricing, where the network operator sends specific locational prices to the trader that can change every 5-minutes based on the congestion in the network. Project Edith undertook a study[46] to examine the different features of dynamic pricing compared to network support procured directly or from a marketplace.

Figure 1

Summary of key characteristics of Project Edith, compared with other network support approaches

Measure	Outcome	Direct procurement	Centralised marketplace	Project Edith
Customers' ability to manage preferences	Enables customer choices	✗	✓	✓
Adjustability	Preserves optionality for the future (no long-term investment lock in)	? Depends on system used	? Whole new system	✓ Integrated system
	Maximises firmness of response	✓	✓ Depends on the service	✗
Simplicity	Avoids traditional demand response challenges such as baselining or specific contracting	~ Most do not	~ Most do not	✓
Scale-up feasibility	Builds on currently established capabilities, such as network pricing and billing	✗	✗	✓
	Leverages future expected capability developments, such as LV forecasting or DOE signalling	? Possibly	✓	✓

Figure 10 Key characteristics of Project Edith compared with other network support approaches, Source: Project Edith[47]

The analysis suggests that there are many advantages and efficiencies due to dynamic network pricing, such as:

- Simple contracting and delivery approach. Traditional network support often (although not always) suffers from baselining and contracting challenges that may be a barrier to offering or procuring the services.
- Scale-up feasibility. As dynamic network prices leverage the communication and forecasting capabilities required for dynamic operating envelopes, and may fit into existing network billing systems, it limits the number of new systems that must be developed and integrated.
- Choice. As customers are not required to respond to dynamic prices, and dynamic prices would be offered on an opt-in basis, customers retain flexibility in how their CER is used.

46 https://cdn.ausgrid.com.au/-/media/Documents/About-us/Future-Grid/Edith/Project-Edith-Knowledge-Sharing-Report-2.pdf
47 https://cdn.ausgrid.com.au/-/media/Documents/About-us/Future-Grid/Edith/Project-Edith-Knowledge-Sharing-Report-2.pdf?rev=5045c84d1e-c241a5ac81c89546549828

One drawback to the flexibility and simplicity offered from dynamic network pricing is that firmness of response is low, which means there is some uncertainty in service delivery. For instance, there could be occurrences where the network price increases to signal congestion, but there is little or no response from CER. To some extent this can be mitigated by an improved understanding of demand elasticity, although "this requires a long learning curve, as the accuracy of current demand elasticity modelling practices is low"[48].

Project Edith suggests that multiple forms of network support could be used, such as:

- utilising direct procurement when there are constraints that require a high level of firm service delivery, and
- dynamic network pricing for other circumstances.

Box 2 – Tariff trials

Tariffs trials, also known as sub-threshold tariffs, are a way that networks can test different tariff arrangements under more flexible arrangements than typical network tariffs are under.

In the 2021 "Access and pricing" rule change determination[49], the AEMC increased the amount of annual revenue that networks could collect from trial tariffs from 1% of cumulative annual revenue, to 5%. This change in conjunction with the growth of CER has encouraged an increased uptake of trial tariffs within the networks, growing from 3 networks proposing trial tariffs in the 2021-22 annual pricing process, to 11 networks proposing trial tariffs in the 2023-24 period.

In total, these 11 networks are testing 29 different tariffs[50]. These tariffs cover many different types of use cases and energy profiles, from rewarding flexible CER and behaviour changes to community batteries and stand-alone power systems.

While networks have historically focused on addressing and managing peak demand, many of the trial tariffs also now address periods of low demand, or high amounts of locally generated solar. Some trial tariffs even included periods with negative prices (meaning you get paid to use the network), thereby offering an incentive to alleviate network congestion at certain times (e.g. exporting from your home battery during a peak demand period).

The tariff trials can give early insights into new and innovative ways networks can structure incentives for and recover costs from users of the electricity network.

48 https://cdn.ausgrid.com.au/-/media/Documents/About-us/Future-Grid/Edith/Project-Edith-Knowledge-Sharing-Report-2.pdf
49 https://www.aemc.gov.au/rule-changes/access-pricing-and-incentive-arrangements-distributed-energy-resources
50 https://www.aer.gov.au/networks-pipelines/network-tariff-reform/tariff-trials

EXCHANGING DATA IN A HIGH DER WORLD

As CER plays an increasingly pivotal role in the energy system over time, it is important to consider how data is sent between relevant parties. This could be asset registration data, dynamic operating envelopes, market bids and other information relevant to the operation of CER.

To date many of these ways of exchanging CER data have been bespoke. For example, a network and aggregator testing a network support service may decide to exchange data in ad hoc or proprietary ways in order to efficiently operate the trial. There may be errors or downtime in these data exchange methods that can be manually remediated due to the small scope of the trial.

As these systems and processes become more widely adopted it becomes necessary to decide how they can be standardised, governed, and scalable. Where data exchange is ineffective or deficient, it can increase the costs and reduce the value of these systems. For instance, when the DER Register[51] was used to examine AS4777 compliance in solar inverters, missing data reduced the accuracy of the analysis:

> ***"The DER Register data was found to have significant shortcomings; only a subset of installations have correct serial numbers recorded and the volume of serial numbers for some installations is excessive (e.g. micro-inverters). From a basic screening of the DER Register, it was identified that at least 12% are clearly invalid (such as blank, N/A, or dummy serial numbers i.e. 123456). Additionally, when serial numbers have been provided to OEMs they reported that 15-25% were considered invalid by the OEM".***[52]

This demonstrates the importance of determining appropriate roles and responsibilities and compliance functions during the initial stages of development.

The four Australian market trials and pilot are looking at three key components: standards, architecture, and cyber-security.

Box 3 — The Future of Distributed Flexibility, Ofgem

Ofgem, the energy regulator in Great Britain is currently consulting on how CER can operate flexibility and efficiently in the energy system through improved data exchange[53]. The consultation considers designing common, digital energy infrastructure to address deficiencies of "information provision, market coordination of operations and actions, and trust and governance" related to CER.

In the consultation they have presented three candidate archetypes of common infrastructure:

Thin: a directory which lists market operators and flexibility providers.

Medium: an exchange platform which hosts multiple markets to facilitate and coordinate market participation and operation.

Thick: a central platform which contains multiple markets, undertaking every step of their process and co-optimising across them.

51 https://aemo.com.au/en/energy-systems/electricity/der-register
52 https://aemo.com.au/-/media/files/initiatives/der/2023/compliance-of-der-with-technical-settings.pdf?la=en
53 https://www.ofgem.gov.uk/publications/call-input-future-distributed-flexibility

They also presented examples of how common infrastructure can be delivered and governed, demonstrating the breadth of options and well-known examples of existing implementations of common digital infrastructure.

	Delivery model:	Fully Private (single party or consortium develops)	Mandated central entity	New mandated consortium (regulated entities develop)	Tendered and licenced	Code body (multiple mandated parties collaborate)	Government IT project
Explanation	Selection model	Contracted by government	Mandated by Ofgem/ government	Mandated by Ofgem/ government	Open tender	Mandated/tendered/ contracted	Public
	Governance regime	Governed by contract	Licence regime; legislation	Possible licence; contract	Licenced	Multi-party contract; licenced; legislation	Public body report to government
	Revenue model	Profit seeking – for private entity to develop	Accepted rate of return	Unclear	Accepted rate of return	Unclear	Public budget; energy consumers
	Example	London Stock Exchange	Future System Operator	Open Banking Implementation Executive	Data Communication Company (DCC)	SEC; RECCo	NHS spine
Activity to be undertaken	Accountability	*Government, regulator and/or expert panel*					
	Ownership and responsibility	Single contract from Government to private entity. Operating model must be commercially viable. Must remain competitive e.g., possible to rescind contract.	Mandate a single entity, either in legislation or license.	A collective mandate across multiple entities, either in legislation or license.	Government tender to multiple parties, with role and outcomes relatively defined. Operating model must be commercially viable. Must remain competitive e.g., possible to rescind contract.	Code body is responsible for industry-wide agreement. Code body would need clear powers, which likely requires legislation.	Government retains ownership.
	Input and advice	For the private entity to determine approach. Opaque to others.	For the mandated entity to determine approach. Easier for industry to oversee.	Presumed expertise within the mandated entities.	Guidance in advance of scope being released.	Code body has some in-house expertise and can convene groups easily.	Government team recruits expertise or contracts advisors, and could convene groups.
	Technical delivery	For the private entity to determine approach.	Tender(s) for delivery.	Presumed in-house expertise, or maybe tender(s).	Presumed in-house expertise, or maybe subcontract/tender(s) at entity's discretion.	Tender(s) for delivery.	Build in-house, maybe with tendered elements.

Figure 11 Examples of how common digital infrastructure could be delivered, Source: Ofgem[54]

Ofgem commissioned IBM to undertake a design and assessment study of possible digital infrastructure for flexibility markets[55] and Open Grid Systems to review potential standards[56].

While the use cases and challenges being addressed in the Ofgem consultation are not precisely the same as those in Australia, there are many similarities. There is an opportunity for Australian industry and market bodies to observe and utilise useful information from the Ofgem consultation and later steps, as well as collaborate where appropriate.

STANDARDS TO SUPPORT DATA EXCHANGE

Efficient data exchange requires agreed-upon and well implemented communication standards. This encompasses not only the standard development itself, but how it is applied (e.g. voluntary or mandatory), governed, updated, certified and many other functions to operationalise a standard.

One standard developed in Australia to support efficient data exchange is 2030.5 CSIP-AUS[57]. This standard has been developed through industry collaboration under the Distributed Energy Integration Program[58] (DEIP).

2030.5 CSIP-AUS originally focused on the use case of standardising how information relating to import and export limits are structured. The consistency enabled by the standard means that aggregators and CER assets do not need to create bespoke integrations to communicate to each distribution network. Instead, the aggregator or CER asset can speak "2030.5 CSIP-AUS" to a distribution network and reliably get an answer. This standard also describes expected operational behaviours, such as how long the

54 https://www.ofgem.gov.uk/sites/default/files/2023-03/Ofgem%20Call%20for%20Input%20on%20the%20Future%20of%20Distributed%20Flexibility2023.pdf
55 https://www.ofgem.gov.uk/sites/default/files/2023-03/IBM%20Report%20-%20Digital%20Design%20Study.pdf
56 https://www.ofgem.gov.uk/sites/default/files/2023-05/OGS%20Report%20-%20Markets%20Standards%20Study.pdf
57 https://arena.gov.au/knowledge-bank/common-smart-inverter-profile-australia/
58 https://arena.gov.au/knowledge-innovation/distributed-energy-integration-program/

aggregator has to relay the DOE from the distribution network to the device.

All four of the market trials are using 2030.5 CSIP-AUS to send information about operating envelopes in a variety of different IT architectures (e.g. DNSP to aggregator, or DNSP to datahub). Some of the trials have even implement new use cases with the standard, such as Project Edith sending dynamic network prices to aggregators or Project Converge sending and receiving information for shaped operating envelopes.

> ***"The technology implementation is consistent with using IEEE 2030.5 including the CSIP-Aus extensions for DOEs to implement the required data transfers between the aggregator and DSO. New data endpoints have been defined for the trial and this may be transitioned to existing IEEE 2030.5 functions or propose new standard interface endpoints at the end of the project."***
> **Project Converge**[59]

Currently, there are decisions being made about how this standard is implemented. For instance, the ESB consulted on options to implement 2030.5 CSIP-AUS in a nationally consistent manner[60] and Solar Victoria are requiring the standard to be implemented and certified in inverters from March 2024 to be eligible for subsidies under the Solar Homes and Solar for Business programs[61]. This has raised discussion on details such as how to implement consistency in testing, certification, compliance, and other requirements when adopting the standard.

In the Converge Social Science Report[62], which interviewed various networks, traders, and other industry actors about DOEs and SOEs, standards were seen as a key enabler of better integrating CER into the grid. Interviewees outlined that "the communications standard needed to be well established and stable to provide a frame for setting up DOE systems" and that consistency is needed when rolling out the standard nationally.

There are other use cases too where different standards may need to be developed. This includes "behind the meter interoperability", which is how different devices and controllers at the house or business and communicate and coordinate (e.g. ensuring your EV charges from excess solar rather than stored stationary battery energy, or multiple generating assets conforming to a single site level export limit) and ways of communicating information with the market operator such as SCADA lite[63].

ARCHITECTURES

The four market trials and pilot, and wider industry are examining the architecture of how data can be transferred within the CER ecosystem. One key question in the NEM, similar to the UK's The Future of Distributed Flexibility consultation[64], is as data exchange requirements grow, may it make sense to develop a data hub to better coordinate the exchange of this information?

59 https://arena.gov.au/assets/2023/02/shaped-operating-envelopes-technical-design-implementation-report.pdf
60 https://www.datocms-assets.com/32572/1665556228-interoperability-policy-directions-paper-final.pdf
61 https://www.solar.vic.gov.au/new-notice-market-support-growing-demand-solar
62 https://arena.gov.au/knowledge-bank/social-science-report-1-intermediary-insights-on-dynamic-and-shaped-operating-envelopes/
63 https://aemo.com.au/initiatives/trials-and-initiatives/scada-lite
64 https://www.ofgem.gov.uk/publications/call-input-future-distributed-flexibility

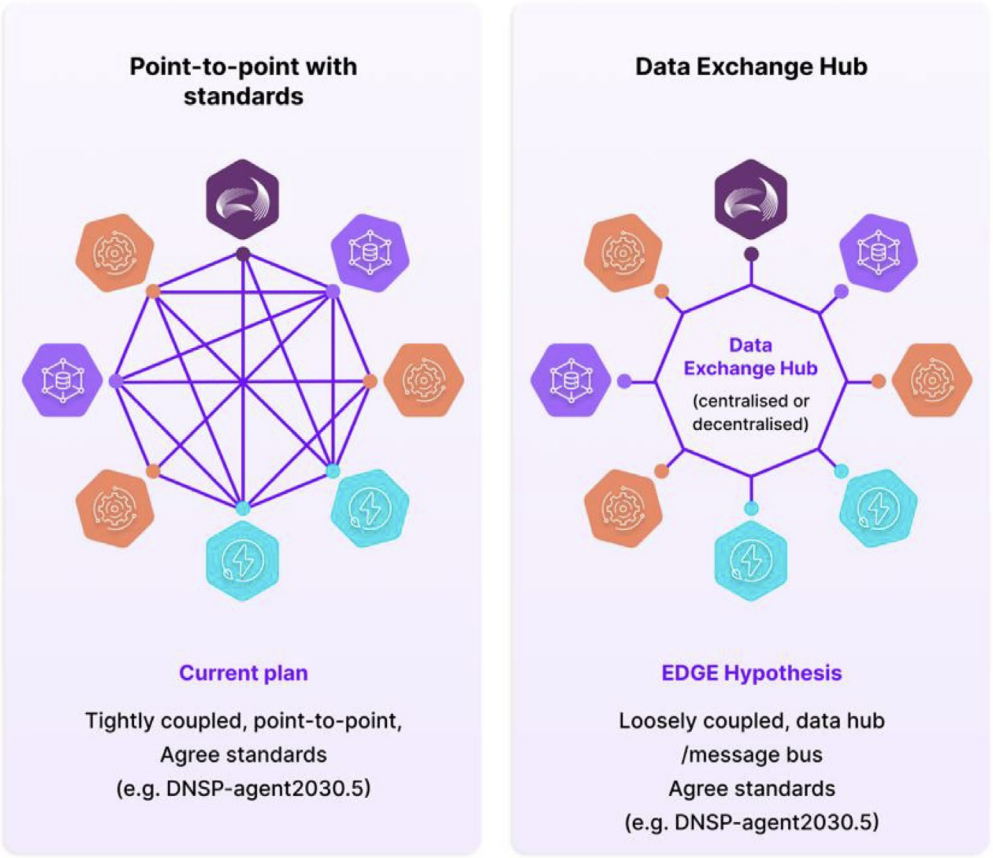


Figure 12 Examples of point-to-point and data hub architectures, Source: Project EDGE[65]

The way of exchanging data in the near term is point-to-point with standards. Using the example of flexible exports, this would mean aggregators requesting flexible export limits directly from the various networks their customers are in, and those networks sending the limits if required to AEMO.

The DEIP Interoperability Steering Committee has developed a Reference Architecture for Consumer Energy Resources[66] which provides "a visual understanding of architectures that exist (and may be commonly used) currently, or are predicted to emerge over the next 1 to 3 years." These reference architectures are a useful resource to understand the protocols, standards, and signal types in various architectures.

Edith demonstrates how current point-to-point architecture can be extended to include network signals on capacity limits (DOEs) and price (Dynamic prices). In this model, the Aggregator receives information from the network and tailors their bids to the market operator taking the network limits and incentives into account.

65 https://aemo.com.au/initiatives/major-programs/nem-distributed-energy-resources-der-program/der-demonstrations/project-edge/project-edge-reports

66 https://bsgip.com/wp-content/uploads/2023/09/ISC-reference-architecture-for-CER-v1.0.pdf

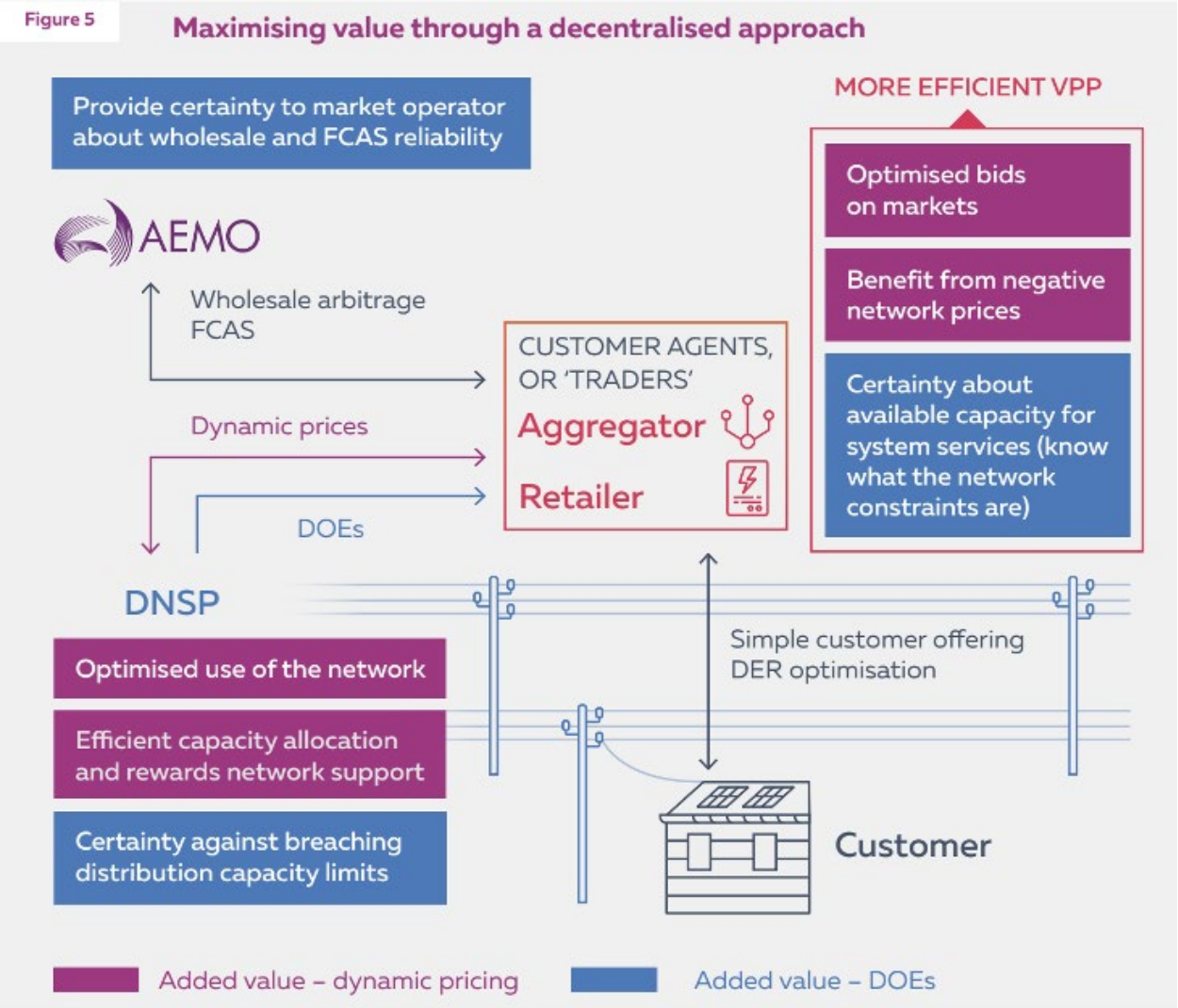


Figure 13 Example of extending existing data flows to support DOEs and Dynamic Pricing, Source: Project Edith[67]

Additionally, with the staggered rollout for flexible exports by DNSPs over the next decade, we have and are likely to continue to see use of point to point integrations between DNSPs and aggregators (or devices).

67 https://cdn.ausgrid.com.au/-/media/Documents/Reports-and-Research/Project-Edith/Project-Edith-2022.pdf

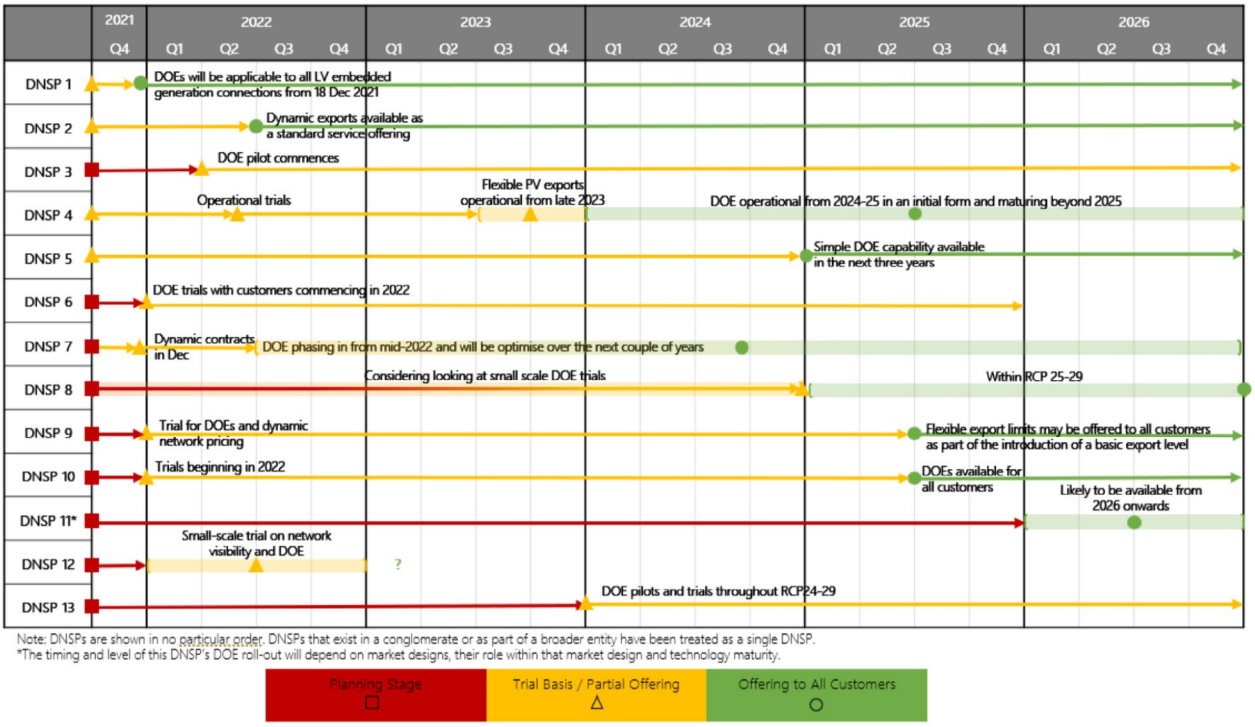


Figure 14 Timeline of planned small-scale DOE offerings, Source: CutlerMerz[68]

Over time, as the number of actors exchanging information grows, it may become suitable to transition to a datahub for some or all of the functions. This may in some circumstances create benefits through reducing the number of integration points:

> ***"The importance of AEMO receiving DOEs via a data exchange hub rather than direct point to point integration between each DNSP would be more pronounced for a future where many VPPs need to be directed across many DNSP boundaries."*** – Project EDGE[69]

Project EDGE has published a theoretical analysis[70] of different technologies that can facilitate data exchange, as well as an upcoming CBA[71]. A drawback to these analytical approaches is to be precise there are many assumptions that need to be made about how different technologies are implemented.

For instance, the CBA methodology for the centralised methodology assumes a central hub would pay licensing fees, and a decentralised hub would not pay licensing fees. While this may be the case, it also may be the case that a vendor offers a centralised hub without licensing fees or a decentralised hub with licensing fees. Licensing fees are not inherently linked to technology choices. There are many examples like this, throughout.

There are, though, some overarching concepts when considering data exchange in the energy industry that are important.

1. **Governance is largely independent from technology choices.**

   Examples of how common digital infrastructure could be delivered (Figure 11) demonstrate the range of governance structures that can and have applied to existing data hubs. Whether point to point, centralised or decentralised hub, there is a wide range of governance that can be applied to any of these architectures.

68 Review of Dynamic Operating Envelope Adoption by DNSPs – Australian Renewable Energy Agency (ARENA)
69 https://arena.gov.au/assets/2022/11/project-edge-lessons-learnt-2.pdf
70 https://aemo.com.au/-/media/files/initiatives/der/2023/project-edge-technology-and-cybersecurity-assessment-final.pdf
71 https://aemo.com.au/-/media/files/initiatives/der/2022/project-edge-cba-methodology.pdf

3. **Modern software engineering allows highly reliable and scalable systems in many architectures.**

   Point-to-point architectures largely run on the internet, and many occur in the telecommunication and banking sectors. Centralised architectures are made highly resilient[72] and scalable[73] through modern software and infrastructure techniques and there are many examples of long running implementations serving hundreds of millions or billions of users per day. Many different technology architectures are likely to be sufficiently scalable and reliable to meet use cases and should be assessed on a case-by-case basis during design and tendering processes.

3. **In a well-functioning regulated system like energy, trust, and transparency in relation to data is created and limited through regulation, not through technology choices.**

   One drawback to a technology-only review is that it tends to consider only technological solutions to problems. For instance, on trust, the EDGE technology review states:

   "A decentralised integration hub offers the most trustworthy system of all three approaches. In a public DLT platform, no single entity has complete control to view, write, or modify the protocol. In a permissioned platform, any change conducted can be seen and verified by other parties which results in a highly transparent ecosystem. Furthermore, any change or modification is also immutable, increasing trust in the platform."[74]

This means is that when data is received by a data hub in a decentralised digital ledger technology (DLT) solution, it cannot be changed without other parties being aware of this change. The fact that parties cannot change data without others being aware creates trust.

This is an advantage of decentralised data hubs, in that all actors in the system do not have to rely on a singular trusted party (commonly called a "trusted third party" or "centrally trusted entity") to solely operate and administer a data hub. While there are situations where no centrally trusted entity exists, and therefore implementing trust and transparency through DLT may be useful, in a highly regulated energy system, it may be unnecessary.

Currently, AEMO, DNSPs and others store and process large amounts of data for settlement, billing, and other purposes. These entities are trusted to correctly handle data through adequate regulation and oversight. Therefore, if techonology solutions were required to ensure trustworthiness and avoid data tampering, it would be indicative of deeper issues.

Others have also raised questions as to why a DLT would be used in environments that already run with "centrally trusted entities". When IBM ran a design study on the UK system-wide flexibility exchange they dismissed the use of DLT solutions for this reason:

> ***"In summary, DLT is a good solution for providing data visibility and transactional integrity in the absence of a central trusted entity. Given the SFE platform's central role, DLT has been discounted."*** – IBM[75]

Accenture's review of the impaired ASX DLT Data Exchange (Box 4) came to similar conclusions:

> ***"ASX is the central source of truth and final arbiter of outcomes, minimising many of the benefits of a DLT architecture."*** – Accenture[76]

72 https://aws.amazon.com/blogs/architecture/understand-resiliency-patterns-and-trade-offs-to-architect-efficiently-in-the-cloud/
73 https://aws.amazon.com/blogs/architecture/architecting-for-reliable-scalability/
74 https://aemo.com.au/-/media/files/initiatives/der/2023/project-edge-technology-and-cybersecurity-assessment-final.pdf
75 https://www.ofgem.gov.uk/sites/default/files/2023-03/IBM%20Report%20-%20Digital%20Design%20Study.pdf
76 https://www2.asx.com.au/content/dam/asx/markets/clearing-and-settlement-services/asx-chess-replacement-application-delivery-review-2022.pdf

Box 4 – ASX Data Exchange

The Australian Securities Exchange's Clearing House Electronic Subregister System (CHESS) provides clearing, settlement, asset registration and other functions to run the exchange. In 2015, ASX explored replacing CHESS with a more modern data exchange. In 2018, the ASX began the 'CHESS Replacement Program' to use Digital Ledger Technology (DLT) with the intention to improve availability, reliability, and performance.

In 2022 ASX commissioned a review[77] to assess the work to date after ongoing delays and problems with the project. The review pointed out a mix of implementation and technology difficulties. These difficulties included latency, scalability problems, and high complexity with the DLT solution.

The outcome of this review was to pause development of the data exchange solution in order to create a more viable path to update or replace CHESS. This change of direction at such a late stage in the project caused a $245-255 million pre-tax write-off for ASX and large losses for participants who were involved in the project.

The ASX CHESS replacement project is now closely overseen by advisory groups, independent experts and even ASIC and the RBA[78] and has commenced more typical software procurement processes.

Ultimately, focusing on creating robust, flexible standards and appropriate governance structures will be key in the short term to ensure data exchange can occur efficiently through all stages of CER growth. Specific technology and implementation choices will naturally emerge through processes built on top of this, such as software tenders with well-developed requirements, where appropriate technologies can be assessed.

77 https://www2.asx.com.au/content/dam/asx/markets/clearing-and-settlement-services/asx-chess-replacement-application-delivery-review-2022.pdf
78 https://download.asic.gov.au/media/dtleywap/23-236mr-20230830-asic-and-rba-joint-letter-of-expectations-public-version.pdf

APPENDIX: REPORTS & PROJECTS REFERENCED

CONSUMER

PROJECT/GROUP	TITLE	DESCRIPTION
EDGE	Gaps in Existing DER Customer Insights Research	A literature review of existing customer insights research to identify gaps.
EDGE	General Community Perceptions of Distributed Energy Resources	Analysis of 898 residents survey to understand their interest and values relating to CER and VPP programs.
EDGE	Surveying customers to understand their experiences participating in a VPP field trial	Analysis of 63 customers participant in the EDGE trial.
AER	Review of consumer protections for future energy services	An options paper outlining three reform options for how appropriate consumer protections can be designed for future energy services.
ANU BSGIP	Customer focussed distribution network management project	How customers can be better included in decision making processes in the energy system.

TRADER

PROJECT/GROUP	TITLE	DESCRIPTION
CONVERGE	Intermediary Insights on Dynamic and Shaped Operating Envelopes	Insights shared by stakeholders relating to dynamic operating envelopes and shaped operating envelopes.
ESB	Interoperability Policy Directions Paper	Analysis and directions of ways to improve CER interoperability.
MARKET ACTIVE SOLAR TRIAL	SA Power Networks Market Active Solar Trials	A trial examining how dynamic operating envelopes can act in concert with retailer solar schemes that actively manage the output of solar in response to market signals.

HOW CER CAN OPERATE WITHIN THE LIMITS AND SUPPORT THE LOCAL NETWORK

PROJECT/GROUP	TITLE	DESCRIPTION
AER	Tariff trials	A reference to all DNSP tariff trial notifications outlining the structure and objectives of each tariff trial.
EVOLVE	On the Calculation and Use of Dynamic Operating Envelopes	A paper outlining the concept of dynamic operating envelopes.
EDGE	Fairness in Dynamic Operating Envelope Objective Functions	Examining different ways of allocating DOEs measured against a set of metrics such as fairness and network utilisation.
EDGE	Determining the Impact of Update Frequency on Operating Envelope Efficacy	A study into how different DOE forecasting periods (day ahead, intra-day, and close-to-real-time) can impact the accuracy and outcome of DOEs.
SYMPHONY	Distribution Constraints Optimisation Algorithm Report	Examining different ways of allocating DOEs measured against a set of metrics such as fairness and network utilisation.
EDITH	Network support: a comparison of current and emerging solutions	The development of a framework of different features and settings network support solutions can have, and an international review of some network support solutions.
DERIAPITWG	Common Smart Inverter Profile Australia	A guide to implementing CSIP-AUS.
CUTLERMERZ	Review of Dynamic Operating Envelope Adoption by DNSPs	A review of the state of implementation of dynamic operating envelopes across Australian DNSPs.

EXCHANGING DATA IN A HIGH DER WORLD

PROJECT/GROUP	TITLE	DESCRIPTION
OFGEM	Call for Input: The Future of Distributed Flexibility	An Ofgem consultation on how common digital energy infrastructure can address information and data sharing deficiencies relating to CER.
IBM/OFGEM	Flexibility Markets: Digital Design Study	Analysis into what a UK flexibility exchange platform requires, and how it could be implemented.
OPEN GRIDS SYSTEMS/OFGEM	Flexibility Markets: Market Standards Study	An assessment of candidate standards for interfaces to common digital infrastructure related to CER.
AEMO	SCADA Lite	An operational data exchange solution for parties which cannot exchange operational information via a network service provider.
ISC	Reference Architecture for Consumer Energy Resources	A description of current and potential future communication architectures relating to the management of CER.
EDGE	Technology and Cyber Security Assessment	A theoretical review of different architectures for CER data exchange, and assessment of cyber security risks.
EDGE	Project EDGE CBA – Methodology	Assumptions, scenarios, and methodologies used in the cost benefit analysis of different architectures for CER data exchange.
ACCENTURE/ASX	ASX CHESS Replacement Service Delivery Review	A review into an ASX data hub implementation project.