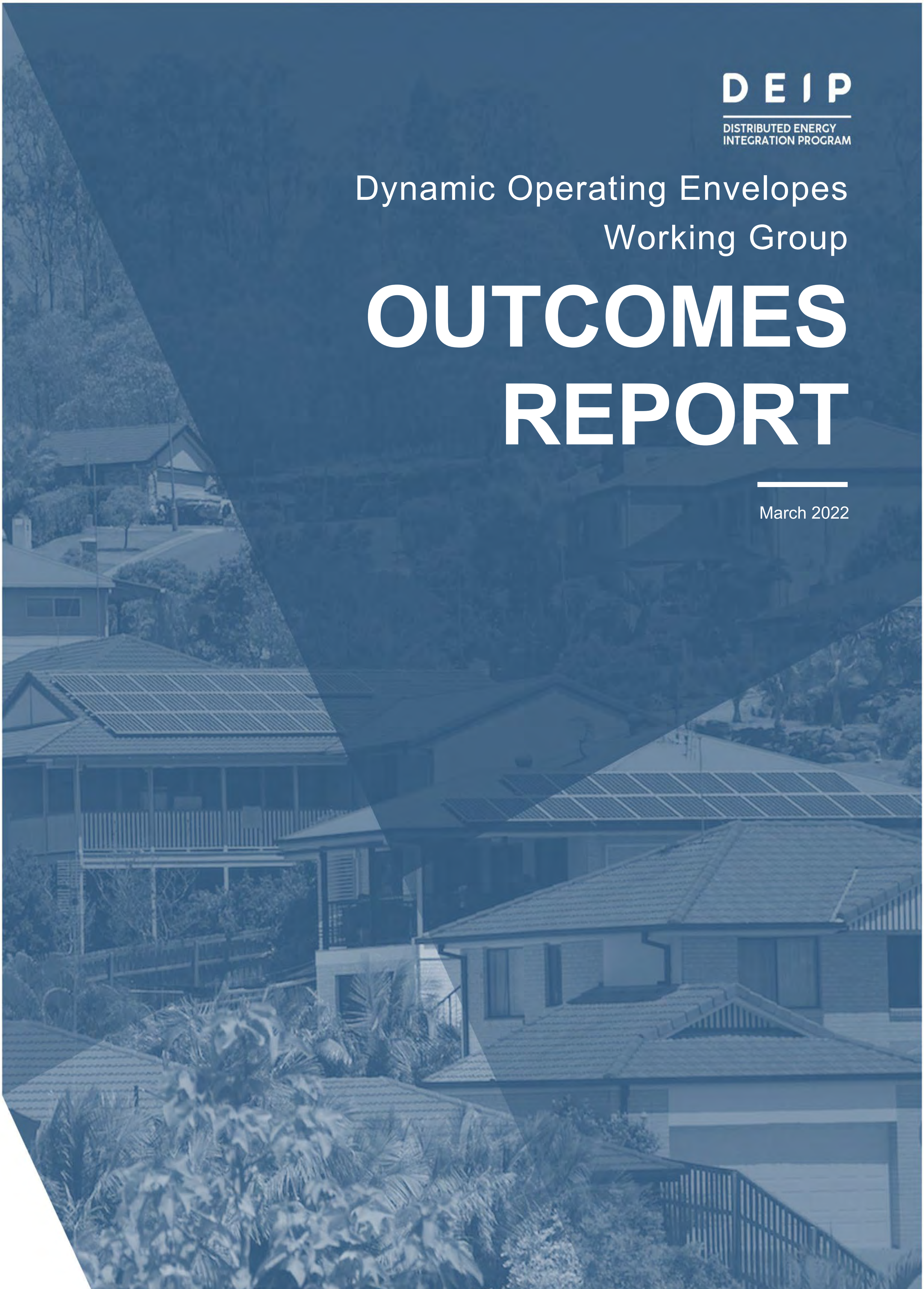

DEIP

DISTRIBUTED ENERGY INTEGRATION PROGRAM

Dynamic Operating Envelopes Working Group

OUTCOMES REPORT

March 2022

ABOUT DEIP

The Distributed Energy Integration Program (DEIP) is a collaboration of government agencies, market bodies, industry associations and consumer associations aimed at maximising the value of customers' distributed energy resources (DER) for all energy users. DEIP is not an organisation, it is a forum where organisations come together to share insights and develop priorities.

A key element of DEIP is to facilitate workshops with key stakeholders across the sector that inform potential changes to fully integrate DER into Australia's energy market frameworks and operational processes. These forums are driven by the premise that collaborating on DER issues will more efficiently identify knowledge gaps and priorities, as well as accelerate reforms in the interest of customers.

For more information on DEIP, visit the DEIP website[1].

DEIP DYNAMIC OPERATING ENVELOPES WORKING GROUP

This report has been drafted by the DEIP Dynamic Operating Envelopes Working Group (the Working Group). The Working Group includes representatives from the Australian Energy Market Commission (AEMC), Australian Energy Market Operator (AEMO), Australian Energy Regulator (AER), Australian Renewable Energy Agency (ARENA), Energy Consumers Australia (ECA), Energy Networks Australia (ENA), Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australian National University (ANU), and SA Power Networks (SAPN). The report has been informed by the Working Group, several studies[2] and collaboration with a broad range of industry and consumer stakeholders, through multiple workshops and additional feedback provided to the Working Group. The workshop materials and reports can be found on the DOE section of DEIP's website[3].

[1] DEIP website, arena.gov.au/distributed-energy-integration-program

[2] See Appendix C for more information on CutlerMerz's "*Review of Dynamic Operating Envelope Adoption by DNSPs*" and Appendix D for more information on ENEA's "*Smarter Homes for Distributed Energy*".

[3] Dynamic Operating Envelopes webpage, arena.gov.au/knowledge-innovation/distributed-energy-integration-program/dynamic-operating-envelopes-workstream

DISCLAIMER

This report has been published by the Distributed Energy Integration Program (DEIP) and was drafted in a collaborative co-authoring approach using inputs from stakeholders through the workshops and feedback provided by the Working Group. The Working Group organisations have not officially endorsed the contents of this report, nor does the report necessarily represent the official views or opinions of the DEIP or Working Group members, including the Australian Government. The views expressed herein are not necessarily the views of the Australian Government, and the Australian Government does not accept responsibility for any information or advice contained herein.

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The conclusions and findings contained in this report reflect the feedback of stakeholders and are intended to be used as guidance only to be considered when undertaking future dynamic operating envelope reforms. While the findings reflect a strong alignment of stakeholder views, absolute consensus across a broad range of stakeholders is not always possible. It is envisaged that further consultation is likely required on how the findings should be implemented and how any impacts are to be addressed.

LIST OF ABBREVIATIONS

AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
API	Application Programming Interface
ARENA	Australian Renewable Energy Agency
BTM	Behind the Meter
DEIP	Distributed Energy Integration Program
DER	Distributed Energy Resources
DNSP	Distribution Network Service Provider
DOE	Dynamic Operating Envelope
ECA	Energy Consumers Australia
ENA	Energy Networks Australia
ESB	Energy Security Board
EV	Electric vehicle
FCAS	Frequency Control Ancillary Services
FRMP	Financially Responsible Market Participant
LV	Low voltage
MSGA	Market Small Generator Aggregator
NECF	National Energy Customer Framework
NEM	National Electricity Market
NEO	National Electricity Objective
NER	National Electricity Rules
NETCC	New Energy Tech Consumer Code
NMI	National Meter Identifier
PV	Photovoltaic
Qld	Queensland
RERT	Reliability and Emergency Reserve Trader
SA	South Australia
V2G	Vehicle to grid
VPP	Virtual Power Plant
WDR	Wholesale Demand Response
Working Group	DEIP Dynamic Operating Envelope Working Group

EXECUTIVE SUMMARY

The purpose of this Outcomes Report is to inform ongoing and future considerations by industry, governments, market bodies and regulators in the energy sector. It is a summary of extensive consultation with industry and consumer groups undertaken by the DEIP Dynamic Operating Envelopes (DOE) Working Group over the last 18 months[4] to explore and advance the role of DOEs in Australia's future power system. It has been jointly developed by members of the DEIP DOE Working Group (the Working Group) with input from the energy market bodies, industry stakeholders, researchers and consumer representatives.

This report focuses on the use of DOEs for export management and seeks to identify the current "state of play" of DOEs and capture the future policy, regulatory, technical and industry actions needed to implement a nationally consistent model for DOEs that will work in consumers' interests.

While it is possible that DOEs could be used to manage 'flexible loads' such as water heaters, battery storage and electric vehicles (EVs), the implementation of import DOEs are likely to have additional issues that warrant further consideration and consultation. Therefore, the use of DOEs to manage electricity consumption is not in the scope of this paper.

Supporting efficient network management

It is commonly accepted that as more customers adopt solar and other distributed energy resources (DER) such as home batteries and EVs, the approach to managing network capacity and arrangements by which customers access the electricity grid must evolve.

Electricity networks have a finite capacity to accept electricity exports from customer DERs. The continuing increase in customer exports means parts of the distribution network are reaching their limits to accept further exported energy. To ensure network integrity is maintained within a region of their network, distribution network service providers (DNSPs) place limits on how much customers are allowed to export[5]. Currently these limits are static (fixed) and are set based on maintaining integrity in all network conditions including during peak net export times (representing worst-case scenarios), which occur rarely. The current approach can be overly restrictive and lead to excessive amounts of customer exports being curtailed. To this end, DOEs provide a more efficient approach to managing network capacity by allowing DNSPs to vary customer export limits dynamically. They allow customers to export more electricity and limit exports only when necessary.

By way of analogy, DOEs are like the variable speed limits in a school zone. A static limit is likened to imposing a single low-speed limit at all times. With a dynamic limit, during busy school times, the variable speed limit drops to ensure the community (in this case, the power system) stays safe. Outside busy school times the variable speed limit is higher, so as not to unduly restrict traffic flows. Overall, having variable speed limits allows traffic to move as fast as conditions allow.

Through various consultations, the Working Group has adopted the following working definition of DOEs:

> *"Dynamic operating envelopes vary import and export limits over time and location based on the available capacity of the local network or power system as a whole."* [6]

DOEs can allow the network to support greater levels of exports at low cost and provide for greater levels of customer access to the network for exports. They are calculated by the DNSP and can be communicated to customer devices over different pathways. "DOE ready" DER devices or aggregators can maintain output within the "envelope".

This report is focused on the opportunity to increase deployment of DOEs in the immediate term and increase export limits for distributed solar and other embedded generation. The Working Group has considered options for the initial implementation of DOEs based on widely available technology in

[4] See [Appendix A: Overview of DOE Workshops](#)

[5] Export limits are programmed into embedded generation devices as determined by a customer's connection agreement with their DNSP.

[6] As discussed in the opening paragraphs, this report only considers the use of DOEs for export management. The use of DOEs to manage imports is out of scope of this paper.

consumer premises. Further consideration is required as new technology, uptake and industry understanding of DOEs, their application and most efficient design in the long-term interests of consumers is investigated.

Customer and system benefits

DOEs represent an advancement in the approach to managing network capacity and they can bring significant benefits for the customers and the electricity system. They can significantly increase the amount of customer-generated renewable energy, such as rooftop solar PV exports, that is delivered through the network while maintaining safe operation of the electricity system without the need for costly network upgrades. In doing so, they can also support greater de-carbonisation of the electricity system, and provide opportunities for customers to create more value from their DER investments.

Overall, the potential benefits of DOEs include:

More Solar / Battery Export	Market Efficiency	Greater Interoperability	Network Efficiency
DOEs enable more solar customers to connect and export electricity, and for more of the time. Initial trials of DOEs are supporting a doubling of the average customer connection and the ability to economically connect many more customers than via traditional methods.	DOEs enable more embedded generation, like solar and batteries, to get to market which helps to reduce wholesale energy prices for all customers, not just those that have generation themselves. In particular, opening up greater network capacity in the morning and evening peaks will allow batteries and V2G to capture value from frequency control markets (FCAS) and during high cost 'ramping events'.	DOEs support efficient signals to customers to shift their demand to times of surplus solar energy, reducing the need for networks to invest in costly upgrades resulting in reduced network charges for all customers. DOEs also future proof the connectivity between customers, the network and the market enabled by a more dynamically connection.	Flattening network loads, thereby improving network asset utilisation, reducing volumetric network charges for all customers, enabled by DOEs, provides for a more efficient use of the network. DOEs also support the future stability of the energy grid during periods of excess generation (i.e. minimum system load conditions) reducing the need for redundancy in the system or additional investments to be made.

Figure 1: The potential benefits dynamic operating envelopes can offer to the electricity system

While the current focus for DOEs is on export management, the technical capabilities that support dynamic export management are also likely to enable smarter homes and grids and allow customers to play a more active role as Australia transitions to greater levels of DER. In the future, DOEs may have the potential to help manage the integration of electric vehicles by signalling the additional capacity that may be available at certain times of the day for low-cost EV charging, and times when charging would contribute to grid congestion. This use case has the potential to keep the costs of managing networks to a minimum – reducing network charges for all electricity customers.

Establishing a social licence for DOEs

To realise these potential benefits, the rollout of DOEs requires a social licence. A social licence in this context refers to the informal permissions granted by stakeholders for institutions to make decisions on their behalf about the operation of their DER systems[7]. The cost or effort required to establish this social licence depends on the consumer's ability to recognise direct benefits from the program and their ability to opt-out. To build a social licence industry and policy makers must frame the design of a DOE program (and other DER activities) from a consumer-outcomes perspective, and not just from the perspective of fixing a technical problem. Recognising values and expectations will be essential in implementing a DOE program that consumers buy-in to and trust. Without this social licence and consumer buy-in it will be difficult to recognise the benefits for individual consumers and the broader system.

[7] ECA Social Licence for Control of Distributed Energy Resources 2020, energyconsumersaustralia.com.au/wp-content/uploads/Social-License-for-DER-Control.pdf

Current state of play

Appropriate settings for DOEs are needed

DOEs are expected to be an important feature of the grid of the future. The development of DOEs in Australia is being led by DNSPs, with DOEs being considered by majority of the DNSPs[8]. They are at an early stage of industry adoption and the focus is on the use of DOEs for managing electricity exports. There are various ongoing projects and trials at different scales and maturities that are testing different dimensions of DOEs. Nevertheless, DOEs are expected develop further as DER penetration increases and markets or business models are created to provide customers with value.

While there are many similarities in the approaches being taken by networks, a key finding of stakeholder consultation[9] is that consumer's interests will be enhanced through greater national consistency in the implementation of DOEs. As a result, this report seeks to explore ways to enhance national consistency.

Given the expected roll-out of DOEs, it is important to ensure that policy and regulatory settings, and industry practices are fit-for-purpose to support the adoption of DOEs in a manner that benefits customers.

The Working Group has identified that there is a need for increasing oversight by regulators and greater transparency for customers, whilst retaining the flexibility to accommodate learning from early trials. The Working Group's findings and recommendations for actions needed to support the implementation of DOEs in customer-centric manner are outlined in Table 1 below.

However, it should be noted that these recommendations do not seek to provide a final blueprint for the adoption of DOEs. Instead, the report considers pertinent issues and suggests actions towards addressing more immediate concerns. Some of the issues and approaches highlighted need to be considered at a later stage as DOEs mature and their applications expand.

Implementation considerations

The current landscape of DOEs has been considered from the perspective of various stakeholders. Below is a summary of the Working Group's findings:

- **Networks:** The *Review of Dynamic Operating Envelopes Adoption by DNSPs* study underway by CutlerMerz highlights that DOEs are an emerging feature of the electricity distribution system and all DNSPs have either adopted or have an intention to introduce DOEs. The timing to incorporate DOEs into connection agreements varies according to the expected rate of DER uptake in each network area. Four networks that have the most pressing need are already undertaking field trials, with SA and Qld planning to incorporate DOEs into their standard connection offers from 2022.
- **Industry participation:** From the trials completed and underway there has been a high level of interaction between DNSPs and installers, product OEMs or suppliers, aggregators, AEMO and retailers. Despite this experience, industry capability and experience must be further developed to support the widespread deployment of DOEs.
- **Building and maintaining customer social licence:** The Working Group has identified the need to build transparency and social licence around DOE design and operation through effective consultation with customers and their representative groups. Some stakeholders consider that, as DOEs become more widespread, there may be a need for additional regulations to ensure that there is consistency, transparency and fairness. This will provide customers the confidence that DOEs are aligned with the National Electricity Objective (NEO), For more information, refer to Chapter 3.
- **Policy and Regulation:** The NER supports the delivery of DOEs and the AER has approved SA Power Networks' expenditure proposal and 'model standing offer' enabling them to offer DOEs in South Australia from 2021.[10] The market bodies are actively investigating policy and regulatory reform to accommodate the widespread deployment of DOEs to manage exports by networks, and

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[8] CutlerMerz, *Review of DOE Adoption by DNSPs* (See Appendix C of this report)

[9] *National Regulatory and Policy Design Issues* workshop hosted by DEIP DOE Working Group in November 2020

[10] A model standing offer is a connection agreement imposed on customers connecting to a network that includes AER approved terms and conditions. It defines technical requirements and fees and charges.

customers' desire for greater oversight, consistency, alignment of incentives and transparency on how DOEs are designed and operate. For more information, refer to *Chapter 4*.

- **Standards:** DNSPs and the DER industry are aligning on IEEE2030.5 as the national standard for DOE communications and the cross-sector national DEIP Interoperability Steering Committee has recently released the *Common Smart Inverter Profile – Australia* (CSIP-AUS)[11], now in the process of standardisation through Standards Australia.
- **Government support:** There has been some support by State and Federal Government, most notably:
    - ARENA supported trials are exploring the use of DOEs by DNSPs, in managing the operation of customer technologies such as battery, rooftop solar PV and EVs, in helping to manage electricity exports in distribution networks. The knowledge gained from these trials is important in understanding the potential application of DOEs for current and future use cases. Information on these trials is included in Chapter 2.
    - Of particular note is South Australia where the state Government has mandated that all new solar installations are 'dynamic exports-capable' from December 2022 to enable it to manage the highest penetration of PV, relative to underlying demand, currently in the NEM.
- **Technology readiness:** Where customers have multiple devices in their home, the Working Group's review of Customer and Home Energy Management Systems[12] finds that these systems are generally capable of being orchestrated to conform to single export limit applied at the point of connection to the network. However, there are technical and commercial barriers within the behind-the-meter (BTM) ecosystem that require further consideration, especially in relation to device-to-device open interface and flexible demand management (e.g. water heaters, pool pumps and EVs) under DOEs that can assist customers use their embedded generation during periods when their exports are constrained.

DNSPs are at varying levels of DER uptake and therefore experiencing differing levels of network constraint. Despite this variability, the Working Group has noted the medium-term trend to DOE adoption by most DNSPs. The diagram below is an excerpt of a report prepared by CutlerMerz (see *Appendix C*) and illustrates the current DOE trials and the status of DOE development for a range of DNSPs.

[11] Common Smart Inverter Profile – Australia, arena.gov.au/knowledge-bank/common-smart-inverter-profile-australia/

[12] For more information see *Appendix D: Smarter Homes for Distributed Energy*

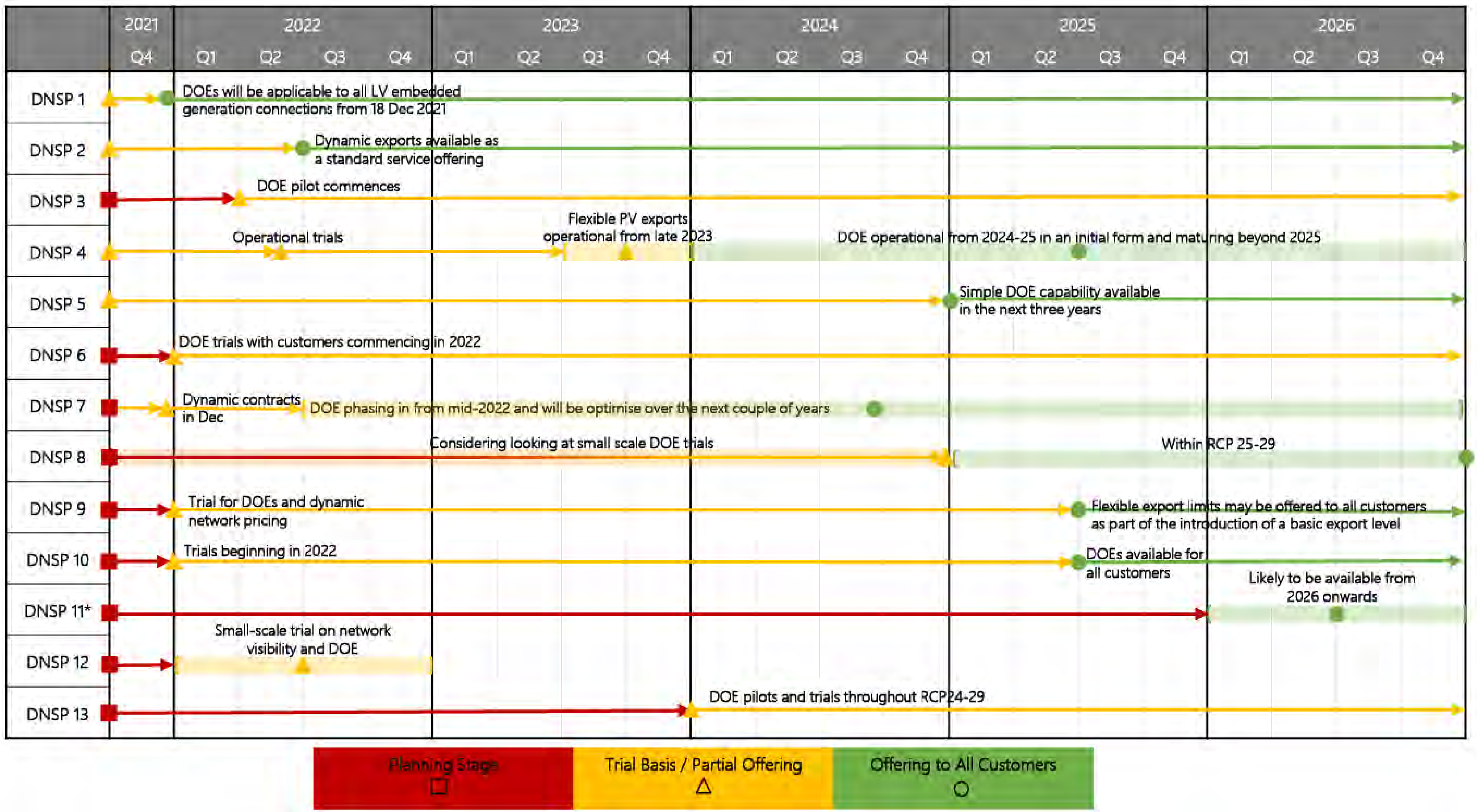

Figure 2: Overview of DOE implementation[13]

[13] The information in this graph is of a general nature and represents activities that are in development or planning at the time of publication, which may change over time and may only apply to selected customer groups. The timing and level of this DNSP's DOE rollout will depend on market designs, their role within that market design, and technology maturity. DNSPs are shown in no particular order. DNSPs that exist in a conglomerate, or as part of a broader entity, have been treated as a single DNSP.

Summary of Working Group findings and recommended actions

The findings and actions embedded in this report are summarised from observations made by the Working Group and are included in the table below. It should be noted that these findings are expected to complement and leverage existing consultations underway and should be considered within the context of other reforms.

Collaboration with industry and consumer groups has been key to the DEIP DOE workstream and this needs to continue through subsequent stages of work. This is especially important to build transparency, understanding and social licence for DOE design and associated reform processes.

Table 1: Summary of key actions for implementation of DOEs

#	Working Group Findings
Supporting the roll-out of DOEs	
1.	**DOEs do not need to be mandated:** A mandate on DNSPs to implement DOEs is likely to result in bringing forward their implementation only where they are not already considered an efficient and prudent investment. A mandatory requirement on DNSPs to deploy DOEs is therefore not in the interests of electricity consumers.
2.	**Build on learning from trials:** Insights from current or future trials should be broadly shared. This will help industry develop a richer understanding of the strength and limitations of technical approaches and of customer needs, preferences and experiences. These can inform the evolution of DOE models including the roles and responsibilities of networks and other parties involved in the consumer journey.
3.	**Strengthen linkages with international technology standards processes:** Seeking consistency with international standards needs to be balanced with the recognition that the emerging use cases for DOEs in Australia are world leading. Stronger alignment with international standards will require greater Australian representation on international standards committees to influence standards development.
4.	**Implementation of DOEs should not be limited to new solar customers only:** While the initial application of DOEs will be on new solar customers, care should be taken to not create barriers to adoption by existing solar customers and innovative future use-cases. Future proofing current DOE implementations can reduce costs and increase choice for consumers in the medium term.
5.	**Establishing a social licence for DOEs:** A social licence is essential to a successful DOE roll out – both for current and future use cases. If consumers don't trust and buy into the program the potential benefits will be reduced. To do this DNSPs and regulators need to provide accessible information on the purpose of DOEs, how they are being designed and managed over time. Greater transparency and accountability by industry, and the use of language that is meaningful to consumers, can support community social licence for DOEs and related reforms. This will also be essential if industry, in the future, seeks to expand the use cases for DOE usage.
6.	**Transparency about dynamic constraint levels:** The Working Group agrees with the ESB's view that the introduction of DOEs warrants a corresponding focus on the transparency and reporting requirements by networks to justify the reasons for constraints that are applied via DOEs and that this should include regular data reporting to the AER, similar to the Regulatory Information Notices (RIN) frameworks for reliability reporting.
Supporting customers in their choices	
7.	**Supporting the greater uptake of DER:** Industry and regulators should retain a focus on the efficiency of network investments and how DOEs can contribute to supporting increased uptake of DER. The Working Group notes the AER is implementing a DER Integration Guidance note for DNSPs that specifically requires consideration of DOEs.

8.	**Customers should be able to opt in or out of DOEs:** The Working Group considers that where DOEs are enabled on a local network, customers should be provided the choice to opt into or out of DOEs according to their preferences, noting that the alternative may be a lower static limit.
9.	**Utilise existing risk assessment tools**: Market bodies should consider using the ESB's Consumer Risk Assessment Tool to ensure consumer benefits and risks are explicitly considered in the design and implementation of DOEs. This should be demonstrated through consultation papers, options analysis that explicitly considers the benefits, gaps or risks to consumer protection principles.
10.	**Enable affordable and accessible dispute resolution:** Regulatory bodies should identify and address any gaps in customers accessing affordable dispute resolution when it comes to DOEs and related DER issues. Consideration could be given to ensuring that state-based energy ombudsman schemes have adequate capacity and powers.
11.	**Solar retailers and installers have an important role in information provision:** Solar retailers and installers will play a critical role in communicating a customer's connection options, product options, expected benefits and ways of managing their energy uses. The Working Group supports DNSPs working closely with solar retailers and installers to appropriately inform them and help them develop effective communication material for customers on DOEs.
12.	**Protecting consumers from misinformation:** The New Energy Tech Consumer Code (NETCC), where adopted, will provide some protections to customers from misinformation provided by installers and energy system retailers. Industry engagement by DNSPs, the scope of the NETCC, and its adoption, should be monitored by the market bodies to ensure appropriate information is delivered to customers to support their technology investment decisions.
13.	**Build up compliance information and incentives**: DOE non-compliance may be associated with on-site configuration issues and relate to the work of equipment OEMs and installers. The Working Group supports DNSPs working closely with solar retailers, aggregators and installers to build compliance capacity.
14.	**Information on DOEs must be easily accessible:** Customers need to be provided with easily accessible and digestible information to be able to make informed decisions and choices. Market bodies and the industry should, through evidence-based research work together to further identify the current gaps in information customers may want or may need.
15.	**Consumers should have easy access to data on their DOE performance:** Access to operational data is important to a range of customer decisions and data transparency is critical to building and maintaining social licence. There is a need to further explore what DOE related data customers want access to and can benefit from and how this data is communicated. Consideration will need to be given to how this data is shared, the merits of nationally consistent approaches, central repositories, open APIs, and access and sharing rights for data held by DNSPs, OEMs or aggregators.
16.	**Assigning compliance risk to the right parties:** Market bodies should consider reforms to the connection framework that assigns the risks associated with DOE compliance to the party best placed to manage those risks.
17.	**Poor BTM interoperability presents a potential barrier to consumers recognising full potential benefit:** The Working Group considers that greater BTM device interoperability, to support HEMS market development will help customers achieve the greatest benefits from DOEs. The *Smarter Homes for Distributed Energy* study conducted by ENEA on behalf of the Working Group recommends that market bodies, governments and industry further consider the cost and benefit of introducing mandatory or voluntary behind-the-meter open device standards.

Nationally consistent approaches to implementation	
18.	**Work towards nationally consistent approaches:** DNSPs and market bodies should continue to work toward national consistency to reduce costs and simplify participation for consumers and industry stakeholders.
19.	**CSIP-AUS/ IEEE2030.5 provides a suitable framework for network-client communication** - CSIP-AUS/ IEEE2030.5 is being adopted by various DOE trials underway and provides a suitable framework for network-client communication. Further work is required to determine whether and how this could be applied as a national standard in the industry.
20.	**DOEs can be initially allocated at the connection point:** The Working Group considers that DOE allocation is best applied initially at a customer's point of connection to the network, in relation to net exports (after accounting for customer demand). This approach may evolve in future to support new market frameworks such as flexible trading arrangements.
21.	**Draft principles for good practice DOE allocation:** The Working Group has developed draft export hosting capacity allocation principles to provide guidance to DNSPs in developing their capacity allocation approaches. These relate to transparency, efficiency, fairness, incentives for demand management, technology neutrality, customer choice and incentives. More work is required to further define how these principles will be applied in practice.
22.	**More work needed to finalise a device control hierarchy:** The Working Group has developed a draft control hierarchy that is consistent with current practice and reinforces the principle that customers should be free to operate within the physical constrains of the local network or the power system more broadly.
23.	**Further consultation is needed on device fall-back behaviour.** A nationally consistent framework for determining device fall-back behaviour on loss of communications for customer devices should ensure minimal disruption to customers and earliest possible restoration of DOE operation. Such a framework should provide flexibility for DNSPs to determine local settings reflecting local conditions while supporting AESCSF[14] processes and outcomes.
24.	**Using a 5-minute interval duration is efficient:** DNSPs should implement or provide a plan to transition to setting DOEs at a 5-minute duration interval. The short-term additional costs (if any) of implementing this approach are likely to be small in relation to the longer-term benefits of clear and consistent product development signals to industry and efficient market outcomes that benefit all consumers.
25.	**A framework for constraints forecasting should be developed:** A nationally consistent framework for constraint forecasting should be developed and be guided by the information needs of customers and their agents and the need to align with existing forecasting and bidding systems for AEMO and market participants. Further work is needed to recommend appropriate national settings for constraints forecasting and to assess the costs and benefits of adopting these settings nationally.
26.	**Longer range forecasting is a priority:** The Working Group considers that longer-range constraint forecasting should be an important focus area for industry over the course of 2022 to inform customers currently considering investing in embedded generation.
27.	**Detailed DOE calculation methodologies need not be standardised:** The Working Group considers that the national harmonisation of the detailed DOE calculation methodology would be unnecessary and difficult to achieve.

[14] Australian Energy Sector Cyber Security Framework

CONTENTS

1. INTRODUCTION

1.1. The energy transition

The popularity of rooftop solar capacity and resulting increase in exports has meant that managing the stability, security, and reliability of the grid is becoming an increasing challenge and DNSPs are now required to adapt to how customers want to use the network.

Solar generation is both variable and coincident. Its variability means that power system protection and management settings need to account for various outcomes to ensure the grid remains stable. The coincidence of solar generation in a local area can result in major reductions in demand or even net outflows from a network area which can lead to network voltage and thermal limits being breached.

Similar challenges will be associated with the operation of batteries and EVs in the future. Orchestrated energy storage systems can switch quickly from charge to discharge modes in response to wholesale market movements, system frequency or other events. While it is possible that dynamic operating envelopes could also apply to setting import limits this Outcomes Report refers to dynamic operating envelopes only in the context of exports. Further issues arise when considering how DOEs could, in the future, be applied to imports, which are not considered in the scope of this paper.

To ensure the security of the grid, DNSPs have historically imposed static limits (kW/customer) on exports that are calculated based on the limits of the network under 'worst case scenarios'. As more customers install embedded generation, the further these limits will need to be tightened. As they apply all the time, these static limits also often constrain customer exports much more than is required.

DOEs provide an alternative model which allows customers to export more electricity outside of peak times and curtail exports only when necessary. They therefore provide for a greater return on customers' investments in solar and other DER. In the future, DOEs will support smarter homes and grids and allow customers to play a more active role as Australia transitions to higher levels of renewable energy on the grid. While it is possible that dynamic operating envelopes could also apply to setting import limits this Outcomes Report refers to dynamic operating envelopes only in the context of exports. Further issues arise when considering how DOEs could, in the future, be applied to imports, which are not considered in the scope of this paper.

It is forecast that the amount of rooftop solar on customer roofs will continue to grow up to 4-times the volumes we have today.[15] DOEs will enable increased access to networks for these new connections as well as supporting more efficient operation of the grid.

1.2. The DEIP Dynamic Operating Envelopes Working Group

Recognising the value that DOEs could offer to the energy transition, the Distributed Energy Integration Program (DEIP) created the DOE workstream as part of its 2021 work plan. The workstream aims to:

- build a shared understanding of the opportunities and challenges
- share insights on approaches currently under investigation
- identify reforms that could be implemented to establish DOEs.

The workstream was led by the Working Group which consists of representatives from:

- Australian Energy Market Commission (AEMC)
- Australian Energy Market Operator (AEMO)
- Australian Energy Regulator (AER)
- Australian National University (ANU)
- Australian Renewable Energy Agency (ARENA)

[15] AEMO, Draft 2022 Integrated System Plan, page 10, aemo.com.au/en/energy-systems/major-publications/integrated-system-plan-isp/2022-integrated-system-plan-isp

- Commonwealth Scientific and Industrial Research Organisation (CSIRO)
- Energy Consumers Australia (ECA)
- Energy Networks Australia (ENA)
- SA Power Networks (SAPN)

1.3. The purpose and scope of this Outcomes Report

This paper sets out the Working Group's insights on how a national design and implementation framework for DOEs can be progressed, as further work is undertaken to test potentially alternate models, and technology uptake advances alongside market design reforms. It is intended to synthesise the current industry developments on DOEs, learnings from trials and crucial insights to develop social licence that would support decision making processes by industry and policy makers.

This Outcomes Report intends to reflect the extensive consultation by the Working Group with industry and customer representative groups. In many cases however, consultations revealed divergent opinions. This highlights the need for continued consultation on detailed design options and communication of DOEs. This report seeks to present a balanced approach to implementation – settling several major design features for DOEs while leaving room for further consultation and analysis to resolve outstanding issues, and also ensuring customers values are at the centre of decision making.

The Working Group's consultation has also revealed that DOEs can potentially have a broad range of applications beyond what is currently being considered and trialled. As DOEs are still a developing concept, this Outcomes Report scope of focus has been narrowed to the following:

- **Focus on exports** - While consultations[16] have recognised DOEs were applicable to both customer export and imports of electricity, this paper is focussed primarily on the export application. It was concluded that a staged approach, where DOEs can initially alleviate network export hosting capacity constraints and help to manage minimum demand offers the greatest benefits now. The Working Group has formed the view that significant further work would be required before the use of DOEs for imports can be considered. The Working Group considers that further consultations with customers and industry would be required to provide insights.[17]
- **Initial focus on measurement at the point of connection -** The Working Group has agreed in principle that DOEs should apply at the point of connection to the network, during the first step in their roll out. This reflects the that DOEs are currently enabled by current customer-network connection agreements. The implications of this approach on retail product innovation and customer choice are, however, yet to be fully considered, particularly in the context of possible future flexible trading arrangements involving multiple meters at the premises. This is touched on in *Chapter 4 - Policy considerations for making DOEs in the long-term interest of all* . Further work is planned to explore this area more fully.
- **Focus on local network constraints** - The Working Group's investigation has focused on the use of DOEs as a tool to manage network constraints, whilst acknowledging the applications and flow on benefits for broader system security management**.** Again, focusing on export management within the limits of network hosting capacity was seen as having the most benefit in the short term.

The energy sector is still in the early stages of a transition and reform approaches today will likely need to evolve, and thus must be designed with the flexibility to evolve. This will deliver the most efficient end state in the long-term interests of consumers.

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[16] See *Appendix A: Overview of DOE Workshops*

[17] References to DOEs in the context of imports are not applicable to what would be considered 'primary' load of a connection point, or typical household electricity usage. The reference to imports considers the potential for future development of smart 'secondary' flexible devices, such as EVs, that could respond to signals for dynamic imports (e.g. by temporarily adjusting the charge rate of the EV) with the consent of customers.

1.4. Implementing the outcomes of this report

This Outcomes Report presents various findings that have implications for the work of the market bodies, industry and consumer groups. The finding in this report will be considered by the ESB and market bodies as part of their ongoing work program on distributed energy resources integration. Outcomes will also provide an input into the ESB's DER Implementation Plan and Customer Insights Collaboration processes.

1.5. DEIP's DOE workstream

In late 2020, the DOE Working Group facilitated a knowledge sharing event and two exploratory workshops with over 140 participants. Through this process, the Working Group identified several concerns, opportunities and priority projects that could be progressed to ensure that consumers get the greatest benefit from DOEs.

Several projects were proposed to the DEIP CEO Forum in March 2021[18] which the Working Group then implemented over the course of 2021. The progress of activities completed is summarised in Table 2.

Table 2: Summary of DOE consultation activities for 2021

Work item	Description of activities completed
Understand the current state and implementation pathway of DOEs across Australian distribution networks	ARENA contracted the consultancy CutlerMerz to review the current state of DOE implementation across Australian distribution networks and the approaches taken by Distribution Network Service Providers (DNSPs). The report (yet to be published) identified that DOEs are an emerging feature of the electricity system with the bulk of Australian DNSPs either trialling or planning their DOE service offerings. A summary of this report is provided in *Appendix C: Review of DOE Adoption by DNSPs*. Note: This work item was additional to the work plan proposed to the DEIP CEO Forum.
Develop national capacity allocation principles to inform DOE development	The Working Group brought together stakeholders from across the industry - consumer groups, networks, research organisations, market bodies, retailers, aggregators and other organisations - to discuss the preferred allocation principles for DOEs. A summary of this workshop and its outcomes is provided in *Appendix A: Overview of DOE Workshops*.
Determine a preferred information architecture model with market participants and AEMO	This item in the DOE work plan was incorporated into broader industry consultation and working group process. Outcomes of the work to date in relation to data provision and forecasting are presented in this report and further work is required to settle a nationally consistent information architecture model.
Understand the technology and commercial readiness of customer energy management systems	ARENA contracted the consultancy ENEA to deliver a report on the market readiness of customer energy management systems for DOEs as they exist today. The report identified that a range of suitable products and services exist to manage exports, but there is benefit in further maturing device communications standards and there are limitations on what types of energy-using devices can be realistically controlled.

[18] DEIP CEO Forum, March 2021, arena.gov.au/knowledge-bank/presentation-deip-ceo-forum-18-march-2021/

	A summary of this report is provided in *Appendix D: Smarter Homes for Distributed Energy*.
Consider how to build a social licence for DOEs	The Working Group reviewed the social licence implications and the importance of communication, information and operational customer protection considerations associated with the deployment of DOEs. This work highlights the need for industry to bring customers along, in a manner that aligns to their needs and addresses the differences in real and perceived benefits/impacts of DOEs. For more information, refer to *Chapter 3: Building a Social Licence for DOEs* which summarises the findings from this work.
Review the regulatory, standardisation and operational considerations for DOE implementation	The Working Group reviewed the emerging regulatory, standardisation and operational considerations associated with the deployment of DOEs. The work explored the need for any changes to the regulatory framework and areas where consistency in the approach to implementing DOEs could support the wide-spread deployment of DOEs in a manner that supports the long-term interest of consumers. For more information, refer to *Chapter 4: Policy consideration* which summarises the findings from this work.

2. WHAT IS A DYNAMIC OPERATING ENVELOPE?

2.1. Why are they useful and how are they currently being rolled out?

Operating envelopes are the technical limits within which customers can import and export electricity as set by the physical constraints in the local network. Moving from static to dynamic operating envelopes represents one of the most significant changes to the customer connection model in a hundred years.

Currently, DOEs are focussed on rooftop solar PV energy exports with early demonstrations moving the average residential customer connection from a static limit of 5kW to a dynamic limit of up to 10kW. DOEs may support a doubling of the size of customer DER connections. The DOE concept may also, in the future, support the efficient management of other demand-side resources, such as electric vehicles, batteries and other flexible smart home devices. For example, as the rollout of EVs gains momentum, DOEs could signal when there is spare network capacity to enable faster EV charging.

DOEs will allow for more DER connections and larger capacities through more efficient utilisation of the existing electricity system infrastructure. This will benefit all customers, not simply DER customers. By using DOEs, distribution network operators can support greater access to customer generated renewable energy without the costs of major network upgrades, while maintaining current reliability, security, safety and quality of supply.

As we increase the overall amount of renewable energy connected to the grid, we are seeing periods where renewable generation exceeds the demand for electricity. By providing dynamic network connections, the DOE model will play an important role in enabling the future system by ensuring resources are coordinated.

Working Group Finding: *Supporting the greater uptake of DER*

Industry and regulators should retain a focus on the efficiency of network investments and how DOEs can contribute to supporting increased uptake of DER. The Working Group notes the AER is implementing a DER Integration Guidance note for DNSPs that specifically requires consideration of DOEs.

2.1.1. The current approach: static export limits

Most customers are allocated a fixed export limit when connecting a generation system to the network. This is established through the connection agreement between the network and the customer that is regulated under part 5A of the National Electricity Rules (NER). Each network business has its own connection agreement terms drawing on national standards and regulatory requirements imposed under the NER or jurisdictional technical regulations.

A typical residential fixed export limit is 5kW per phase, measured at the meter, and this applies to all distributed generation sources at a customer premises. Exports are also measured net of consumption. This means that a customer with a 5kW fixed export limit could operate 9kW of solar if they consumed at least 4kW themselves (with the remaining 5kW exported to the grid).

Network limits have historically been based on an estimate of diversified maximum or minimum demand conditions that may only occur on the network for 1-5% of the year. This means that customers are constrained further than what the physical limits of the system require for the remainder of the time. In practice, this means customers can export less solar than they otherwise would, meaning a potentially slower payback for their solar investment and less supply in the wholesale market overall.

2.2. An emergent approach: dynamic limits

New technology is emerging that provides customers greater flexibility regarding how they use their devices and the local electricity network. Specifically, rather than static export limits based on long-run forecasts of diversified minimum and maximum demand (outlined above), dynamic limits are based on the available capacity of the local network at that time and location.

Dynamic limits can be updated in near-real time to reflect current and local conditions and communicated to customer devices. For example, a dynamic export limit may increase a customer's flexible exports when the grid can accommodate it and reduce them only when there is local network congestion or other system risks. In effect, DOEs will help consumers access the existing underutilised network capacity which is currently not available under static limits.

DOEs could be compared to the variable speed limit at a school zone. Most of the time traffic can move at higher speed limits, however, during specific windows of time it is safer to reduce the speed limit. Variable limits are a much more efficient use of the road, allowing traffic to pass through at faster speeds than if the speed limit was permanently set to a lower rate.

Within a DOE, customers are free to use the grid in their preferred way, including participating (through their retailer or aggregator) in retail electricity, wholesale electricity and essential system services markets using a smart battery, electric vehicle and solar control systems. From a network's perspective, this can ensure the grid's security while supporting maximum economical utilisation of their assets.

DOEs will be an important feature of the future grid as they significantly increase the amount of customer-generated renewable energy, such as rooftop solar PV exports, delivered through the network without the need for costly network upgrades. This has multiple benefits to customers:

- DER customers can create more value from their solar, batteries and other resources.
- More significant amounts of customer generated renewable energy in the system may reduce wholesale market prices for all customers.
- Avoiding costly network upgrades will mitigate against electricity bill rises for all network customers.

Establishing a social licence and trust will be critical in consumers realising these potential benefits as without consumer buy-in, there may be limited uptake of a DOE program.

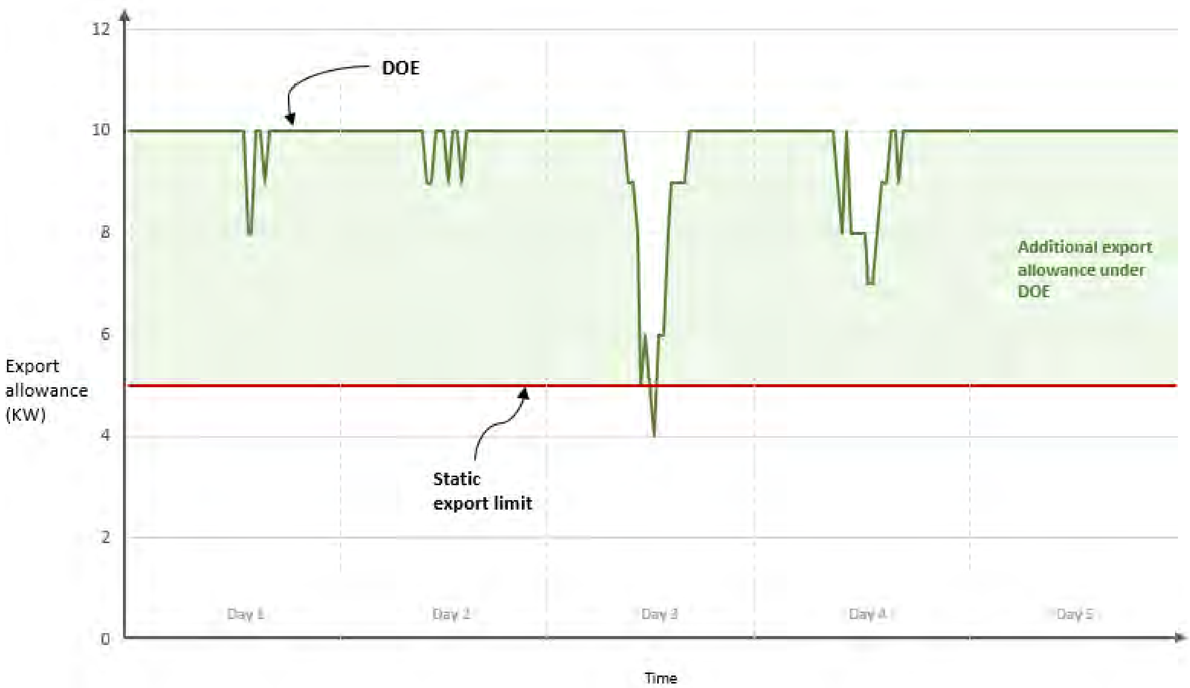

Figure 3: Illustration of the additional capacity a DOE can create

2.2.1. DOEs are useful in managing network constraints and offer benefits to customers

Power distribution networks are designed to operate under a peak capacity limit with a level of flexibility. They allow power flows and distributed generation to vary over time, while maintaining reliability, protecting electrical network assets, and managing voltage. The rapid uptake of rooftop solar (amongst other forms of DER) is pushing system limits in many parts of the grid.

These technical limits can be summarised as:

- **Network issues (voltage and thermal):** Fluctuations in solar output can significantly impact on both instantaneous and average voltage making it harder for network operators to comply with regulated voltage limits. As rooftop solar continues to grow, other constraints emerge as distribution network assets like transformers reach their thermal (current carrying) limit during times of high reverse power flow.
- **System issues (security):** The electricity system needs to be always maintained in balance. Too much generation or too much demand will result in blackouts. The system operators manage this at a macro scale through instructions to generators to increase or decrease their output. Residential solar is not currently linked into this model and cannot be turned down if required. The DOE model provides system operators with a means to limit customer exports when the security of the electricity system is at risk.

The extent to which a part of the network can host more solar generation or other distributed generation is sometimes referred to as 'network hosting capacity'. Several complementary strategies are expected to be employed by network businesses to enhance network hosting capacity and keep solar exports within system limits.

2.2.2. Implementation Considerations

DOEs are an emergent solution, complex in their implementation. Trials today are probing what they are to get a sense of why they're useful, which will shift them from good to best practice for all consumers.

Despite the consensus by a wide variety of stakeholders that DOEs have a net benefit, the specifics of how the model will be implemented requires further consideration. Some of the characteristics identified by the Working Group for mass deployment that will require future ongoing consultation include:

- **National standardisation of grid management practices** – Network businesses are currently deploying a range of technologies and operational practices (e.g. transformer dynamic tap changes) that enhance the grid's overall capacities. It is expected that customer use-cases and preferences will change, as will the maturity of new technologies and our understanding of best practices. The Working Group understands that there is already a high degree of communication between DNSPs to share best practice and suggest this should continue as we continue transitioning to host greater volumes of DER on the grid. The Working Group notes the AER is implementing a DER Integration Guidance note for DNSPs that specifically requires consideration of DOEs. The Customer experience is discussed in more detail in Chapter 3 and allocation principles are also discussed in Chapter 4.
- **Communication protocols:** Communications systems and protocols (including cyber security) require ongoing development. DNSPs and the DER industry are aligning on IEEE2030.5 as the national standard for DOE communications and the cross-sector national DEIP Interoperability Steering Committee has recently released the *Common Smart Inverter Profile – Australia* (CSIP-AUS)[19], now in the process of standardisation through Standards Australia, which describes how IEEE2030.5 is to be used to implement DOEs in the Australian market[20]. The adoption of the CSIP-AUS is a successful example of DNSPs and industry coming together to address a common gap. The Working Group considers further work on developing consistent standards through the DEIP Interoperability Steering Committee and other forum as essential.
- **Compliance obligations:** DOEs will ensure that the local grid and overall electricity system remain in a stable and secure state. Therefore, it is essential that the customer systems that are enrolled in a DOE comply with the DOE instructions. See Chapter 4 for details.
- **Customer protections:** DOEs represent a significant change to the way customers understand solar exports and connect to the electricity grid. DOEs that are being implemented today show a greatly increased level of access for customers with very limited restrictions on the customer's devices. While the models for DOE implementation are being developed, it will be critical for the

[19] Common Smart Inverter Profile – Australia, arena.gov.au/knowledge-bank/common-smart-inverter-profile-australia/

[20] The CSIP-AUS is derived from the original Common Smart Inverter Profile (CSIP) developed for the California energy market.

customer to be informed and have accessible information to help build trust and social licence. See Chapter 3 and 4 for details.

- **Inverter standards** – The AS/NZS4777.2:2020 inverter standard has recently been updated to better align the operations of these devices with the needs of the electricity grid. Again, the Working Group expects this standard to evolve over time and to support the operation of DOEs specifically.
- **Social licence:** Consumer buy-in and trust are essential for the successful deployment of DOEs. Without a social licence there may be limited uptake of DOE offers, diluting the potential benefits. This will be further explored in Chapter 3.
- **Customer transparency:** Explored further in Chapter 3, customers will require easily accessible information about where constraints exist, how DOEs are being used and what the overall benefits are of their use. This includes transparent and accessible access to data on where constraints exist that can be applied to practical contexts for consumers such as energy or real estate investments. The development of transparency and reporting frameworks will likely require consultation between customers, networks and regulators.
- **Network tariffs** – Cost reflective network tariffs encourage customers to change their electricity usage patterns, including shifting consumption to times of high solar production. Although some DNSPs are already offering 'solar soaking' or peak solar tariffs, there isn't a clear connection between tariffs and the use of DOEs. The focus currently is on embedding DOEs in the connection agreement with the customers however, it is expected that future tariffs will compliment this physical mechanism by offering customers improved financial signals.
- **Network regulation:** Under the Access, Pricing and Incentives rule change networks are regulated to host DER. As a result, regulatory oversight will need to evolve to ensure customers can have comfort that networks are investing and using DOEs in an efficient way that meets the NEO. See Chapter 4 for details.
- **Potential future use cases:** The potential use of DOE infrastructure for operational functions, market integration and managing system security (including system strength and inertia constraints management) as well as flexible loads such as EVs could be pursued if considered to be in consumers' interests.

Working Group Finding: *Work towards nationally consistent approaches*

DNSPs and market bodies should continue to work toward national consistency on DOE implementation to reduce costs and simplify participation for consumers and industry stakeholders.

Working Group Finding: *Strengthen linkages with international technology standards processes*

Seeking consistency with international standards needs to be balanced with the recognition that the emerging use cases for DOEs in Australia are world leading. Stronger alignment with international standards will require greater Australian representation on international standards committees to influence standards development.

2.3. How DOEs technically work in practice

The following section considers the technical implementation of DOEs. The processes for customer consultation and regulatory oversight are discussed in chapters 3 and 4.

The operation of DOEs can involve a series of steps:

1. **Calculation of the envelope –** As a first step the maximum export allowance for a customer for a given time needs to be calculated by the DNSP. This involves:

A. **Network hosting capacity estimation:** Estimate the initial power-flows due to uncontrollable supply and demand and determine the available hosting capability before network technical limits are reached.

B. **Incorporate any system-level requirements:** DNSP are required to help manage system reliability and resilience when directed to do so by AEMO. During extreme Lack of Reserve (LOR) or Minimum System Load (MSL) contingency events when the system is at risk, the DNSP may be directed to reduce the capacity made available via DOEs to achieve a system-wide reduction in generation or load.

C. **Capacity allocation:** Identify the DOE-capable connection points available to use the available hosting capacity. Allocate available capacity to each connection point for a given time and location in accordance with defined capacity allocation principles and methods.

D. **Ongoing monitoring and refinement:** Monitor and refine envelopes as forecasts change with the regulatory framework.

2. **Communication of the envelope to customer devices –** Once the appropriate allowance for each connection point (or device) has been determined, it will need to be communicated to customers, their agents or devices directly. In communicating the envelopes, the DNSPs may face a range of different types of customer site configurations that are capable of receiving DOEs as described in the behind the meter implementation scenarios below. The communication may take place over the internet and using a common communications protocol such as the CSIP-AUS v1.0 standard. The publication is expected to be done via APIs that allow a device or aggregator to communicate with a utility server to receive the DOE.

3. **Response to the envelope by customer devices –** Upon receiving the envelope, the customer device(s) will need to ensure that their operation does not breach the operating limits specified by the envelope. To achieve this, the customers devices will need to be "DOE enabled" i.e. be configured to receive a DOEs and adjust performance so that the prescribed DOE is not breached.

2.3.1. Communication framework

There could be different types of customer site configurations that need to be accommodated for a wide-spread deployment of DOEs. The CSIP-AUS implementation guide for IEEE2030.5[21] considers different DOE communication scenarios. Under all cases, a single IEEE 2030.5 client to manage net exports at the customer's connection point is needed, but the communication pathway for the envelope to the customer's devices could differ in the following ways.

Location of the IEEE2030.5 client

The IEEE2030.5 client receiving the envelope from the DNSP could exist:

- **Natively in the device:** the device has an embedded IEEE2030.5 client. This model is generally suitable for single inverter installations
- **In a separate physical gateway device**: this model is suitable for single "non-native" inverter installations or multiple BTM device and enables greater BTM optimisation
- **In the cloud**, either for a device manufacturer or third-party aggregator, where they are then responsible for communications interfaces with the customer devices

[21] IEEE2030.5 is a communications protocol for DER integration applications.

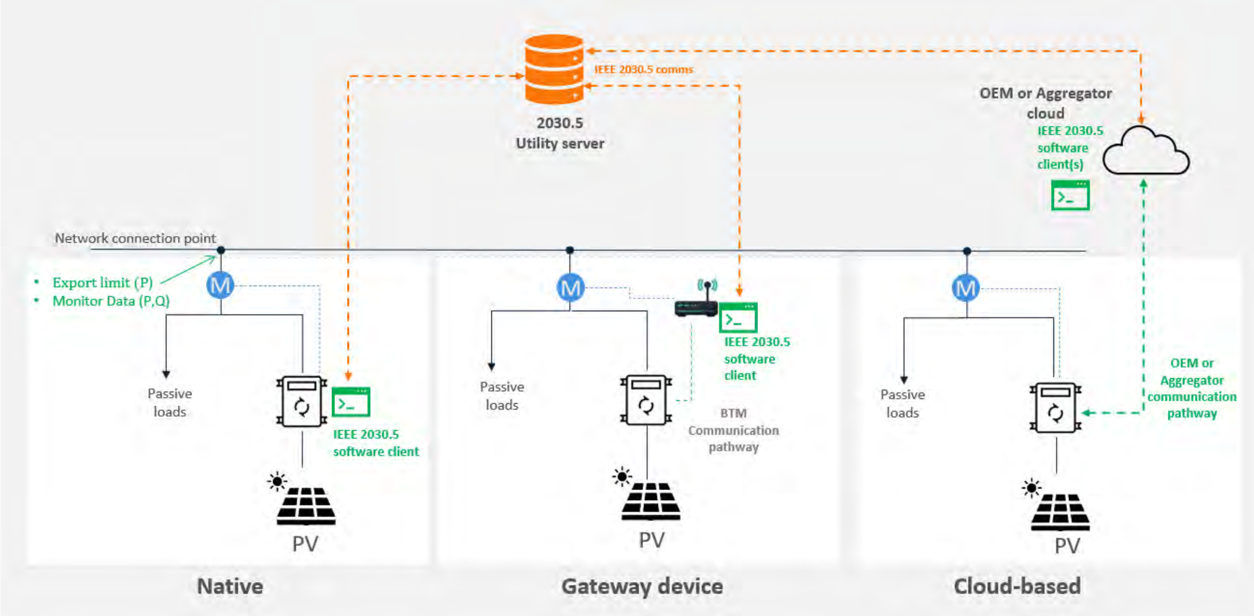

Figure 4: Overview of DOE interface landscape

Regardless of the location of the IEEE2030.5 client, power flows must be measured at the point of connection to the network net of embedded generation and the customer's electricity demand in order to verify compliance.

The system running the 2030.5 client contains the 2030.5 certificate. In the native/gateway models, this is located in the inverter/gateway respectively. In the cloud model, the certificate exists within the cloud platform and does not need to be embedded in the device.

While the communication between the DNSP utility server and the IEEE2030.5 client will make use of the IEEE 2030.5 standard, the communications pathway between the gateway device or cloud platform (if used) and the inverter controlling the embedded generation could, under current arrangements, be proprietary or follow unspecified standards.

Coordination of customer devices

A NMI-level implementation of DOEs using IEE2030.5 necessitates that there is a single nominated device or gateway device for a customer's site that controls and measures power flow at the point of connection. The operation of multiple behind the meter devices gives rise to a coordination challenge to ensure optimal device performance and compliance with the DOE at the connection point. This leads to the need for Home Energy Management Systems (HEMS). A report on the *Customer Energy Management Systems* by ENEA commissioned by ARENA takes at a closer look at these systems including their market readiness.[22]

Behind-the meter coordination, to ensure multiples devices work together to comply with a DOE issued at the connection point, can be achieved under gateway or 'master inverter' models as shown in the diagram below. Under the master inverter arrangement, one of the inverters may act as the 'master' to receive the DOE and coordinate the other BTM devices to ensure DOE compliance. While under the gateway device model, a separate HEMS device may act as the site gateway to monitor and manage all DER on the site and ensure compliance with the DOE.

[22] For more information see *Appendix D: Smarter Homes for Distributed Energy*

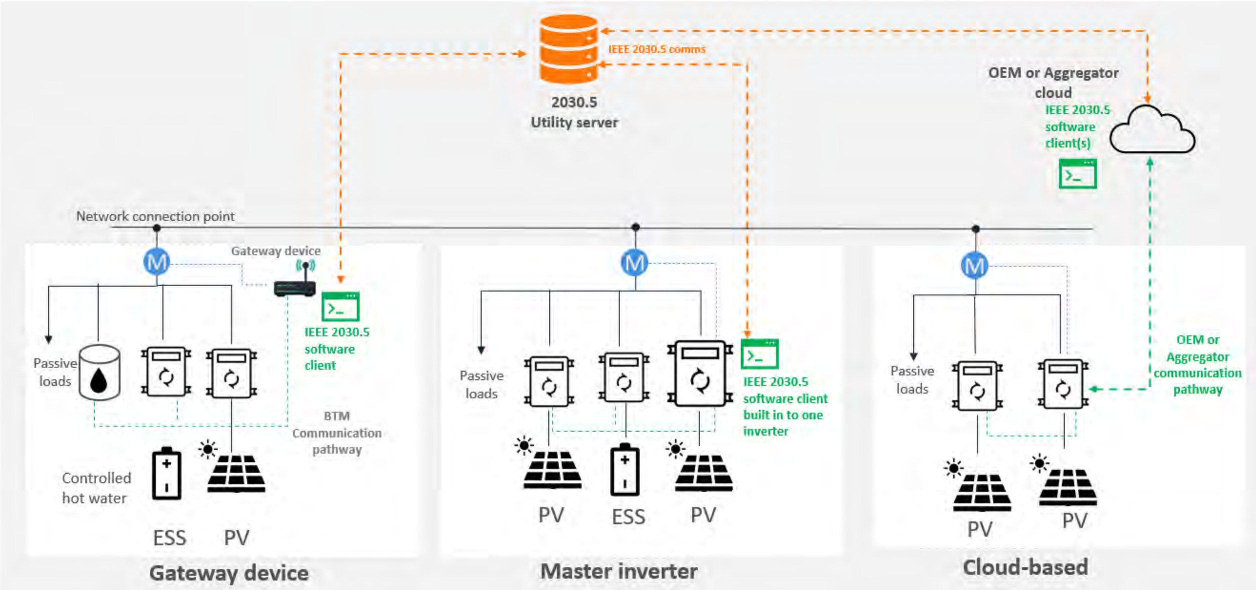

Figure 5: Examples of DOE interface landscape

Customer's use of agents

A customer's site could have:

- **Site direct communications** whereby a customer device (inverter or gateway) can receive the DOE from the DNSP. This may be achieved through direct communication between a site and DNSP or communications may be passed through a vendor's cloud platform. This is expected to be a popular option with manufacturers who have existing cloud-based solar monitoring solutions as it allows quick pathway to achieve CSIP-AUS compliance by leveraging existing (proprietary) communications pathways between a device and cloud platform and build the 2030.5 interface to the DNSP within the OEM cloud platform. In the short to near term, most customer sites are expected to fall in this category.
- **Agent-mediated communications** whereby a customer is registered with an agent such as an aggregator (potentially an energy retailer) that actively manages one or more of the devices on a customer's site. This model would support agents who wish to orchestrate the customer's devices to participate in the electricity spot market and ancillary service. The communication between the customers site and the agent's platform can be done using the agent's chosen communication protocol. The figure below shows an example for arrangements for a site actively managed by an agent.

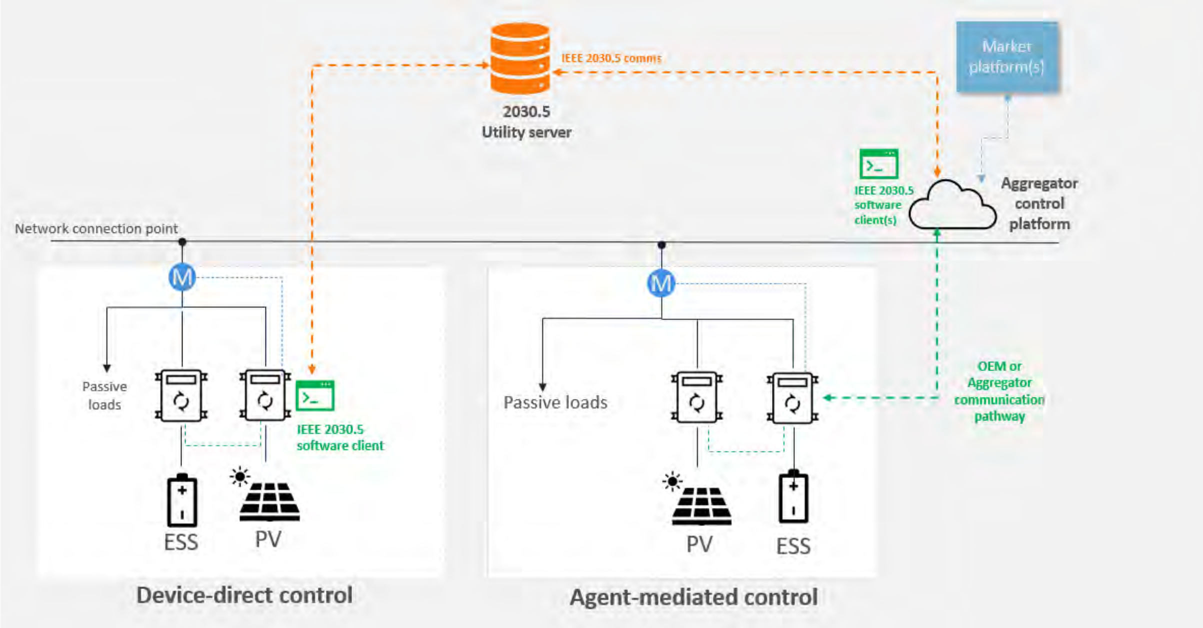

Figure 6: Summary of alternative communication pathways with DOE-enabled devices

A consequence of agent-mediated control approaches is that the DNSP doesn't communicate the DOE directly to a customer's DER but it instead communicates with the agent's platform and relies on the agent to communicate the instruction to the relevant site. It is possible that aggregators may opt to 'actively manage' customer devices while employing the device-direct model. In this case the customer's gateway device would likely have to resolve the various communications locally while ensuring compliance with the DOE.

Location of the IEEE2030.5 Certificate Authority

IEEE.2030.5 provides for secure communications between the 'client' (customer device or aggregator) and 'server' (the DNSP). This is enabled using digital certificates issued by a Certificate Authority (CA) that verifies the identity of each party when exchanging information. DNSPs are currently developing their own ICT systems to support DOEs including CA functionality. It is expected in the future that a national body will take on the CA role as this is considered beneficial in standardising and simplifying requirements for industry.

Working Group Finding: *CSIP-AUS/2030.5 provides a suitable framework for network-client communication*

CSIP-AUS/2030.5 is being adopted by various DOE trials underway and provides a suitable framework for network-client communication. Further work is required to determine whether and how this could be applied as a formal standard in the industry.

2.4. Networks are trialling DOEs in various ways across Australia

The concept of managing network capacity is not new, especially to network service providers, but the economic, technical and societal impacts of DER uptake are leading networks to develop more dynamic, efficient and equitable solutions to meet evolving customer expectations.

Working Group Finding: *Build on learning from trials:*

Insights from current or future trials should be broadly shared. This will help industry develop a richer understanding of the strength and limitations of technical approaches and of customer needs, preferences, and experiences. These can inform the evolution of DOE models including the roles and responsibilities of networks and other parties involved in the consumer journey.

The diagram on the next page is an excerpt of a report prepared by CutlerMerz[23] and illustrates the status of DOE development for a range of DNSPs. See *Appendix B: Overview of Current Industry Developments* for further details on relevant trials underway. The sections that follow summarise some of the key areas being explored in these trials and early learnings from them.

[23] For more information see *Appendix C: Review of DOE Adoption by DNSPs*

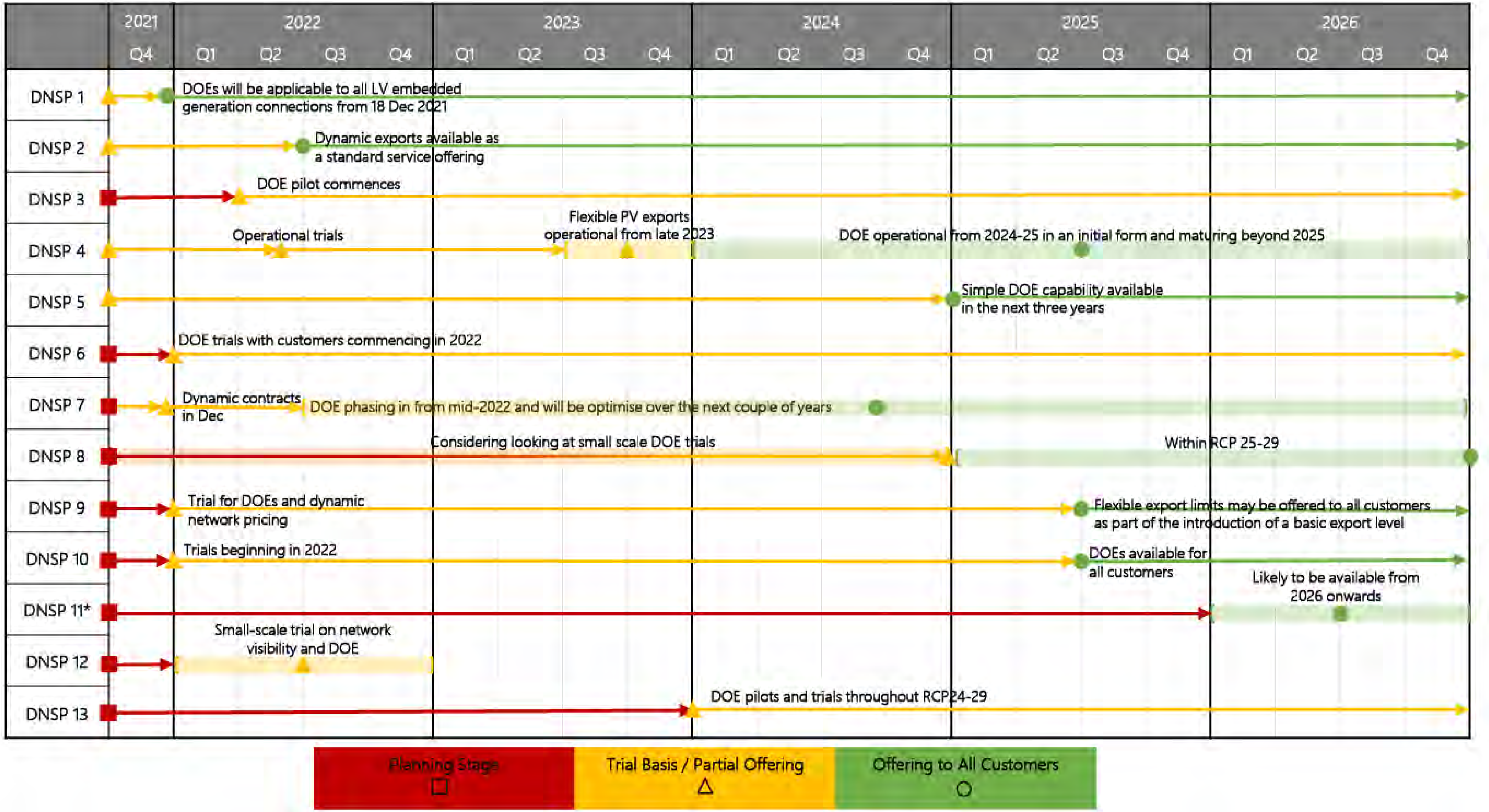

Figure 7: Overview of DOE implementation[24]

[24] The information in this graph is of a general nature and represents activities that are in development or planning at the time of publication, which may change over time and may only apply to selected customer groups. The timing and level of this DNSP's DOE rollout will depend on market designs, their role within that market design, and technology maturity. DNSPs are shown in no particular order. DNSPs that exist in a conglomerate, or as part of a broader entity, have been treated as a single DNSP.

2.4.1. The current state of play

The development of DOEs in Australia is being led by DNSPs including SA Power Networks (SAPN), AusNet Services and Energy Queensland. DOEs will develop further as DER penetration increases and markets or business models are created to provide customers with value. The development of DOEs is still in its infancy and there are many aspects of DOEs under active consideration.

There are various ongoing projects and trials at different scales and maturities that are testing different things. As an industry, we are relying on these projects to provide data and an informed path forward. If there are gaps found, the ideal path forward would be to develop more projects in these areas.

Projects related to communications standards and interoperability

The establishment of a common, national communication and interoperability standard to communicate DOEs is considered an important step to:

- Signal to OEMs and aggregators how to invest in developing DOE capable equipment and systems;
- Provide consumers with a broad range of DOE capable products to choose from; and
- Ensure consistent communication and behaviour across all vendor equipment.

Two of the earlier operating envelope trials, the Evolve DER project and SAPN Advanced VPP Grid Integration project developed to a common API based on a simplified subset of IEEE 2030.5 and the original Common Smart Inverter Profile (CSIP) developed for the Californian electricity market. This API differs from IEEE 2030.5 CSIP in two ways:

1. IEEE 2030.5 CSIP is device oriented and does not recognise the concept of a "site" or point of connection to a distribution network. This concept is fundamental to enabling the publication of DOEs at the connection point and was incorporated into the API spec.
2. The SAPN project implemented 'group limits' which apply to a group of NMIs connected to the same network constraint or 'constraint node' (e.g., connected to the same LV transformer). Publication of 'group limits' is not supported in CSIP.

The lack of site level management is one of the reasons why identical IEEE 2030.5 CSIP adoption is not possible to enable DOEs within the Australian context. This was the basis for the DER Integration Application Programming Interface Technical Working Group to develop CSIP-AUS v1.0, published in August 2021. The guide has now been tested in the following trial projects:

- the Evolve DER project transitioned to a full CSIP-AUS implementation
- SAPN's current DOE project, Flexible Exports for Solar PV, requires CSIP-AUS compliance
- Ausgrid's Project Edith is using IEEE 2030.5 for communication to Reposit, and
- United Energy pole top battery project is using IEEE 2030.5 to communicate to the battery fleet.
- Project EDGE and Symphony are testing a model where the communication of DOEs is facilitated through a centralised data exchange. This platform is communications protocol agnostic, but EDGE is aligning to the data model of IEEE 2030.5 for communicating DOEs.

Some jurisdictions with high DER penetration have already announced plans to leverage the CSIP-AUS in scaled deployment. These include

- The Government of South Australia's requirement for all new sites to be capable of remotely updating and enacting dynamic export limits from 1 December 2022 using IEEE 2030.5 and CSIP-AUS[25].

[25] Government of South Australia Department of Energy and Mining, energymining.sa.gov.au/energy_and_technical_regulation/energy_supply/regulatory_changes_for_smarter_homes/dynamic_export_limits_requirement

- Energy Queensland's plan to enable Dynamic Connections using IEEE 2030.5 CSIP and later CSIP-AUS[26].

There is consensus amongst the projects and DNSPs that IEEE 2030.5 CSIP-AUS is the most suitable standards-based protocol to enable dynamic export limits. Some projects and DNSPs also have plans to leverage IEEE 2030.5 to enable DOEs on the load side, but more work is required to achieve national consensus in this area.

Projects related to customer connection agreements

The SA Power Networks/AusNet Services Flexible Exports for Solar PV Trial project produced a flexible connection option for solar PV systems, offered as an alternative to fixed near-zero export limits in congested areas. To achieve this in South Australia, SA Power Networks' existing Model Standing Offer (MSO) was modified to include definitions of connection areas, separating the network into two categories:

- Traditional generation areas: These areas retain the 5kW/phase export limit
- Advanced generation areas: these areas are congested due to high existing PV penetration. Customers these areas have a choice between:
    - 1.5kW/phase static export limit
    - 1.5-10kW flexible export limit.

The inclusion of the technology specifications and parameters were also captured MSO which was approved by the AER.

Projects related to DOE calculation

Across the DOE trials and demonstrations that have been completed and are in flight is a wide range of calculation and implementation methodologies. The methodologies under test range from a statistical analysis based on limited data through to fully optimised power flow analysis and forecasts optimised to the customer NMI. Each project and each DNSP's approach to calculation methodology is driven by availability, accuracy and timeliness of data, the DNSPs existing systems and integrations and the outcome to be achieved. This variation in base capability and objectives will drive each network employ a different methodology. Some specific examples of this variability include:

- LV network data availability and accuracy.
- Network monitoring. e.g. AMI data (Victoria), transformer monitoring (Qld and SA emerging), SCADA only.
- Operational forecasting capability. This will impact on how the DOE is calculated and whether it might be month ahead, week ahead or day ahead.
- Type of network. Different network types of underground, overhead or SWER will impact on the DOE calculation mainly due to the different topology and impedance models.
- Issues driving DOE uptake. This will depend on the type of constraint and at what node level the constraint exists that is driving the DOE requirement, whether it be voltage, thermal or for system security.
- Cost benefit assessment. The degree of accuracy and efficacy of the DOE will depend on the level of investment a DNSP has to progress the DOE. There will be a point of diminishing returns which hopefully the current research projects can help identify.

It is for these reasons that a consensus on detailed calculation methodology across DNSPs is not practical nor required.

There may be similarities in approach that emerge if common tools are adopted across networks, such as those being developed in the trials such as GridQube from the Solar Enablement Initiative (SEI) as well as the open-source tools Project Evolve has developed.

[26] Energy Queensland, *Enabling Dynamic Customer Connections for Distributed Energy Resources (DER) Stage 2 Consultation Paper* November 2021

Projects related to Level of DOE Market Integration

There is diverse range of integrations being trialled such as a common industry data exchange hub, through to DNSP direct to aggregator or device in multiple trials. From a review of the projects, it is evident that the degree of complexity in the project increases with the number of market participants involved and the use cases to be trialled. For example, projects like EDGE and Symphony involving a DNSP, AEMO and Aggregator/Retailers seek to understand what market systems and capabilities give the flexibility to efficiently scale into a high DER future (i.e. ISP Step Change scenario). They are exploring two-sided DOEs via integration to a common industry data exchange hub. Project EDGE hypothesise that direct integration methods for DOEs may be warranted initially but may become inefficient as DER penetration and the number of actors in-market scales.

Projects like Flexible Exports for Solar PV, UE’s Pole Top BESS, Evolve and Project Edith are testing simpler integrations to market and less actors involved.

In 2023, Project EDGE will deliver a cost benefit analysis (CBA) on its approach. This CBA will reflect how the value proposition to all customers under the NEO changes over time as the scale of DER providing wholesale and local network support services within distribution network constraints increases.

3. BUILDING A SOCIAL LICENCE FOR DOES

This chapter covers what DOEs means from a customer perspective. The Working Group considers that social licence is needed in order to have customer buy-in. A social licence cannot exist unless industry and policy makers frame the design and solution of DOEs (and other DER activities) from a consumer outcomes perspective, and not from the perspective of fixing a system problem.

Working Group Finding: *Establishing a social licence for DOEs*

A social licence is essential to a successful roll out of DOEs. If consumers do not trust and buy into the program, the potential benefits will be reduced. To do this DNSPs and regulators need to provide accessible information on the purpose of DOEs, and how they are being designed and managed over time. Greater transparency and accountability by industry, and the use of language that is meaningful to consumers, can support community social licence for DOEs and related reforms. This will also be essential if industry seeks to expand the use cases for DOEs beyond export management.

3.1. A social licence will be key for DOE success

Solving the technical challenges of the transition to a low-carbon grid cannot happen in isolation of the impacts they will have on households and small businesses who make up the energy system[27].

While DOEs may represent a more efficient way to operate the network, the potential benefits of DOEs can only be realised if consumers consider them an attractive alternative to simple static export limits. This means a successful DOE program will require a social licence, as, without one, there will be little customer buy-in.

In 2020, Energy Consumers Australia worked with CutlerMerz to develop a framework for establishing a social licence for control of distributed energy resources (DER)[28]. A social licence in this context refers to the permissions granted by stakeholders for institutions to make decisions on their behalf about the operation of their DER systems.

Without a social licence DER control programs are more likely to be unsuccessful and not realise the full potential of benefits, as customers either choose not to opt-in or disengage or may not comply with mandatory programs. Limited uptake or non-compliance risks diluting the purpose and long-term benefits of DOEs to the grid and may put the customer in a worse-off position. Public acceptance and trust have also been highlighted in *The DER Customer Insights: The Customer Journe*y report[29] from ARENA as essential to a successful DER program.

The cost or effort required in establishing a social licence depends predominantly on a consumer's ability to opt out of the program and whether the private benefits clearly outweigh private costs. The CutlerMerz report identifies that DOEs require ongoing effort to gain and maintain a social licence. This reflects the fact that although the program is likely to be opt-out, those who choose a static limit may instead only have access to a reduced export limits and as a result feel penalised.

While the physical limits of the network cannot sustain increasing non-DOE customers, research indicates customers have very little awareness of this limit and the challenges associated with increased solar exports on onto the grid[30]. Historically, generous feed in tariffs (FiTs) and freedoms in selling electricity back to the grid have been used to incentivise the uptake of solar. These perceptions may have continued to shape

[27] Energy and Water Ombudsman Victoria 'Voices Report' 2021, ewov.com.au/reports/voices
[28] Energy Consumers Australia 'Social Licence for Control of Distributed Energy Resources' 2020 energyconsumersaustralia.com.au/wp-content/uploads/Social-License-for-DER-Control.pdf

[29] ARENA 'DER Customer Insights: The Customer Journey' 2020 uts.edu.au/sites/default/files/2020-08/der-customer-insights-the-customer-journey.pdf

[30] ECA 'Community Attitudes to Rooftop Solar and the AEMC's Proposed Reforms' 2021 energyconsumersaustralia.com.au/publications/community-attitudes-to-rooftop-solar-and-the-aemcs-proposed-reforms

consumers' expectations and attitudes towards selling excess solar energy back to the grid. This means that although a DOE may represent only a technical or physical limitation of the grid, what a consumer sees is a type of control over an investment they are planning to make with the expectation on how it will perform and benefit them. This highlights the need for industry to build a better understanding of consumers perceptions and attitudes towards solar exports, limits and grid health. By understanding these perceptions industry can help bring consumers along the journey through effective communication, helping to build a social licence.

While there is currently limited understanding of consumer perceptions of solar exports and grid health, some preliminary insights can be drawn from research by Energy Consumers Australia and Newgate Research in 2021[31]. The result of this research indicates that current consumers' knowledge of the challenges related to excess solar on the electricity system is low. The research found that 'grid health' was not a strong unpromoted concern for consumers and there was limited awareness or understanding of the impact of increased solar on exports and system reliability. On a scale from 0-10, consumers ranked grid health as 7-8 in terms of reliability. Those who did have low confidence in the reliability of the grid raised underlying suspicion of underinvestment in the network as private network companies seek to maximise their own profits[2]. These results indicate that further research on consumers' perceptions and current understanding of issues surrounding DOEs (grid health, solar exports, etc.) is required to be able to effectively communicate and implement a DOE program.

South Australia provides a useful case study of understanding consumer perceptions as, in the VOICES report released in 2021, solar curtailment was the most common complaint from solar customers to the Energy and Water Ombudsman, with consumers expressing scepticism of their underlying need[32]**.** This is from a cohort, that perhaps are subject to more information on the topic, yet clearly are not feeling well informed, and or simply do not believe the information they are being provided. Therefore, consumer experiences and general understanding need to be appropriately addressed if consumers are going to come on this journey. Further understanding of customer perceptions was also a key lesson learnt in SAPN's first report from their 2021 flexible exports trial[33].

It is important to acknowledge that while a flexible exports trial is already running in South Australia and the government has mandated that from December 2022 all new solar installed must have capacity to comply with DOEs, not all jurisdictions are at the same stage of implementation[34]. Accounting for the wide variety of jurisdictional differences in policy, network hosting capacity and rooftop solar uptake will be critical in establishing a DOE framework that can be applied at a national level.

While easily accessible and useful information on solar and exports is an important part of building a social licence industry also needs to look further into understanding the communities' values and the social norms which influence their decision making. Consumer decisions and motivations are not always based on weighing up expert advice or rational cost benefit analysis. Instead, social science evidence tells us that consumers are influenced by narratives that align with their values presented by sources they trust.[35] The energy industry needs to consider this evidence in developing effective communication to bring consumers along the journey of the transition to build the trust required for a future low cost, efficient, and clean energy system. As DOEs are highly technical and complex from the consumer perspective, it is important to establish transparency and communication.

This chapter will emphasise that building a social licence for a DOE program requires a holistic view of the entire consumer journey and experience. As new players and services emerge, such as DOEs, what consumers care most about is how their needs will be met and align with their expectations and values. If the benefits of a program such as DOEs depend on a consumer having to understand the organisational

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[31] ECA 'Community Attitudes to Rooftop Solar and the AEMC's Proposed Reforms' 2021 (as above)

[32] Energy and Water Ombudsman Victoria 'Voices Report' 2021, ewov.com.au/reports/voices

[33] SAPN Flexible Exports Trial Report, arena.gov.au/assets/2021/09/flexible-exports-for-solar-pv-lessons-learnt-3.pdf

[34] Government of South Australia – Department of Energy and Mining 2020, energymining.sa.gov.au/__data/assets/pdf_file/0003/372153/Smart_Homes_-_Installer_FINAL.pdf

[35] Moreland City Council 'Electricity Everything! Communications Message Guide for Households' 2021, morelandzerocarbon.org.au/wp-content/uploads/2021/11/Electrify-Everything-Communications-Message-Guide-for-Households.pdf

chart of the energy industry to participate, then the program may fail to reach its full potential for both consumers and the industry. Instead, a more successful DOE program will see networks, aggregators, retailers, and market bodies working together to ensure the consumer is delivered a program that integrates cohesively and makes products and services easy to navigate and with desired outcomes. The remainder of this chapter explores the key considerations for establishing a social licence for DOEs including by:

- Consumer motivations, attitudes and expectations
- Establishing customer protections
- Supporting customer access to information and data.

3.2. Consumer motivations, attitudes and expectations

New, smart and efficient energy technologies or products don't always easily fit into customers' routines and energy usage behaviour. Assumptions from the energy industry on how customers will use a new automated energy services are often disrupted because customers purchase, install and use their DER for a variety of reasons[36]. Understanding customers' motivations and expectations of their DER will be critical in delivering a successful DOE program. While there is limited research on customer attitudes or perceptions towards solar export limits, research from ARENA[37], the AEMC[38], ECA[39] and the VOICES Report[40] on customer motivations, attitudes, and expectations towards DER and the control of assets more broadly can provide some insight. Customer motivations and attitudes can be broadly divided into segments that include:

- Community and environmentally motivated customers who are looking to contribute to a sustainable future energy system for future generations. These customers may be concerned about ensuring their solar electricity is effectively shared and distributed within their local community.
- Practically and financially motivated customers may be concerned with ensuring they receive the best monetary value for their DER system and a return on their investment.
- Independence focused customers who are concerned with the reliability and security of their DER systems and are motivated to meet their own electricity needs through their DER.
- Early adopters and investors are motivated to be seen as leaders in adopting new technologies and which will help them 'get ahead' for the future.

It is important to understand the diversity of customer values, expectations, and motivations as it highlights customers do not only value economic benefit, but prize other values associated with their DER, such as sustainability and independence. For example, for customers with environmental motivations, DOEs may offer the benefit of seeing a greater amount of local solar electricity being used across the system and requiring less investment in expensive, large-scale generation assets.

In their research, CutlerMerz noted that most customers with controllable DER devices must perceive that the benefits of control outweigh any disadvantages in order to reach acceptable levels of social licence[41] . This suggests that control and what customers need to feel comfortable when relinquishing control are very important in any DER setting. While DNSPs frame DOEs as an opportunity for customers to potentially access more of the available capacity of the network than the alternative static limits, customers are likely

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[36] User-Centred Energy Systems 'Social License to Automate' userstcp.org/wp-content/uploads/2019/10/Social-License-to-Automate-October-2021.pdf

[37] ARENA 'DER Customer Insights: The Consumer Journey' 2020 uts.edu.au/sites/default/files/2020-08/der-customer-insights-the-customer-journey.pdf

[38] Australian Energy Market Commission 'Consumer Archetypes for a Two-Sided Market' 2021 acilallen.com.au/projects/energy/consumer-archetypes-for-a-two-sided-market

[39] Energy Consumers Australia 'Energy Consumer Sentiment Survey' 2021, ecss.energyconsumersaustralia.com.au/

[40] Energy and Water Ombudsman Victoria 'Voices Report' 2021, ewov.com.au/reports/voices

[41] Energy Consumers Australia 'Social Licence for Control of Distributed Energy Resources' 2020, energyconsumersaustralia.com.au/wp-content/uploads/Social-License-for-DER-Control.pdf

to be wary of arrangements that involve some level of external control of their devices. In their VOICES report, EWOV[42] grouped concerns around third party control of DER raised by participants as:

- The existing energy system is not capable of delivering sophisticated, trusted 'smart' grid technologies
- Energy companies are not trusted to serve the public/householder interest
- Privacy and data misuse, particularly using data for profit or surveillance
- Control over the level of automation in the home should ultimately be controlled by customers.

Problem framing, solutions design and providing customers with the knowledge, information and tools necessary to participate with an acceptable level of risk are essential for any future DOE program. This means that DOEs cannot be designed to benefit the system alone and will need to take into account customers' perspective. They directly impact customer-owned assets and consequently the design of a program that will dynamically manage exports must be tested against customer values, behaviours and expectations if it is to succeed.

For customers, and the industry more broadly, knowledge brings empowerment and trust in the market. Supporting customers and their agents to understand the forecast and historical impacts of DOEs (in terms of frequency and duration) should be addressed by industry as a whole. DNSPs should explore how DOE constraint information can be made available and clearly outlines what actions they are taking to maximise customer benefit. Further exploration of what information customers, installers and the broader industry want is essential to support compliance, seamless system interface and assurance in the fair application of DOEs by DNSPs.

Working Group Finding: *Information on DOEs is easily accessible*

Customers need to be provided with easily accessible and digestible information to be able to make informed decisions and choices. Market bodies and the industry should, through evidence-based research work together to further identify the current gaps in information customers may want or may need.

3.3. Establishing customer protections

3.3.1. Considerations for establishing fit-for-purpose customer protections

In 2020 alone, Australian households and businesses installed more than 300,000 rooftop solar systems. This uptake of solar and increased interest in other DER devices such as batteries is developing within an evolving regulatory environment. As the energy system rapidly decarbonises and decentralises, each new initiative or intervention that works towards long-term grid solutions, such as DER and DOEs, cannot be assumed to operate in a vacuum. The customer does not experience these interventions singularly, but rather in combination. Consideration must be had for the whole of the customer journey, the touchpoints that relate directly or indirectly with DOEs, and the customer protections that overlay them to ensure the right customer outcomes are achieved.

Below we address the current regulatory landscape in relation to DOEs and DER technology,_detailing potential gaps particularly in access to dispute resolution. We then draw attention to a customer journey information map from the perspectives of new and existing solar customers, as well as customers who are not in the solar market. This is to highlight that, at each stage of the journey, customer protections are not just about regulatory measures, but also involve delivering information to help consumers establish appropriate levels of trust in various parties involved in the market. In the case of DOEs, information, knowledge and capability building are critical to mitigate power imbalances and potential customer harm.

Currently, the National Energy Customer Framework (NECF) and specific state-based rules (such as the Energy Retail Code) primarily make up the energy customer protections landscape. These rules and regulations were built upon the historical one-way relationship between centralised generation, networks,

[42] Energy and Water Ombudsman Victoria 'Voices Report' 2021, ewov.com.au/reports/voices

energy retailers and customers. The existing regulations may maintain some application that is relevant to DOEs, for instance notification of FiT changes in Victoria, but further work is required to understand potential gaps in protecting customers in the new energy world. A review should also consider the introduction of new consumer protections such as the New Energy Tech Consumer Code (NETCC) or the role of the Clean Energy Regulator with regard to solar retailers and installers.

Existing consumer protection tools should be leveraged

The Consumer Risk Assessment Tool, as recommended to ministers as part of the ESB Post 2025 Market Design Report[43], aims to determine whether any new or additional customer protections are required as new energy services expand and evolve. The Consumer Protection Principles, also developed through the Post 2025 process, are considered when assessing the potential benefit of a rule change, guideline, process, etc. There are five principles, two of which are particularly relevant in building social licence for the implementation of DOEs:

1. Access to information: Customers should have access to information that is sufficient, accurate, timely and minimises complexity and confusion to allow them to make informed decisions
2. Dispute resolution: Customers should have easy access to no-cost dispute resolution mechanisms when things go wrong.

Both information and dispute resolution are discussed in further detail below.

Working Group Finding: *Utilise existing risk assessment tools*

Market bodies should consider using the ESB's Consumer Risk Assessment Tool to ensure consumer benefits and risks are explicitly considered in the design and implementation of DOEs. This should be demonstrated through consultation papers, options analysis that explicitly considers the benefits, gaps or risks to consumer protection principles.

Working Group Finding: *Enable affordable and accessible dispute resolution*

Regulatory bodies should identify and address any gaps in customers accessing affordable dispute resolution when it comes to DOE and related DER issues. Consideration could be given to ensuring that state-based energy ombudsman schemes have adequate capacity and powers.

3.3.2. Affordable and accessible dispute resolution

Generally, the first port of call for customers when trying to resolve an issue in the solar space is to reach out to the 'company or operator' at the centre of the problem. In practice this process is not always easy to navigate, and customers sometimes face instances of organisations 'passing the buck[44]. In some cases, the relevant party ceases trading, and customers are not able to resolve their issues[45]. With no remedy arising through the responsible party, in most instances, the next step is to seek support from the relevant fair-trading office or small claims court.

Both scenarios create a high-friction experience with considerable barriers to achieving redress, often resulting in further dissatisfaction and distrust towards the market. In their 2019 report '*Sunnyside up*,' Consumer Action Law Centre (CALC) recommended that EWOV have their jurisdiction extended to include new energy technology. ECA made a similar recommendation in their response to the *Independent Review into the Future Security of the National Electricity Market* (Finkel Review)[46]. AEMC recognised a similar

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[43] ESB Post 2025 Market Design Report, esb-post2025-market-design.aemc.gov.au/32572/1629945838-post-2025-market-design-final-advice-to-energy-ministers-part-c.pdf

[44] Consumer Action Law Centre 'Sunnyside up report' 2019, consumeraction.org.au/wp-content/uploads/2019/04/1904_Sunny-Side-Up-Report_FINAL_WEB.pdf

[45] Consumer Action Law Centre 'Sunnyside up report' 2019 pg. 32 (as above)

[46] *Independent Review into the Future Security of the National Electricity Market,* energyconsumersaustralia.com.au/wp-content/uploads/Finkel-Review-Submission-March-2017.pdf

need in their *2020 Retail Energy Competition Review*[47] and the EWOV made the same recommendation in its 2021 *'VOICES'* Report[48].

Even though the above is a brief overview, the absence of accessible and affordable dispute resolution for consumers interacting with new energy tech is clear. The Working Group recommends regulatory bodies lead a collaborative process to consider changes to the dispute resolution processes that is suitable for a decentralised energy system, including extending the powers of the ombudsmen scheme. As a further consideration, the creation of a national 'single source of truth' public register for all complaints, disputes, and outcomes would provide a resource that customers can reference check against as part of their due diligence, while further making the industry accountable.

3.3.3. Building social licence and trust through the consumer journey - New solar customer

As DOEs are increasingly deployed by DNSPs in the future, their benefits and impact will need to be factored into a customer's decision to purchase and install solar panels. The figure on the following page illustrates the customer journey map for new solar customers.

[47] *2020 Retail Energy Competition Review,* aemc.gov.au/sites/default/files/documents/2020_retail_energy_competition_review_-_final_report.pdf

[48] Energy and Water Ombudsman Victoria 'Voices Report' 2021, ewov.com.au/reports/voices

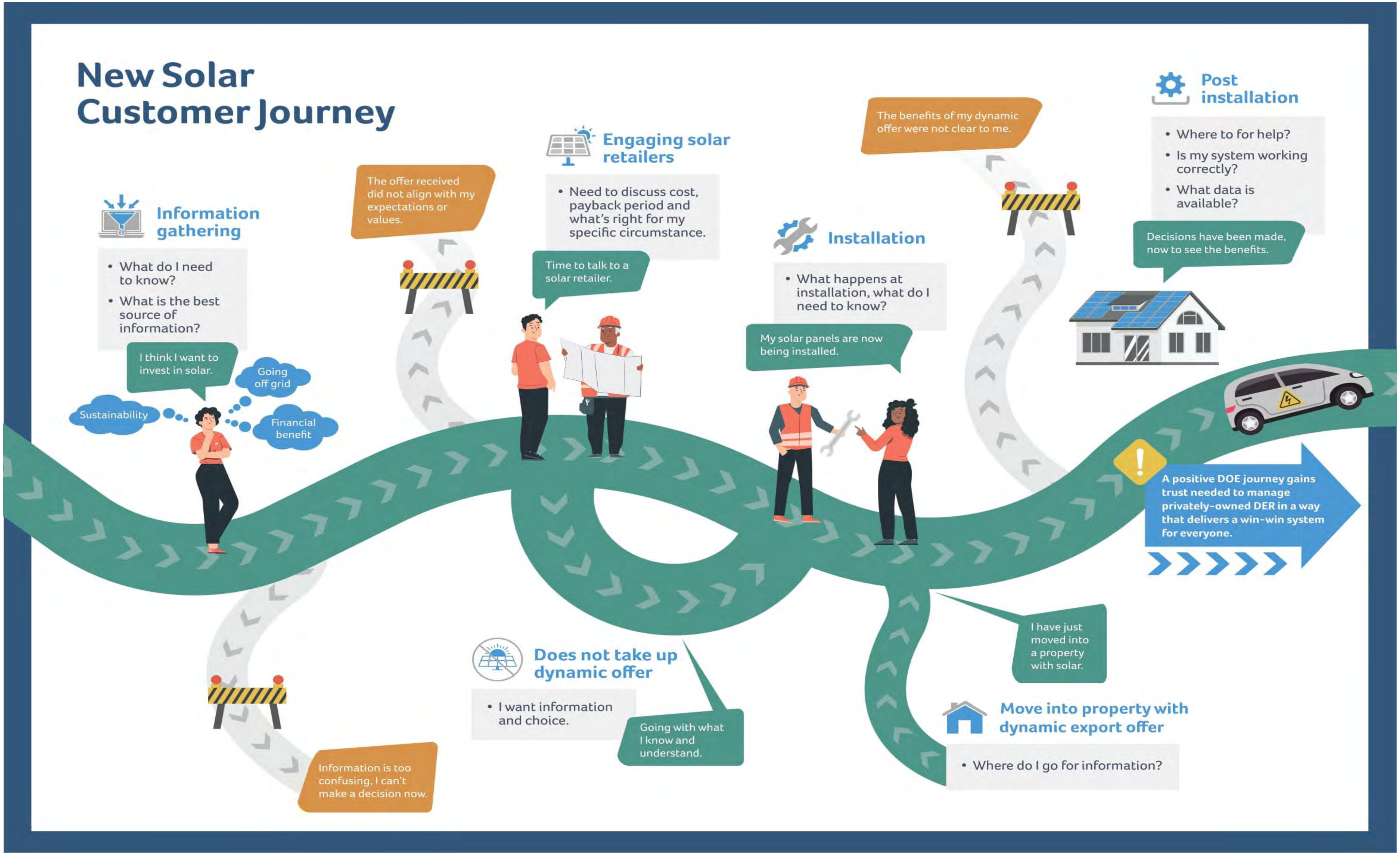

Figure 8: Customer journey map – new solar customer

Information gathering

As discussed in section 3.2.1, customers decision to purchase rooftop solar systems are based on different motivations and values, which plays an important role in the information a consumer might find most important. Information sources need to account for the wide variety of customer expectations and values to successfully build the trust required for a DOE. The Working Group recommends that customers receive information that is meaningful to them on DOEs as early in the customer's decision-making process as possible. This information should be particularly targeted at moments when the information has the most practical application[49].

The information provided to customers will also need to evolve as the energy sector's transition continues. For example, the optimal time to export energy to the system is likely to change as more customers connect DER to the grid, and this may affect the type of investment (number of panels to purchase or choosing a solar/battery package) that a customer may choose to make. Utilising the customer journey, industry and policy makers should investigate where this kind of information is working well, what can be improved (taking into consideration demographics, literacy, etc), and where it is missing. This will assist in determining if any additional protections are required around information at this touchpoint.

Engaging a solar retailer

A customer is likely to make their decision regarding a dynamic or static export limit once they have gathered information and engaged a solar retailer as it impacts their pay-back period and FiT benefits. If customers do not trust or see value in what they are being told they may be hesitant to take up any dynamic offer. Understanding customers' current perceptions and expectations of solar exports will be critical in providing them with the right information to enable them to make an informed decision. New solar customers may have already formed ideas of generous FiTs which will impact their preferences and judgments, regardless of the accuracy of these assumptions.

It will be important to provide information on:

- How will the benefits of DOEs be explained in relation to the overall benefits of installing a solar PV system?
- Will this be accompanied with information on how to best utilise self-generation during the day?

Installation

ARENA's *DER: Customer Insights: The customer Journey* report identified installation as a critical moment in the customer journey[50] as solar retailers and installers are often the first point of contact for customers, it is important that these parties are well informed and supported to communicate the dynamic limit offers available to customers. This is evidence in a report from SA Power Network's Flexible Exports Trial[51] which highlighted the need for DNSP's to work closely with solar retailers and installers to establish clear messaging and communication on flexible exports that can be delivered as part of the installation process.

Post-installation handover and after-sale support

Ongoing support and dispute resolution will be an essential part of a positive customer experience following the installation of a customer's rooftop solar system and uptake of a dynamic export offering. Part of this is providing communication with customers on how their system is performing. For example, a reliable internet connection is necessary for DER devices to receive DOE signals. If communications between the DNSP and DER devices are lost, it is likely that DER devices will be required to revert to a conservative static export limit to prevent the customer from potentially breaching their dynamic limits during the period of lost communications. Customers will need to be made aware if their internet connection is unstable and therefore, they may not be able to fully realise the expected benefits of dynamic export connection. Research

[49] Consumer research and policy centre' Five Preconditions

[50] ARENA 'DER Customer Insights: The Customer Journey' 2020 uts.edu.au/sites/default/files/2020-08/der-customer-insights-the-customer-journey.pdf

[51] Aurecon 'Flexible Exports for Solar PV' arena.gov.au/assets/2021/09/flexible-exports-for-solar-pv-lessons-learnt-3.pdf

is required to determine how often compliance issues currently occur, as well the current status of connection loss and what benefits are being missed.

The ARENA *DER Customer Insights: The Customer Journey*[52] report identified the need to provide customers with a single point of contact if they require support to ensure a positive and beneficial DER control program. A DOE framework will need to clearly outline the responsibility of each party and detail who will be responsible for providing support at each touchpoint, as well as where the customer may go for this information. Further work is required to better understand the potential roles and responsibilities of various stakeholders.

An example of just one part of this process is the customer's energy bill. A customer, who may be financially motivated to purchase a rooftop solar system for the purpose of bill reduction and earning FiT credits, may rely on their electricity bill or data from their energy retailer to understand the impact a DOE is or isn't having. In the AEMO VPP trial, the market operator found that customers' motivations and interests waivered when they were unable to recognise the financial benefits of being part of a VPP.[53] Without appreciating and addressing this part of the customer journey, what information is required and at what time, customers may choose not to participate in further energy activities of this nature, further eroding trust in the market.

We consider the information requirement discussed above is also applicable to 'new move in' customers who inherit a rooftop solar system and the pre-existing connection agreement with the local network service provider. Under the Access, Pricing and Incentives Rule change reforms, DNSPs are required to make information on terms and conditions applicable to solar connections publicly available on their websites in simple and concise language. However, these provisions do not require that information to be proactively delivered to move in customers. Policy makers should consider whether there is a need to proactively offer such information to customers and if so, in what form and if it is sufficient information for consumers to make decisions from.

3.3.4. Existing solar customer

The need to provide access to appropriate information and data is not limited to new solar customers. It is equally important for industry and policy makers to consider the information needs for customer who have already invested in rooftop solar system as some of them may choose to opt in to DOEs. The figure on the next page provides an overview of the customer journey for an existing solar customer.

[52] ARENA 'DER Customer Insights: The Customer Journey' 2020 uts.edu.au/sites/default/files/2020-08/der-customer-insights-the-customer-journey.pdf

[53] AEMO 'Virtual Power Plant Demonstrations Consumer Insights Report' 2021 arena.gov.au/assets/2021/09/vpp-power-plant-demonstrations-consumer-insights-report.pdf

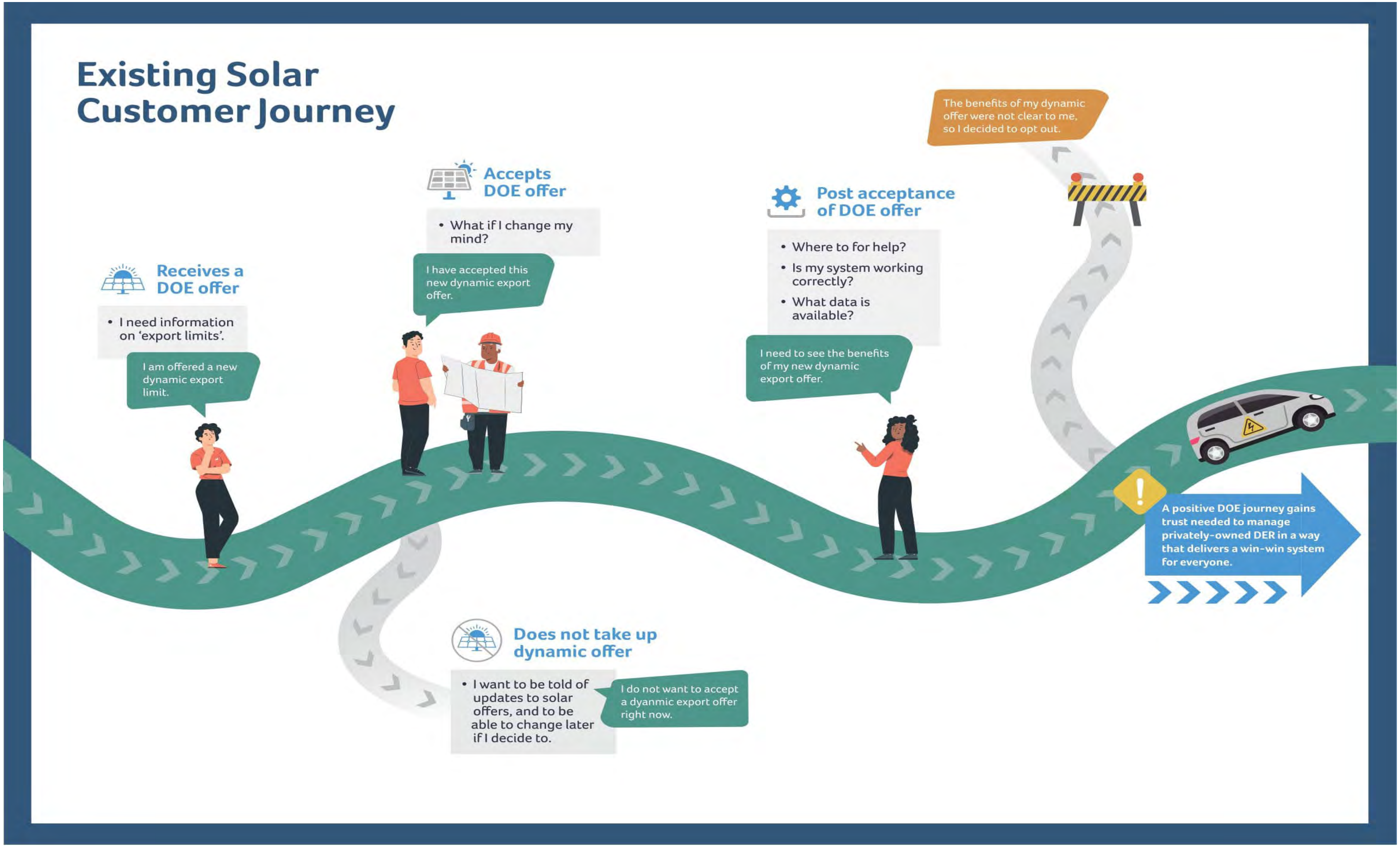

Figure 9: Consumer journey map - existing solar customer

Awareness

For customers who have existing rooftop solar systems, their reaction to the offer of DOEs are likely to depend on their awareness of both the existence and the level of their current level of export limit. This perception of the benefits of DOEs (or lack thereof) will be critical in realising the benefits or costs of DOEs for existing solar customers. Customers will not judge the benefits or costs of DOE in a vacuum but in comparison to what they understand or believe to be their realistic alternative. For existing solar customers who are already subject to low or zero export limits, and aware of this limit, DOEs may present very clear direct benefits. On the other hand, if an existing solar customer is not aware of the current static export limit they are subject to, then even when presented with the potential benefits of a dynamic limit there may be hesitancy or lack of trust.

Options such as grandfathering need to be explored for existing customers who decide they don't want to take up the dynamic export option. In current trials, existing solar customers in both SA Power Networks and AusNet Services jurisdictions remain on their original export limit with no penalty for opting out if they choose not to take up the dynamic offer. Regardless of whether current solar owners are exempt from DOEs, customers should be informed of the changes in the market that may impact current or future decision making. Information provided should perhaps also include a link to the government comparison website if a re-assessment of FiTs would be beneficial.

Acceptance / refusal

Once a customer understands the current and potential future implications of the DOE an informed decision can be made as to what works best in their circumstances. Depending on a customer decision or grandfathering period, their connection agreement may need to be updated to reflect the change.

Maintenance

As the maturity of DOEs develops, the industry needs to ensure that grandfathered customers (if applicable) are not left behind on agreements that leave customers financially worse off. Solar customers should not be assumed as 'set and forget' customers and should not be penalised for doing so.

3.3.5. Customers not in the solar market

We note that a customer may also not yet be in the solar market, for various reasons such as affordability, housing context, or confusion and distrust. When providing information about DOEs and solar to all customers, the industry should consider how accessible the information being provided is. Information on DOEs should not be limited to only one message, to one particular audience, or based on assumptions. We suggest drawing on trials and further research in this field to better understand customer sentiment and behaviour. The more customers feel engaged with the energy transition whether it be indirectly or directly, the closer we move towards building and maintaining a social licence.

Working Group Finding: *Implementation of DOEs should not be limited to new solar customers only*

While the initial application of DOEs will be on new solar customers, care should be taken to not create barriers to future use cases including EV managed charging and adoption by existing solar customers. Future proofing current DOE implementations can reduce costs and increase choice for consumers in the medium term.

3.3.6. Supporting customer data access

Customers need access to information regarding when their systems are constrained, or are likely to be constrained, and this information must be presented in a simple, clear and accessible format. To establish trust and maintain a social licence, customers will require access to information about when this event is occurring. Providing this information in an accessible way will also give customers full opportunity to shift their energy usage behaviour for their own potential benefit. For example, if a customer was aware that their solar exports were likely to be curtailed in the middle of the day, they may be able to shift some of their energy usage to this time. Then, later in the day when they are not constrained, they will be able to export more of their solar electricity back to the grid.

Data on the current and projected hosting capacity from networks must also be shared transparently with customers. This is part of the ESB Data Strategy[54] which requires network businesses to support greater transparency of local network performance, hosting capacity, and physical constraints. Transparent and fair allocation of network capacity was a clear outcome of the DEIP Consumer Perspectives workshop in October 2020[55], as allocation capacity could have a direct impact on the amount of energy a customer's system can export. Communicating this information transparently to customers is important not only to help customers make informed investment decisions in energy (and real estate) but also to build trust and a social licence for network interventions such as DOEs.

Working Group Finding: *Consumers should have easy access to data on their DOE performance*

If a customer would like to understand a DOE and the impact it may be having financially or otherwise, data transparency is crucial, and without, building the necessary social licence may be diminished. There is a need to further explore what DOE related data customers want access to and can benefit from and how this data is communicated. Consideration will need to be given to how this data is shared, the merits of nationally consistent approaches, central repositories, open APIs, and access and sharing rights for data held by DNSPs, OEMs or aggregators.

[54] ESB Data Strategy esb-post2025-market-design.aemc.gov.au/32572/1630275857-esb-data-strategy-july-2021.pdf

[55] ARENA DEIP Consumer Perspectives workshop in October 2020, arena.gov.au/assets/2020/11/dynamic-operating-envelopes-workstream-consumer-perspectives-workshop-summary.pdf

4. POLICY CONSIDERATIONS FOR MAKING DOEs IN THE LONG-TERM INTEREST OF ALL CUSTOMERS

This chapter covers the emerging regulatory, standardisation and operational considerations associated with the deployment of DOEs. It seeks to highlight the need for any changes to the regulatory framework and areas where consistency in the approach to implementing DOEs could support the wide-spread deployment of DOEs in a manner that supports the long-term interest of consumers.

4.1. Is there a need to mandate the roll out of DOEs?

While the current regulatory framework does not prescribe the technological solutions that the networks should adopt, it is worth considering whether mandating DOEs could accelerate the benefits associated with DOE implementation for customers.

A mandatory regulatory requirement on the DNSPs to implement DOEs provides assurance that customers will be able to access their benefits in the future. This can help inform customers' investment decisions such as whether to install solar or a battery and the optimal size of the system in light of future export hosting capacity. It could also provide manufacturers and installers certainty around when any DOEs may be deployed allowing them to make better investment decisions about what products and services they should develop and market, and the communications capabilities they should build into their products.

However, it is unlikely to be optimal for all network businesses to implement DOEs in all places at the same time. There may be circumstances where their deployment is not necessary or appropriate (e.g. if a DNSP faces a low penetration of embedded generation and they retain reasonable hosting capacity on their network). In these cases, a mandatory obligation to implement DOE arrangements could lead to inefficient deployment, costing consumers without an associated benefit.

4.1.1. A mandatory requirement on DNSPs to deploy DOEs is not needed

The current regulatory framework provides incentives for DNSPs to provide distribution services in the most efficient manner.[56] It supports DOE implementation where there is an identified network need (e.g. an emerging export constraint) and DOEs represent an efficient approach to addressing this need.

Along with conducting trials, several DNSPs already have plans to roll-out DOEs to their customers in the near term as part of their normal network expenditure planning processes. These are subject to the AER's expenditure assessment process as part of a DNSPs' regulatory determination and this process provides flexibility for local circumstances and options to be considered. DNSPs such as SAPN have already received approval from the AER to build the systems required to implement DOEs across the network with plans to offer dynamic connection arrangements to all new solar customers from 1 July 2022.

DOEs are expected to be implemented by DNSPs in the near term in such circumstances as:

- On existing networks to accommodate expected growth in new connecting embedded generators,
- On constrained parts of the distribution network providing an alternative to network augmentation and/or customers facing reduced static export limits,
- Across whole network areas to address DER related network contingency and minimum system load directions issued by AEMO,
- To manage the potential network impacts of many orchestrated devices, such as where a particular aggregator has significant levels of DER under management,

[56] For example, NER Clauses 6.5.6 and 6.5.7 require that opex and capex must be approved by the AER as efficient and prudent. NER clause 6.6.2 requires the AER to provide an incentive scheme for distribution services (including export hosting). NER clause 6.27A requires that the AER must report on the performance of each DNSP in providing distribution services for supply from embedded generating units into the distribution network.

- An innovative product offering for customers to provide them with greater access and flexibility in their use of the network.

Working Group Finding: *DOEs do not need to be mandated*

A mandate on DNSPs to implement DOEs is likely to result in bringing forward their implementation where they are not already considered an efficient and prudent investment. A mandatory requirement on DNSPs to deploy DOEs is therefore not in the interests of electricity consumers.

4.1.2. Supporting regulatory reforms

Recent regulatory changes, including those introduced under the *Access, Pricing and Incentives arrangements for DER* rule change,[57] recognise that DNSPs provide export services to customers and clarify the planning and investment arrangements for DER integration. The AER is also currently developing a *DER integration expenditure guidance note* to provide further clarity and certainty to DNSPs on what it expects to be included in DER integration investment proposals and how they will be assessed. The draft guidance note foreshadows the potential use of DOEs by DNSPs as part of their DER integration strategy. These changes are expected to further clarify and support DNSPs in developing future DOE business cases and undertaking DER integration planning.

4.2. DOE implementation will require additional consumer safeguards

The additional benefits DOEs offer customers come with added complexity in decision making, including at the time of purchasing and installing DERs and how to best operate their embedded generation and manage their energy usage. This complexity carries specific technical, regulatory and financial risks for customers. There is a need to carefully consider how these changes could impact customers including how challenges and risks can be best managed, and benefits to customers enhanced.

DOEs represent a significant shift in how customers interact with electricity networks and the current regulatory framework doesn't specifically contemplate dynamic export curtailment of embedded generators. The Working Group considers DOE implementation should be accompanied by some additional customer safeguards. These safeguards can complement the development of a social licence to operate DOEs discussed in Chapter 3.

The following sections explore some potential customers impacts and safeguard options in the context of the transition to DOEs.

4.2.1. The ideal future state protects customer choice

Under the current regulatory framework, the DNSPs can set requirements for customers connecting DER to their network, including equipment and performance requirements. Where approved by the AER, this could allow DNSPs to implement DOEs as a voluntary or mandatory requirement when entering into a connection agreement (for a new or altered connection).

This raises the question of whether there is a need to include protections in the framework to preserve an option for customers to choose a static export limit. There could be circumstances where a customer may prefer to have a static connection offer, even if it provides for a lesser level of exports (e.g., a customer with a small system who prefers a simpler connection arrangement, or that does not wish to allow other parties to have control of their devices). Some customers may also be more receptive to DOEs if they are presented as an option, with inherent benefits, rather than it being the only way to connect an embedded generator.

Providing flexibility for customers needs to be weighed against the whole-of-customer base and system-wide benefits from a greater penetration of DOEs. If the uptake of DOEs is set as a requirement for all new and upgraded DER connections, it could promote greater penetration of DOEs and a larger share of the customer DER fleet being controllable. This could benefit customers by enabling higher level of exports to be supported by networks and better management of system wide security issues.

[57] aemc.gov.au/rule-changes/access-pricing-and-incentive-arrangements-distributed-energy-resources

The treatment of existing solar customers also warrants consideration. While the connection arrangements for the existing DER customers may not allow DNSPs to change connection requirements without customer consent, many existing DER customers are likely to opt-in for DOEs to increase their export limits. In these circumstances, customers should be notified when DOEs become available and transitional processes should be offered to customers if they can meet the relevant dynamic connection requirements.[58]

> ***Working Group Finding:*** *Customers should be able to opt in or out of DOEs*
>
> The Working Group considers that where DOEs are enabled on a local network, customers should be provided the choice to opt into or out of DOEs according to their preferences, noting that the alternative may be a lower static limit.

Inherent in this approach is the expectation that the increased export hosting capacity offered by DOEs will be of material benefit to many new and existing customers and that DOEs will be become an easy choice for customers into the future. Where this is not the case, customers should be free to choose an access arrangement that best meets their needs.

The Working Group notes that the above recommendation on customer opt-in/out of a DOE is separate to minimum capabilities for actively managing DER as a last resort that may be required to maintain power system security in the future, which could be enabled by the same platform.

4.2.2. The regulatory framework should provide customers with appropriate information, efficient levels of export, and clarity of the responsibility of parties

Customer access to appropriate information

Chapter 3 highlighted the importance of customer access to information that is sufficient, accurate, timely and simple, to allow them to make informed decisions. There is a need to identify the customer information requirements throughout their DOE journey. This section addresses how regulatory reforms could support customers with the information they require.

Pre-installation information

Customers looking to install new or upgraded DER will need to understand the network access options available to them and what they mean for their future ability to export. Customers would need this information to make product selection choices including about the sizing of a PV array or the incorporation of energy storage.

As with current rooftop solar installations, the solar retailers and installers will play a critical role in communicating a customer's connection options, product options, expected benefits and ways of managing network constraints and other operational issues.

> ***Working Group Finding:*** *Solar retailers and installers have an important role in information provision*
>
> Solar retailers and installers will play a critical role in communicating a customer's connection options, product options, expected benefits and ways of managing their energy uses. The Working Group supports DNSPs working closely with solar retailers and installers to appropriately inform them and help them develop effective communication material for customers on DOEs.

> ***Working Group Finding:*** *Protecting consumers from misinformation*
>
> The New Energy Tech Consumer Code (NETCC), where adopted, will provide some protections to customers from misinformation provided by installers and energy system retailers. Industry engagement

[58] Connection to a DOE platform may be required for new connections in areas where DOE infrastructure is also being used for system security 'backstop' purposes. A potential outcome is that a new customers may be connected to the DOE platform for backstop operation whilst electing to have a static limit normal operation.

by DNSPs, the scope of the NETCC, and its adoption, should be monitored by the market bodies to ensure appropriate information is delivered to customers to support their technology investment decisions.

4.2.3. Information on operation of DOEs and the responsibilities of the different parties

Dynamic connection arrangements involve the active management of customer assets in order to ensure compliance to dynamic limits. As such customers will need clear and appropriate information regarding their rights and responsibilities and those of different parties. Further work needs to be undertaken to consider the approach to and the benefit of providing information to customers on issues such as:

- Their role in ensuring compliance with the DOEs, including in scenarios where a customer has a nominated coordinating agent
- The level of service they can expect under alternative connection arrangements
- Any use of home internet connections and expected impact of internet outages
- How customers can have visibility of their DOEs, if the data is made available
- The responsibility of their installers in ensuring correct DOE configuration
- Who to contact if system operational issues arise
- Steps involved in switching technology providers and coordinating agents.

4.2.4. Access to historic and current customer DOE data

4.2.5. **Some customers may wish to have visibility of current and historic DOEs issued at their metering point, and their corresponding exports. As described in chapter 3, the availability of such data could help maintain consumer confidence. It could also help customers and installers troubleshoot any issues they may be facing and make more informed decisions about future investments. Supplying this data is likely to involve costs for the parties involved. Customers will benefit from targeted harmonisation of connection agreement arrangements**

DOE arrangements are likely to be set out in customers' connection agreements with their local network service provider when they establish a new connection or make a change such as an increase in their connection point power transfer capacity or the connection of a new embedded generator. The consumer perspectives provided in chapter 3 have highlighted a preference for harmonisation or consistency in the delivery of DOE connection models, including how connection agreements are governed.

By harmonising 'front end' interfaces and processes, network businesses can make it easier for service providers to comply with requirements in different network regions and this should reduce overall costs and increase choice for customers. By providing flexibility at the 'back end', national frameworks can support the efficient technical integration with existing network business systems, speeding up DOE adoption and further reducing costs to consumers.

It is reasonable to expect that these processes will evolve overtime to support transparency and consistent and effective regulatory oversight by the AER.

4.2.6. The assignment of compliance obligations for DOEs needs further consideration

Connection agreements are legal documents made between a network business and a customer. As such, under current frameworks (that were not designed for dynamic export limits), customers are the ones ultimately responsible for complying with a DOE and any other party helping to manage compliance (such as an inverter OEM or aggregator) does so as the customer's agent.

The agent's obligations are established by their relationship with the customer, rather than directly with the network business. If the agent fails to comply with a DOE for any reason, enforcement by the DNSP would currently need to be through the customer and the customer would be responsible for seeking remedy from their agent as appropriate. This includes the circumstance where a customer has formally nominated a 'coordinating agent' to manage the device on their behalf.

In practical terms, a customer will likely not have direct operational control of their DOE enabled device, and DNSPs engaged in DOE trials have developed relationships with coordinating agents and use these relationships to encourage (rather than enforce) compliance.

The ESB has highlighted[59] that device aggregators (or 'traders') will need to have responsibilities for DOE compliance and the development of the ESB's proposed 'trader-services model' is expected to consider how customers' agents will interact with the DOEs and how liabilities accrue to different parties. This work should support the compliance risk being assigned to the parties that are best positioned to manage it. For example, in the future:

- DNSPs practices could evolve to allow an agent to become a party to the connection agreement,
- A formal authorisation process for agents could be used to formalise agent rights and responsibilities and provide a contractual basis for DNSPs to enforce compliance, and/or
- Additional consumer protections could be introduced, whereby an agent must indemnify a customer from penalties arising from non-compliance with a DOE.

The AER has an existing role to oversee the customer connection process as well as determining and enforcing some service levels that are delivered to consumers. The AER has indicated an intention to review the future impacts of DOEs on the customer connection process and service levels to determine whether any changes are required to preserve and enhance customer outcomes. The AER's review will also consider the desired customer outcomes that are identified in Chapter 3 of this paper.

Working Group Finding: *Assigning compliance risk to the right parties*

Market bodies should consider whether reforms are needed to the connection framework so that the risks associated with DOE compliance are assigned to the party best placed to manage those risks.

A large proportion of DOE non-compliance may also be due to site-configuration issues and relate to the work of equipment OEMs and installers.

Working Group Finding: *Build up compliance information and incentives*

DOE non-compliance may be associated with on-site configuration issues and relate to the work of equipment OEMs and installers. The Working Group supports DNSPs working closely with solar retailers, aggregators and installers to build compliance capacity.

The DNSPs could also develop other incentive-based arrangements that promote better practices and compliance by solar retailers and installers such as benchmarking and publishing compliance rates and applying penalties for non-compliance (to be set out in the connection agreement with the customer or through a parallel installer/agent authorisation agreements). Such processes would need to be efficient and transparent, and customers are likely to benefit from a degree of national harmonisation.

4.2.7. Supporting efficient levels of export under DOEs

Once operational, DOEs will have the ability to increase or decrease customer access to the network for exports at a given time. Recent modelling suggests that major decreases in export limits would be applied rarely. For example, in its current trial, SAPN has indicated that "flexible export limits will typically be at 10kW for 98% of the time"[60] .

However, network conditions may change over time, and the level of DOE curtailment is likely to increase with the addition of more solar generation capacity. This creates a different set of conditions to the current arrangements for static export limits where customers have a higher degree of certainty over export limits over the life of their investment. Working Group consultations have revealed the need for regulatory

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[59] Post-2025 Market Design, Final advice to Energy Ministers, Part B, p.69, esb-post2025-market-design.aemc.gov.au/32572/1629945809-post-2025-market-design-final-advice-to-energy-ministers-part-b.pdf

[60] sapowernetworks.com.au/industry/flexible-exports/fixed-v-flexible/

oversight of DOE curtailment outcomes as embedded generation penetration increases and DOE curtailment becomes more material to customers.

The introduction of the service performance incentive arrangements for exports are expected to support an efficient level of export service delivery to customers under DOEs.[61] Following the recent reforms, the NER now provides for an export service performance reporting framework to be developed by the AER.[62] These arrangements could be used to incentivise DNSPs to deliver an efficient level of export service in line with customer expectations.

Working Group Finding: *Transparency about dynamic constraint levels:*

The Working Group agrees with the ESB's view that the introduction of DOEs warrants a corresponding focus on the transparency and reporting requirements by networks to justify the reasons for constraints that are applied via DOEs and that this should include regular data reporting to the AER, similar to the Regulatory Information Notices (RIN) frameworks for reliability reporting.[63]

4.3. A nationally consistent implementation of 'technical readiness' should benefit more customers

4.3.1. For a customer's site to support DOEs a common communications standard is required

The following section explores the arrangements and capabilities of customer and aggregator devices that would support customers to be "DOE ready."

Definition: *What does it mean to be DOE ready?*

The customer's DERs will need to be enabled to receive and respond to DOE instructions sent by the DNSP. To receive and respond to these instructions, a customer must have appropriate communications capabilities to receive the envelope set by the DNSP for their site and the corresponding device-level capability to adjust and coordinate performance in line with the envelope.

National adoption of Common Smart Inverter Profile – Australia

For DOEs to deliver benefits to customers, they must be supported by devices at the customer premises. A common communications protocol, used across different DNSPs, will reduce costs and enhance market access for device manufacturers, thereby supporting competition and choice for consumers.

A standardised approach to communication has been explored by DEIP DER Integration API Technical Working Group resulting in the development and publication of the 'Common Smart Inverter Profile – Australia' (CSIP-AUS)[64] that leverages existing standards namely, the IEEE 2030.5-2018 specification and the Common Smart Inverter Profile (CSIP). Along with defining a common communications approach for the Australian context, the CSIP-AUS Implementation Guide also considers some of the operational requirements for DOEs, such as agreed fallback behaviour in the event of a loss of communications or of connectivity.

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[61] [1] NER 11.141.3 requires the AER to undertake a review to consider arrangements (which may include a service target performance incentive scheme) to provide incentives to DNSPs to provide efficient levels of distribution services to retail customers to supply from embedded generating units into the distribution network.

[62] For example, NER Clause 6.27A now provides that the AER must develop a network service performance report, which provides information about the performance of each DNSPs in delivering distribution services for exports from DER into the distribution network over the previous 12-month period.

[63] ESB, Post-2025 Market Design, Final advice to Energy Ministers, Part B, pg.90

[64] Common Smart Inverter Profile – Australia, arena.gov.au/assets/2021/09/common-smart-inverter-profile-australia.pdf

4.3.2. Alternative protocols maybe be used between devices and the cloud

If a DNSP were to adopt the IEEE 2030.5 based CSIP-AUS, then a DOE ready customer will need to have a 2030.5-capable software client. This client could exist natively in the inverter, in a separate physical gateway device, or in the cloud as described in Chapter 2.

For circumstances where the IEEE 2030.5 client exists in the cloud, a channel of communication between the cloud platform and the customer's device is required. In this case, DOE readiness is achieved for exports via the ability of the customer device to receive and respond to instructions from the cloud platform, even if this occurs via a non-standardised or proprietary communications protocol.

Device level capabilities

In addition to complying with a common communication protocol, customer devices will also need to have applicable device level capabilities to respond to instructions by the DNSP, such as by managing power flows. Performance and testing standards, adequate control functions, metering points, and input capabilities are expected to be included in most new and replacement inverters for embedded generators installed by customers. Many older inverters may not have these device level capabilities, meaning that customers wanting to participant in a DOE arrangement may have to upgrade or replace their inverter or install a separate controller.

Behind-the-meter (BTM) coordination

Under the CSIP-AUS implementation, customers will need a single nominated gateway for a customer's site that can communicate using the common standard (i.e. have a single 2030.5 client) and mange power flow at the point of connection. This gives rise to a coordination challenge where multiple BTM devices may need to be orchestrated to comply with the envelope issued for the connection point.

In this case, the customer may need a Home Energy Management System (HEMS) capable of receiving DOEs, and undertaking the orchestration function, to be "DOE ready". A report on the Customer Energy Management Systems by ENEA, commissioned by ARENA, found that a range of HEMS products and services were available in Australia with the required BTM coordination capabilities and work was underway to get these ready for DOEs. The report notes that some HEMS providers were testing IEEE 2030.5 implementation and most providers interviewed were working towards CSIP-AUS implementation.[65]

Customers that have solar and battery systems currently face this coordination challenge under static export limits and this is typically solved using inverter and third-party gateway devices located at their premises (battery and other flexible loads are often managed by a communication channel to the vendor's cloud platform).

Behind the meter communication

Where a customer has installed a separate physical gateway to receive the DOEs, or where there are multiple BTM devices requiring coordination for the compliance with the DOEs, such as through HEMS, these devices will need to be able to communicate with each other using one or more communications protocols. While the specific standard used for this communication does not need to be the same as the standard for network-to-customer communications, further standardisation of the BTM communications and control functions could assist the market development of HEMS supporting the extension of DOEs to a wider range of use cases.

The immediate priority for industry is to develop a consistent approach for the management of exports from embedded generators, such as solar and battery storage. This can generally be achieved by issuing DOEs to a single inverter or gateway device at a customer premises.

Working Group Finding: *Poor BTM interoperability presents a potential barrier to consumers recognising full potential benefit*

The Working Group considers that greater BTM device interoperability, to support HEMS market development will help customers achieve the greatest benefits from DOEs. The *Smarter Homes for*

[65] For more information see *Appendix D: Smarter Homes for Distributed Energy*

Distributed Energy study conducted by ENEA on behalf of the Working Group recommends that market bodies, governments and industry further consider the cost and benefit of introducing mandatory or voluntary behind-the-meter open device standards.

4.3.3. More work is required on implementing a nationally consistent and common 'technical readiness' for DOEs

Requirements for customer devices to be compliant with a certain communications standard could be set by the DNSPs through their connection arrangements, or through national arrangements such as under the NER. This could include mandatory standards applicable to all new and replacement embedded generators, or this could be supported by incentives whereby customers must adhere to a defined standard to access the benefits of DOEs (as is currently the case in trials underway).

Part 5A of the current NER provides DNSPs the ability to apply connections requirements and associated standards through customer connection agreements. The contents of connection agreements can vary between DNSPs to reflect local conditions including local jurisdictional technical regulations and DNSP business preferences. These connection agreements are reviewed by the AER, however there are limitations on the circumstances in which national standardisation can and should be enforced.

As noted above, moving to consistent and well-targeted national standards could support a more efficient implementation of DOEs, delivering net benefits for all electricity consumers. Compared to each DNSP adopting their own communication standard, greater national standards could streamline market access and compliance processes for technology vendors, reducing costs and increasing choice for consumers. A national standard would also send a strong signal for OEMs to invest in and conform to specified capabilities which would ensure more customers are DOE ready if, and when, DOEs are implemented in their local area.

The need to set national technical standards for customers DER to support interoperability and communication was also recognised by the Energy Security Board's in its *Post 2025 market design advice*[66]. The ESB's advice also noted its intention to progress the introduction of mandatory technical interoperability and communication standards for customers DER as part of its DER implementation plan.

The Working Group supports the introduction of national communications standards for customers' DER as part of the ESB's DER integration plan as a matter of priority. While DNSPs are adopting CSIP-AUS as a nationally standard for DOE communications, further work is required to determine the scope of its application to support the 'DOE-readiness' of customer inverters and gateway devices. When considering the introduction of a national communications or performance standards for customers DER, the ESB should have regard for:

- **The communications standard to be adopted:** As previously noted, the DEIP's DER Integration API Technical Working Group has developed and published the 'Common Smart Inverter Profile – Australia' (CSIP-AUS) based on IEEE 2030.5. The development of the CSIP implementation guideline guide was based on extensive collaboration between network businesses, retailers, equipment manufacturers and aggregators. The CSIP-AUS appears to provide a sound basis for a national communications standard as it has achieved broad support from the key stakeholders. One approach would be for the CSIP-AUS to be referenced in an existing standard like AS4777, along with any other relevant standards for BTM interoperability.
- **Scope of the standards:** Compliance could be sought from all new and replacement embedded generators connected or, alternately, only from customers seeking DOE arrangements. While the Working Group considers that mandating a national communication standard is unlikely to have a material impact on device and installation costs, this should be scrutinised for its merit in providing a

[66] ESB 2021, *Post 2025 market design advice*, Appendix B page 76, esb-post2025-market-design.aemc.gov.au/32572/1629945809-post-2025-market-design-final-advice-to-energy-ministers-part-b.pdf

net customer benefit.[67] The Working Group also considers that appropriate transitional arrangements for industry will also need to be developed.

- **Timing of adoption:** Adopting a standard too early or too late could have consequences for the timing and costs of DOE implementation. An adoption that is too early could force the industry to converge to a standard that is later found to be unsuitable. Waiting too long to adopt a standard could lead to insufficient level of latent interoperability reducing the ability of customers to access the benefits of DOEs at the earliest opportunity. The standard should take effect on the earliest date after it is agreed that does not materially impact competition outcomes for customers.
- **Allowing for innovation and continuous improvement:** In referencing a communications standard for customer devices, regulations and contract arrangements (e.g. connection agreements) should be flexibility to allow the standard to evolve over time.

4.4. DOEs should be well integrated with broader market systems

There are several dimensions of DOE implementation where market participants' and customer's interests will be affected. The following sections explore options in relation to:

1. NMI vs device level implementation and net-metering
2. Capacity allocation principles
3. Enrolling customers for DOEs
4. The need for national harmonisation of DOE interval, forecast periods and calculation methodology

4.4.1. NMI vs device-level implementation

DOEs allow DNSPs to vary the level of network and system capacity available to individual consumers over time. In the future[68], this capacity could theoretically be allocated at four system levels:

- **Allocation to aggregators –** DNSPs allocate available network capacity to an aggregator[69] who then shares the capacity across all DOE-enabled customers or device(s) in their portfolio in the constrained area of the network. This has the benefit of allowing trading (re-allocation) of unused capacity within an aggregator portfolio.
- **At the customer point of connection to the network** – This method involves the DNSP issuing a DOE for a customer, regardless of the number or configuration of devices behind the connection point. As an example, a DNSP could allocate 5 kW of export capacity to a residential customer. Under this model, the customer and/or their agent are responsible for ensuring the overall operation of all generation and load behind the connection point (including that not actively managed) does not breach the export limit.
- **Allocation only to flexible generation** – Future market arrangements may allow customers to have multiple meters or connection points at a single premises, electrically separating their flexible and inflexible generation (or load) resources. In this case, the DOE could be allocated only at the metering point assigned to the flexible resource.
- **Allocated directly to DOE-enabled devices** – This method involves the DNSPs providing available network capacity to individual DOE-enabled devices behind a customer connection point

[67] The US inverter standard IEEE 1547 (AS4777 equivalent) has interoperability requirements for all new installations. Such an approach seems feasible in Australia, while considering if and where some exemptions may be appropriate (stand-alone power systems).

[68] Rule changes may, in the future, allow multiple NMIs behind a connection point and a DOE could potentially be issued for each NMI, or at a lower system level (e.g., a 'child metered' device).

[69] Most small customers have only one connection point for their premises, although there are exceptions to this. In relation to a connection point, a Financially Responsible Market Participant is the entity registered with AEMO that is responsible for making or receiving payments in relation to electricity transfers. This could be Retailer or Small Generation Aggregator, or a 'Trader' under the proposed flexible trading relationships model. In the future, there may be multiple connection points at a single customer premises. For a Small Generation Aggregator, the 'connection point' may only have a single 'device' such as combined solar/battery system.

(for example, an EV or an individual solar inverter). Allocation at such a low system level could potentially be less efficient as the customer would not be able to easily optimise their generation or energy usage across devices. Implementation at this level would be more complex for DNSPs.

There is general agreement among stakeholders to commence roll-out of DOEs at the connection point to facilitate industry collectively learning how to operate this new form of operational control and the various benefits of each different approach. As such this should be viewed and designed as a first step. Industry is also exploring alternative DOE arrangements at the 'grouped' device level. These use cases have been included by industry through collaboration within DEIP's Application Programming Interface (API) Technical Working Group which developed CSIP-AUS to suit the Australian context for IEEE2030.5. This foresight within the drafting of CSIP-AUS permits communication to sites either at the NMI-level or to flexible device(s), with the same protocol. This would enable the consumers' agent to manage individual sites within their export limit and in-turn aggregate their sites together to remain within the overarching 'network-wide' DOE.

Working Group Finding: *DOEs can be initially allocated at the connection point*

The Working Group considers that DOE allocation is best applied initially at a customer's point of connection to the network, in relation to net exports (after accounting for customer demand). This approach may evolve in future to support new market frameworks such as flexible trading arrangements.

The application of DOEs to the point of connection for exports will likely need further consideration in the short term as energy trading and community storage benefits are further investigated and if, in the future, DOEs are adopted to enable more flexible connection management. Addressing this issue is beyond the scope of this paper and it is best considered in the context of the ESB's proposed flexible trader model and its associated metering arrangements.[70]

4.4.2. National allocation principles

The Working Group found universal stakeholder support for the development of 'national allocation principles' to guide DOE design and implementation by DNSPs. Allocation, in this context, refers to the approach to apportioning available network hosting capacity between individual customers.

Such principles would support a more national consistent outcome for stakeholders and provide transparency and assurance to consumers that DOEs are being implemented fairly and in their interests. A principles-based approach is appropriate at this time given the need to continue the process of learning from trials while providing flexibility for DNSPs to respond to local conditions including the efficient use of existing infrastructure.

Capacity allocation involves complex trade-offs between technical efficiency, implementation costs and social equity. In theory, network hosting capacity can be most efficiently utilised through very precise and fine-grain allocations unique to each customer connection point. This may result in, for example, a customer at the end of an urban feeder receiving a tighter export limit than a customer closer to the distribution transformer, even where they reside on the same street. Such an approach could raise transparency and social equity concerns for affected customers even though it may provide a better outcome for customers as a whole. In some cases, the costs associated with establishing sophisticated ICT systems may also exceed the benefits for consumers.

The Working Group considers that flexibility is needed to work out the right balance of considerations and this will benefit from technical innovation and further consultation with consumer groups.

Working Group Finding: *Draft principles for good practice DOE allocation*

[70] ESB, Post-2025 Market Design, Final advice to Energy Ministers, Part C, from p.38, esb-post2025-market-design.aemc.gov.au/32572/1629945838-post-2025-market-design-final-advice-to-energy-ministers-part-c.pdf

Based on DEIP consultations to date[71], the Working Group has developed draft export hosting capacity allocation principles to provide guidance to DNSPs in developing their capacity allocation approaches. These relate to transparency, efficiency, fairness, incentives for demand management, technology neutrality, customer choice and incentives.

1. DNSPs are responsible for setting DOE limits, with the calculation methodology used to determine the limits being transparent and subject to stakeholder consultation.
2. Allocation should seek to maximise the use of network export hosting capacity while balancing customer expectations regarding transparency, cost and fairness.
3. Capacity allocation can initially be based on net exports and measured at the customer's point of connection to the network
4. Capacity should be allocated to small customers irrespective of the size or type of customer technology (e.g. solar or batteries) at the customer premises.
5. In the near term, DOEs should be offered on an opt-in basis with capacity reserved only to make good on legacy static limit connection agreements, with efficient incentives provided for customers to transition to DOEs over time.

More work is required to further define how these principles will be applied in practice.

These principles are intended to provide guidance for the ongoing development of DOE implementation approaches while noting that initial trials may use more basic approaches that make efficient use of existing network telemetric, communications and software infrastructure. It is expected that DNSPs will apply technical innovation and learning from continued consultations to develop more sophisticated approaches over time.

Further stakeholder engagement is required to determine how best to codify and operationalise these principles, and to ensure it is understood the implementation of DOEs will likely evolve. More oversight by the AER over DNSP approaches could increase the consistency and transparency of approaches to capacity allocation, alongside related expenditure proposal reviews to maximise the net benefit for consumers in the long term.

4.4.3. Enrolling customers for DOEs

A customer can enrol themselves in a DOE at the time of making a connection agreement with the DNSP. At this step a customer or their installer will need to provide details of either their local 2030.5 client to be connected with the DNSP's control platform or alternately they can nominate a coordinating agent to enrol their device on their behalf.

It is ultimately a customer's responsibility to ensure that the local or remote controller of their device is properly notified to the DNSP as this may change from time to time. DNSPs can support customer choice and competition in aggregation service markets by streamlining enrolment and switching processes. This may include providing for customers to authorise a coordinating agent to enrol a new device, or update device details on a customer's behalf. While this paper has not examined these issues in detail, streamlined enrolment and switching processes are expected to be a significant contributor to the future development of electricity service markets and this warrants further attention.

The control hierarchy for DOE-enabled devices

The simple philosophy of DOEs is that customers should be free to optimise their energy generation and usage, and provide services to other parties, within the physical limits of the power system. These limits can include local network thermal or voltage constraints identified by the DNSP or, potentially, bulk system constraints identified by AEMO related to maximum or minimum demand in a NEM region. Within these constraints, a customer's embedded generation may be providing a range of functions including supporting self-consumption of solar, supplying wholesale markets or providing frequency response. As described in Chapter 2, control signals from an aggregator or agent may be delivered to the customer device via a

[71] See Appendix A: Overview of DOE workshops

separate communications pathway to the DOE or, alternatively, the aggregator or agent may receive the DOE on the customer's behalf and combine it with any control instructions for market trading.

In addition, various local controls are embedded in inverter settings to ensure they support stable power system operation. These include a requirement on inverters to reduce output in response to local high voltages or to maintain output during short term voltage fluctuations.[72]

Working Group Finding: *More work to form device control hierarchy:*

The Working Group has developed a draft control hierarchy that is consistent with current practice and reinforces the principle that customers should be free to buy and sell energy services within the physical constrains of the local network or the power system more broadly. The Working Group considers the following draft control hierarchy (with number 1 having the higher priority) is consistent with current practice and should be maintained through the future development of DOEs. This may affect the configuration of the nominated IEEE2030.5 client at a customer premises as well as device controllers (either local or cloud-based):

1. Mandated inverter controls as prescribed by regulation or connection agreement (e.g. for voltage response and ride-through)
2. Bulk system export constraints issued by AEMO via the NSP (this is expected to be incorporated into the DNSPs operating envelope formulation in most network locations)
3. Local system export constraints issued by the DNSP (potentially incorporating AEMO bulk system constraints)
4. Market trade[73]

This hierarchy broadly aligns with the way large-scale generators participate in markets within the limitations of their generator performance standards and real-time transmission constraints ('security-constrained dispatch'). Unlike large-scale generation however, small customer devices are not centrally dispatched by AEMO and therefore the problem of optimisation of trade within system constraints is decentralised to individual customers and their agents. The hierarchy should also apply where a gateway device or inverter has to resolve potential conflicting instructions (e.g. reduce exports to meet a DOE vs increase power flows to provide a frequency raise service).

While key elements of this hierarchy are captured in the AS/NZS4777.2:2020 inverter standard and the CSIP-AUS, further work is required to ensure that the above control framework does not unduly undermine the effectiveness of contingency FCAS by constraining the operation of FCAS-enabled resources. Different approaches to this should be considered including:

- Ensuring AEMO has adequate information to factor in local network constraints into the location and volume of procured FCAS, and/or
- DNSPs including headroom in DOE calculations to allow for short duration override of local constraints for the provision of FCAS raise responses. Careful consideration needs to be given to the cost of maintaining that headroom for customers (i.e., potentially inefficient ongoing export curtailment).

Compliance with the control hierarchy, including compliance with the relevant technical requirements of AS/NZS4777.2:2020 and the CSIP-AUS, is ultimately the responsibility of the customer and/or the agent that has operational control over device performance

4.4.4. Communications security and device fall-back behaviour

Chapter 2 discusses two alternate communication and control models that may be employed in issuing DOE to customer devices: *device-direct control* and *agent-mediated control*. In either case it is important to consider the fall-back behaviour of devices should communications channels fail. This is especially

[72] AS/NZS 4777.2:2020

[73] For example, wholesale energy supply, contingency FCAS, RERT and/or wholesale demand response.

important as the communication pathway for DOEs has multiple potential points of failure (E.g. DNSP infrastructure, mobile networks, agent infrastructure, customer WAN and LAN). The widespread use of DOEs increases the overall reliance of the power system on internet and mobile communications infrastructure and this needs to be considered in the broader context of Australia's critical infrastructure security strategies. These issues fall under the scope of the *Australian Energy Sector Cyber Security Framework* (AESCSF) and are beyond the scope of this report.[74]

When a communications failure occurs, devices need to conform to operating requirements prescribed by the DNSP via their connection agreement with the customer. For example, devices may be required to default to a conservatively calculated static export limit or a fixed maximum export profile (e.g. time-of-day) that serves as a compromise between static and dynamic limits while ensuing the grid remains secure. The CSIP-AUS includes a means to set such fall-back controls through the IEEE:2030.5 communications protocol.

Working Group Finding: *Further consultation is needed on device fall-back behaviour*

A nationally consistent framework for determining device fall-back behaviour for customer devices should ensure minimal disruption to customers and earliest possible restoration of DOE operation. Such a framework should provide flexibility for DNSPs to determine local settings reflecting local conditions while supporting AESCSF processes and outcomes.

4.4.5. DOE intervals, forecast period and detailed calculation methodology

DOE intervals period

In implementing DOEs, the DNSPs can currently choose the time duration of an operating envelope setting which would define how frequently the envelopes can change. For example, a DNSP may choose to set DOEs at a 5 min interval or at a 30 min interval as illustrated in the graph below for 2-hour period.

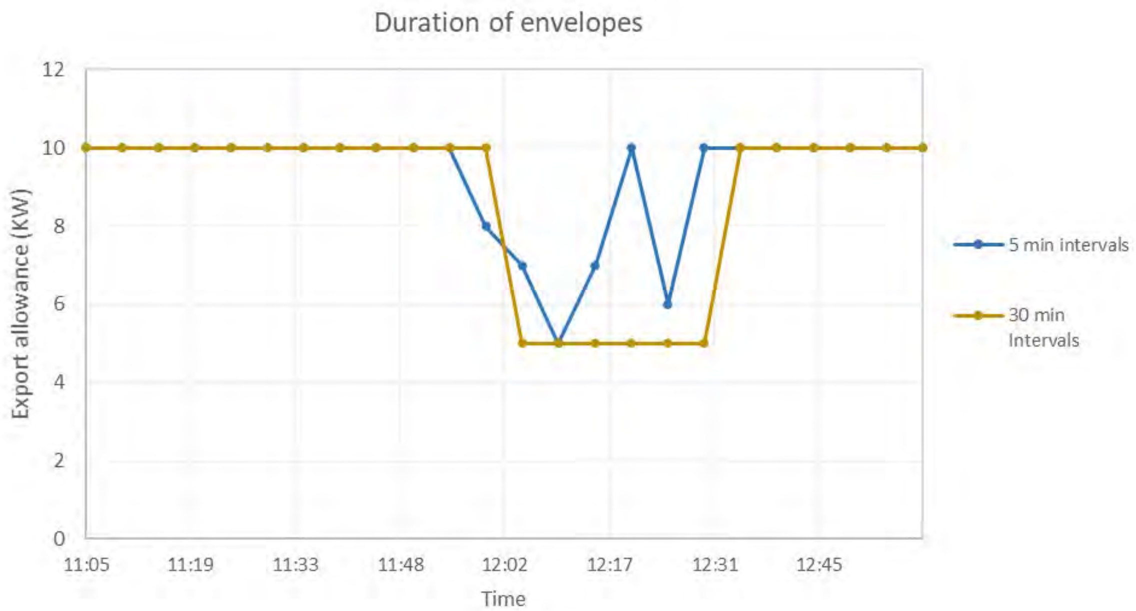

Figure 10: Duration of 5 minute versus 30-minute envelopes

The Working Group considered a range of ways the duration of the envelope could impact DNSPs, market participants and customers:

[74] Australian Energy Sector Cyber Security Framework, aemo.com.au/en/initiatives/major-programs/cyber-security/aescsf-framework-and-resources

- Shorter DOE intervals will require faster metering, higher communication and data storage costs and greater computational capability. This could impact cost of implementing DOEs and form part of the AER's consideration of the efficiency of network DOE network expenditure proposals.
- Shorter DOE intervals can be updated more frequently, this means the envelopes can more accurately reflect the available hosting capacity as it changes over time. This is demonstrated in Figure 10 above. This applies where DOEs are issued in response to both local and bulk system constraints.
- Shorter DOE intervals allow customers participating in energy, W-DR and FCAS markets (settled in 5-minute intervals) to capture greater value from market volatility. This will also support efficient outcomes for all customers by increasing supplies at times of resources scarcity.
- In rare cases, some devices may not be able to respond to shorter duration intervals due software or hardware limitations. In this case devices will need to comply to the lowest DOE export limit over the interval in which it can respond. This is expected to make these devices less competitive to customers.
- Some devices may be configured to receive controls at more frequent intervals (e.g., 1-minute) in which case a facility is required to apply the DOE value at each of the shorter intervals. This facility could be provided by the customer agent responsible for managing DOE compliance.

Working Group Finding: *Using a 5-minute interval duration is efficient*

DNSPs should implement or provide a plan to transition to setting DOEs at a 5-minute duration interval. The short-term additional costs (if any) of implementing this approach are likely to be small in relation to the longer-term benefits of clear and consistent product development signals to industry and efficient market outcomes that benefit all consumers.

Context: *Interval periods for system security notices*

DNSPs are sometimes instructed to respond to system security challenges at short notice. For example, AEMO may instructs a NSP to curtail solar to manage a minimum system load condition, or due to a transformer failure that results in PV reverse flows exceeding a zone substation thermal rating. Manual or autonomous overrides need to be activated quickly in response to such an event and a DNSP could be given 15 mins to respond. A longer DOE internal period (e.g., 30 minutes) could limit the DNSPs ability to respond to such a request in a timely manner and require the DNSP to undertake more costly measures such as 'load shedding' (in this case generation shedding) at the feeder or zone substation level.

4.4.6. Harmonising constraint forecasting for customer and market participants

DOEs for customer electricity exports have implications for a wide range of stakeholders and they will need to be forecast and communicated ahead of time to support efficient market outcomes. For example:

- An aggregator providing services such as RERT, FCAS or W-DR could find themselves unable to make good on a dispatch instruction if a DOE unexpectedly constrains their ability to respond. Advance notice of a likely DOE constraint would enable the aggregator to adjust their bid accordingly.
- Customers can use advance knowledge of DOEs to plan their electricity use behaviour to maximise their self-consumption of solar.
- A tight DOE could increase a retailer's exposure to an electricity spot market during a period of high pricing. Advance notice of a DOE would support a retailer to better hedge their position over various timescales.

- Depending on the control hierarchy adopted, a DOE could reduce the supply of FCAS raise services for AEMO. In this case, AEMO will need to understand the extent of the reduction and factor this into the scale and location of FCAS procurements.

DNSPs will have a range of tools to forecast network hosting capacity based on a range of inputs including weather and known network characteristics, potentially supported by machine learning. However, such forecasts are inherently uncertain and major changes can occur over any forecast period including weather changes and unplanned outages, that impact DOE formulation.

The need to harmonise operational forecasting of DOEs

The DNSPs must choose a period, ahead of real-time, for which they will provide a forecast of likely constraints. For example, DNSPs may communicate its forecasts for each DOE interval for the next 24 hours, or alternately, 1 hour ahead of real-time on a rolling basis. The final DOE would be issued only immediately prior to real-time. In case of a 1-hour ahead forecast, this would leave limited opportunity for a customer or their agent to manage their electricity demand to maximise the use of their embedded generation.

As real time approaches, a DNSP's forecast can be updated based on newer information reducing the uncertainty of the estimate over time. These updates can be issued continuously along with the DOE communication signal, or periodically or through an independent channel. Forecasts could be based on the DOE-interval length (e.g., 5 minute) or a longer duration to reflect the inherent uncertainty of the forecast.

As real time approaches, the value of more frequent and finer-grain forecasts is likely to increase. For example, a household with solar and battery may benefit from knowing that there is likely to be a major constraint on exports around the middle of the next day (they may delay energy use activities until that time). As that time approaches the customer's agent may benefit from understanding the shape of the constraint over specific time intervals so they can plan the battery's market participation in the 5-minute energy spot market.[75]

While a customer's agent may have their own methods to forecast likely constraints, they are unlikely to be a full substitute for a DNSP's own forecast such as in relation to planned or unplanned outages that affect DOE formulation.

The CutlerMerz study (see *Appendix C: Review of DOE Adoption by DNSPs*) found that most DNSPs were considering deployment based on 5-minute intervals and a 24-hour forecasting period, and this appears to provide a reasonable approach for planned trials.

> ***Working Group Finding:*** *A framework for constraints forecasting should be development*
>
> A nationally consistent framework for constraint forecasting should be developed and be guided by the information needs of customers and their agents and the need to align with existing forecasting and bidding systems for AEMO and market participants. Further work is needed to recommend appropriate national settings for constraints forecasting and to assess the costs and benefits of adopting these settings nationally.

The need to harmonise longer range forecasting of DOEs

It is expected that DOE forecasts will be issued using the same communications channel as is used to issue the final DOE instruction. This approach has the potential to streamline communications and reduce costs for the party with operational control of the customer device. However, longer range forecasts may be provided through other channels. This may include forecasts of expected or average time-of-day, day-of-the week or annual constraints that may impact customer operational or investment decisions.

Given that customers may not have direct visibility of information sent to the 2030.5 client, this information could be provided through public sources such as a website or through an 'open API' that would allow aggregators as well as other parties (such as installers) to develop information products for consumers and

[75] In the future, a customer, or their agent, may place higher value on the need to understand the volume of services (e.g., energy) that customers can export given the constraints that are likely to be faced. This will depend partly on the progress of reforms (e.g., load forecasting and scheduling) such as those being considered under 'schedule lite'.

incorporate longer range forecasts into planning or investment decisions. Such decisions could include whether it is economic to invest in solar or battery storage at a given their location in the network. An open-API approach would support innovation in third-party services that may be of value to customers.

Ineffective, inefficient, or nationally inconsistent approaches to forecasting system design would create additional DOE integration costs and complexities for market participants.

> ***Working Group Finding:*** *Longer range forecasting is a priority*
>
> The Working Group considers that longer-range constraint forecasting should be an important focus area for industry over the course of 2022 to inform customers currently considering investing in embedded generation.

4.4.7. Detailed DOE calculation methodologies need not be harmonised

DNSPs may take different approaches to calculating available hosting capacity and operating allowances for customers. As highlighted in section 2.3, the method of calculating DOEs used by a network could depend on factors such as the availability and accuracy of low voltage (LV) network data, network monitoring capability, operational forecasting capability, network topologies, the type of network constraints faced and other factors. DNSPs are likely to differ from one another when it comes to these factors (e.g. some DNSPs may have greater network monitoring capabilities than others). As a result, they may need to take different approaches to detailed DOE calculation methodologies suiting their circumstances.

Generally, DOEs based on more accurate and real time information would provide for more accurate and effective DOEs that better reflect the network capability and support networks in hosting greater levels of DER. However, greater levels of DOE accuracy could require greater levels investments in the DOE infrastructure.

DNSPs adopting different detailed DOE calculation methodologies is not expected to have a significant impact on customers and market participants. This is because the methodology used to calculate the DOE does not affect the integration of DOEs with the market participants' systems as the calculation happens largely 'behind the scenes.

> ***Working Group Finding:*** *Detailed DOE calculation methodologies need not be standardised*
>
> The Working Group considers that the national harmonisation of detailed DOE calculation methodology would be unnecessary and difficult to achieve.

APPENDIX A: OVERVIEW OF DOE WORKSHOPS

The Working Group set out to explore the value that DOEs could offer to the energy transition. The aims of the workstream were to:

- build a shared understanding of the opportunities and challenges
- share insights on approaches currently under investigation
- identify reforms that could be implemented to establish dynamic operating envelopes.

A key component of this work revolved around extensive stakeholder engagement with industry. A series of consultation workshops were run to build understanding and identify areas of consensus on next steps to guide the design and implementation of DOEs. These included stakeholders from consumer groups, networks, research organisations, market bodies, retailers, aggregators and other organisations.

Knowledge Sharing webinar

On 30 September 2020, the Working Group commenced its work with a knowledge sharing event which introduced the audience to the concepts, issues and key projects investigating DOEs.

The panel included representatives from Zepben, Dynamic Limits, SAPN, Enova Energy and Renew.

A recording of the webinar and a written summary is published at: arena.gov.au/knowledge-bank/deip-dynamic-operating-envelopes-webinar-1/

Consumer Perspectives workshop

On 22 October 2020, the Working Group brought together over 100 participants from across the industry to discuss consumer perspectives on DOEs.

Participants discussed what is needed to make DOEs a positive consumer experience and considered important criteria for fair and equitable DOE allocations. Participants considered four key themes:

1. Capacity allocation principles
2. Regulation and governance
3. Information provision
4. Fairness, equity and social licence

A written summary of the workshop outcomes is published at: arena.gov.au/knowledge-bank/dynamic-operating-envelopes-workstream-consumer-perspectives-workshop/

National Regulatory and Policy Design Issues workshop

On 12 November 2020, the Working Group brought together over 40 participants from across the industry to discuss national regulatory and policy design issues relating to DOEs.

Participants considered four key policy and regulatory issues:

1. Regulation of allocation principles
2. Standardisation of customer connection agreements
3. Information and market processes
4. Monitoring and enforcement.

Participants identified areas under each topic that would benefit from national consistency and then discussed how this might be achieved.

A summary of the workshop outcomes is published at: arena.gov.au/knowledge-bank/deip-dynamic-operating-envelopes-workstream-national-regulatory-and-policy-design-issues/

Allocation Principles workshop

On 12 July 2021, the Working Group brought together over 60 participants from across the industry to discuss the preferred allocation principles for DOEs (i.e., how scarce network capacity is apportioned to customers).

Participants were asked to discuss opportunities and challenges of two conceptual questions:

- At what scale should DOEs be applied?
- How should available capacity be allocated between customers?

A summary of the workshop outcomes is published at: arena.gov.au/knowledge-bank/deip-allocation-principles-workshop-summary/

APPENDIX B: INDUSTRY CASE STUDIES

Initial work on DOE development

The following case studies provide a summary of the trials and projects relevant to the implementation of DOEs.

California rule 21

California's Rule 21 describes the interconnection, operating and metering requirements for generators connecting to a utility distribution network in California. The requirements are designed to enable the utility to continue to maintain security and reliability of supply under high DER penetration. The first phase, which came into effect in September 2017, outlines the requirements for trip and ride-through settings and volt-var operation for all new generating systems connection to the network, similar to the requirements in AS4777 in Australia.

Subsequent phases 2 and 3 introduce mandatory communication and control requirements for smart inverters and aggregators to interface with the utility systems, including the requirement for dynamic export power limiting. These requirements are based on a subset of the IEEE 2030.5 smart inverter functions which are described in the Rule 21 Common Smart Inverter Profile (CSIP). Phase 2 (and part of phase 3) requirements came into effect in California on June 22, 2020, meaning that all new inverters installed in California now must have the capability to communicate using the IEEE2030.5 protocol.

SA Power Networks' LV management business case

SA Power Networks developed its Low Voltage (LV) management strategy in 2018 in response to emerging distribution network constraints arising due to the proliferation of solar PV in South Australia. To enable the continued uptake of DER, the strategy explored several investment options across a range of possible future scenarios supported by extensive techno-economic modelling. Options explored included:

- **Static export limiting** – When a local network reaches its limit to host DER, all new DER connections are limited to zero or near-zero export;
- **Network augmentation** – When a local network reaches its hosting capacity limit, invest in network or non-network solutions to support the DER uptake; and
- **Dynamic export limits** – Implement dynamic export limits, constraining exports only during the rare periods of network constraint and enable exports at all other times.

This strategy and analysis informed SAPNs 2020-2025 regulatory proposal[76]. The business case compared the costs of implementing these options, compared to the broader economic benefits of the energy unlocked through enabling exports. Dynamic export limits were shown to be the investment option that resulted in the best long-term economic outcome for customers, and was the option recommended in the business case.

This business case was submitted and approved by the Australian Energy Regulator (AER) as part of SA Power Networks' 2020-2025 regulatory determination and dynamic exports are now being implemented in South Australia through SA Power Networks' 'flexible exports' program.

DER Integration API Technical Working Group

The DEIP DER Integration API Technical Working Group was formed in 2019 to develop a nationally consistent, standards-based approach to integrating high levels of DER with Australian distribution networks. The founding members came from early ARENA-funded DER integration projects and the group has now expanded to more than 20 organisations from across the sector.

Early work consisted of mapping DER integration use-cases and reviewing international standards and approaches. Through this process, the group identified the IEEE 2030.5 DER communications standard and CSIP developed as part of California's Rule 21 process as the most mature and appropriate starting

[76] SA Power Networks revised proposal for 2020-2025 regulatory period, aer.gov.au/networks-pipelines/determinations-access-arrangements/sa-power-networks-determination-2020-25/revised-proposal

point. The group then spent the next 18 months developing the CSIP-AUS IEEE 2030.5 implementation guide which includes the minimal set of extensions required for the Australian context. The first version of the CSIP-AUS was released in September 2021[77].

Ongoing work includes the development of CSIP-AUS test procedures and exploration of further use-cases.

Latest industry developments

The following table provides a cursory overview of the current DOE industry projects and initiatives, with the key focus areas of each project shaded in light blue. Further detail on each project can be found below the table.

[77] DER Integration API Technical Working Group 2019, Common Smart Inverter Profile Australia, arena.gov.au/knowledge-bank/common-smart-inverter-profile-australia/

Table 3: Overview of current DOE industry projects and initiatives

Year **Project Name –** *Organisation*	**Focus area**					***Project Status***
	DOE calculation methodology	**Communications standards and interoperability**	**Allocation methodology**	**Customer connection agreements**	**Level of DOE Market Integration**	
2018 – 2020 **Solar Enablement Initiative (SEI) –** *University of Queensland*	State Estimation based on any available data set including a forecast	N/A	Equal	N/A	None	*Technology spun out into GridQube Being utilised at Energy Queensland for limits to solar systems at small scale*
2019 – 2021 **Advanced VPP Grid Integration Trial -** *SA Power Networks*	Abstract hosting capacity model based on LV network taxonomy & templates	IEEE2030.5 lite	Capacity divided equally between all customers in each LV area. Aggregated (nodal) DOEs also available.	Waiver to allow trial customers to export up to 10kW	Aggregator performs market services within the operating limit	*12-month field trial with 1,000 VPP customers. Knowledge utilised for other projects and transferred into CSIP-AUS*
2019 – 2021 **Evolve DER Project** *– Zepben*	*Information not available*	IEEE2030.5 CSIP -AUS	Transformer Level Equal Feeder Level Equal NMI Level Maximised	N/A	Aggregators perform market services within the DSO shared operating envelope	*Project nearing completion and technology being rolled into other trials. Nearing commercial capability*

2020 – 2023 Project EDGE – AEMO	Operating envelope algorithm based on abstraction from iterative power flow models that take in forecast to determine active customer limits	Open-source data message bus – Energy Web Foundation	Equal capacity and maximum network utilisation	Negotiated contract/ Aggregator owns customer relationship	AEMO hosted market exchange platform for aggregator/DER Offers into market Local services exchange for network services Off market, but testing a real time market	*Currently in phase 1 of 3*
2020 – 2022 **Flexible Exports for Solar PV Trial –** *SA Power Networks*	Abstract hosting capacity model of LV and HV network constraints	IEEE2030.5 CSIP -AUS	Capacity divided equally between all customers in each constraint area	Change to MSO to include flexible connection option	Provides dynamic export limit for solar that would otherwise have a static limit. Utilised for contingency curtailment of generation on AEMO instructions manually	*Field trial commenced in September 2021 with IEEE2030.5 gateway device. Native inverter support from Fronius and SMA due Q1 2022.*
2021 – 2023 **Model free operating envelopes –** *C4NET with Victorian DNSPs*	Machine learning and neural networks applied to smart meter data for NMI level DOEs	N/A	TBD	N/A	N/A	*Early stages of development*
2021 – 2023 **Project Symphony -** *Western Power*	Operating envelope algorithm based on abstraction from iterative power flow models that take in forecast to determine active customer limits	TBC - Various options under consideration, including open-source data message bus, IEEE 2030.5.	Equal capacity and maximum network utilisation. Also exploring alternative allocation methods.	As per recently updated network connection requirements for basic embedded generation (includes provision for operation in a VPP). Aggregator owns	Off-market simulations.	Pilot platforms established. Entering MVP (Bi-directional energy

				customer relationship.		balancing market scenario).
2021 – 2023 **Neighbourhood Battery Initiative –** *Network led (CitiPower, Powercor and United Energy)*	In development but to increase solar hosting capacity and manage network constraints	Network to battery under development/ Custom API to retailer	Multiple use cases: Retailer for FCAS and arbitrage, virtual battery.	None	Community energy sharing and provide network support	Battery deployment second half of 2022
2021 – 2023 **Neighbourhood Battery Initiative –** *Community led (CitiPower, Powercor and United Energy)*	In development but to increase solar hosting capacity and manage network constraints	*Information not available*	Multiple use cases: Retailer for FCAS and arbitrage, virtual battery.	Community model	Community energy sharing and provide network support/ Optimisation by ANU BSGIP	Battery deployment second half of 2022
2021 – 2023 **LV Pole-Mounted Battery Trial –** *CitiPower, Powercor and United Energy*	Manage peak demand and made available for market services all other times	IEEE2030.5 network to battery Custom API for retailer access	FCAS and arbitrage, network support when required	None	Retailer uses asset in FCAS and wholesale markets when battery not required for network support	*Near end of initial development phase*
2020 – 2023 **EV Grid –** *Jemena*	Spare capacity of transformer allocated to smart charger	IEEE2030.5 lite. Not compliant implementation	None	Equal	*Information not available*	*Information not available*
2021 – 2023 **Project Edith –** *Ausgrid*	Leveraging Evolve DER Project DOE calculation methodology	IEEE2030.5 CSIP-AUS and exploring additional fields for pricing (import/export)	Testing interaction between capacity allocation and dynamic pricing (i.e. maximising capacity allocation and managing congestion with pricing)	N/A for trial participants but will include research piece on how to integrate into dynamic connection agreements	Aggregator takes dynamic network prices into account and performs market services within the operating limit (i.e. distributed co-optimisation)	*Project currently in early stages. Testing pricing and DOE impacts with single aggregator (Reposit) with field trial*

Solar enablement initiative (SEI) – University of Queensland

The Increasing Visibility of Distribution Networks project developed a system that provides DNSPs with a better understanding of the operational conditions of their networks, with a new state estimation technique (SEA) that estimates a network's operational conditions from available data. These estimated results form part of a network analysis tool where the likely impact of the additional PV systems can be assessed.

Seven medium voltage distribution feeders – located in South-east Queensland, Victoria and Tasmania – were trialled. Following these successful trials, the system was made available to all Australian electricity distribution companies for rollout on their entire networks.

The system was also trialled in real-time mode for monitoring the operating conditions on a medium voltage network section (feeder) with medium-sized commercial PV systems connected to the LV side of local distribution transformers. This trial explored whether customers could supply useful data to the SEA, and the technical feasibility of a dynamic network capacity assessment and allocation to customers currently on static export limits.

Key insights and learnings:

The trials were successful and demonstrated that there is potential for additional exports beyond the static limits determined during the connection assessment process.

The project demonstrated that more complex representation and optimal allocation of a network's capacity to customers can be done in real-time.

Advanced VPP grid integration trial – SA Power Networks

The Advanced VPP Grid Integration project aimed to show how higher levels of energy exports to the grid from customer solar and battery systems can be enabled through dynamic, rather than fixed, export limits, and to test the value this can create for customers and Virtual Power Plant (VPP) operators. The Project implemented an interface (API) to exchange real-time and locational data on distribution network constraints ('operating envelopes') between SA Power Networks and the Tesla South Australian VPP, enabling the VPP to optimise its output to make use of available network capacity.

Key insights and learnings:

It was found that time-varying and locational export limits could enable DER to be hosted at higher levels of penetration, particularly distributed energy storage VPPs conducting arbitrage between solar and non-solar hours.

The results support the view that a dynamic network capacity management approach can enable larger, more active DER and demand management systems to continue to operate under higher levels of DER penetration than would otherwise be possible with static limits.

Evolve project – ZepBen

The *evolve* DER project aimed to increase the network hosting capacity of distributed energy resources (DER) by maximising their participation in energy, ancillary and network service markets, while ensuring the secure technical limits of the electricity networks are not breached.

It had a strong focus on the development of working software systems that will be integrated with the operational technologies used by distribution networks, and the systems used by aggregators to manage DER under their control. Through multiple demonstrations and trials, the *evolve* project developed new algorithms and capabilities to identify and ease congestion within the distribution network. This will be achieved through the calculation and publication of operating envelopes for all DER connected to the distribution network.

The project uses the following method for the calculation of an operating envelope[78]:

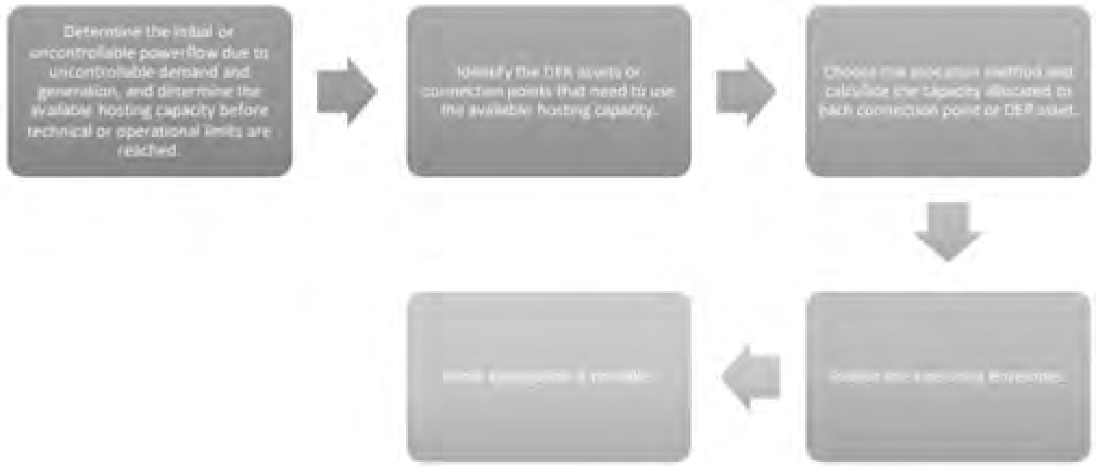

Figure 11: DOE calculation methodology for Evolve project

Key insights and learnings

To be published quarter 1 2022

Project EDGE – AEMO

Project Energy Demand and Generation Exchange (‘Project EDGE’) will develop and test the concept of a Distributed Energy Resources (DER) Marketplace for DER services. Project EDGE is being undertaken by AEMO in partnership with AusNet Services and Mondo, with funding from the Australian Renewable Energy Agency (ARENA). The proof-of-concept DER Marketplace in Project EDGE aims to optimally facilitate DER participating at scale in the wholesale markets and delivering local network support services.

This small-scale off-market trial is taking place in the Hume Region of Victoria, Australia, demonstrating the following key functions:

Data exchange – providing a secure, efficient, and scalable way for data exchange between Project EDGE participants.

Wholesale integration of DER – trialling how aggregated DER might participate with progressive sophistication in the NEM wholesale dispatch process and operate within distribution network limits.

Delivery of local network services using aggregated DER to meet requirements set by the distribution network service provider (DNSP) – providing DER owners and aggregators the opportunity to deliver new value streams.

Understanding and defining the customer value proposition that market aggregators can offer their customer by developing and testing incentives for DER owners (customers) that promote active market participation.

Flexible exports for solar PV trial – SA Power Networks

This SA Power Networks Flexible Exports for Solar PV Trial project aims to produce a flexible connection option for solar PV systems, so customers don’t have to limit electricity export to permanent zero or near-zero in congested areas.

The project acknowledges that the electricity distribution network has a limited capacity to accommodate reverse power flows when solar PV systems export surplus energy to the grid in the middle of the day. To protect the network for all customers, distribution network service providers (DNSPs) must set static export limits at each customer connection point. Some DNSPs have had to impose zero or near-zero export limits for new solar PV systems in constrained parts of the network.

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[78] Battery Storage and Grid Integration Program 2021, *Evolve Project M4 Knowledge Sharing Report,* arena.gov.au/assets/2020/09/on-the-calculation-and-use-of-dynamic-operating-envelopes.pdf

SA Power Networks, in collaboration with AusNet Services, three market-leading inverter vendors (Fronius, SMA and SolarEdge) and one inverter gateway provider (SwitchDin) are co-developing an end-to-end technical solution, using smart inverter technology. The system will enable customers' inverters to automatically adjust their export limits every five minutes based on a locational, dynamic limit signal provided by the DNSP. The Project will also develop a new flexible customer connection offer, and test customer understanding and acceptance during a 12-month field trial.

Key insights and learnings:

Close collaboration with the solar industry is critical to ensure the success of a flexible connection offer based on DOEs, as solar retailers have to communicate the options and benefits to customers.

Project Symphony – Western Power

Project Symphony is a key workstream of AEMO's WA DER Program[79] which has been established to support the effective integration of DER into the Wholesale Electricity Market (WEM) and the South West Interconnected System (SWIS).

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

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

The project officially commenced in December 2021. The trial is expected to run until June 2023.

Project Edith – Ausgrid

Ausgrid, in partnership with Reposit Power, has launched Project Edith. The project will demonstrate a decentralised and cost-effective way of managing network capacity in a growing two-sided market, where services are bought from distributed resources such as rooftop solar and electric vehicles to deliver cleaner, cheaper, and reliable energy for all consumers.

A key feature of Project Edith is that both Ausgrid and Reposit Power will aim to leverage as much of their existing systems and process as possible to set out a practical pathway for the industry to mature over time.

A "Reposit box" installed on household rooftops will monitor household consumption, solar output, battery state, grid behaviour, weather, and market signals. It then decides how best to deliver value to both the homeowner and to the electricity system.

Key insights and learnings

This project will formally commence in March 2022.

[79] AEMO's WA DER Program, aemo.com.au/initiatives/major-programs/wa-der-program

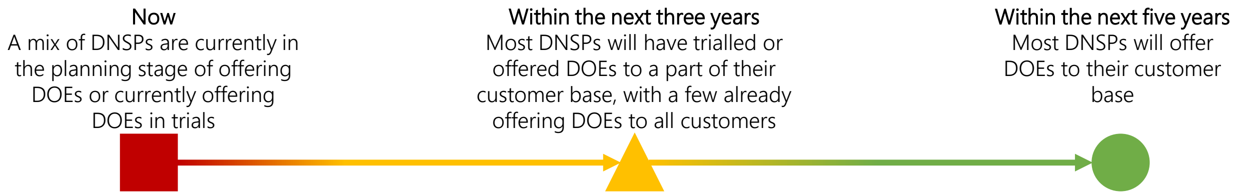
APPENDIX C: REVIEW OF DOE ADOPTION BY DNSPS

To support the Distributed Energy Integration Program (DEIP) Dynamic Operating Envelopes Working Group, ARENA engaged CutlerMerz to review the current state of DOE implementation across Australian distribution networks and the approaches taken by Distribution Network Service Providers.

At the time of publishing the *Outcomes Report*, the CutlerMerz report is not yet published and is expected to be published shortly.

The initial analysis indicates that DOEs are very much an emerging feature of the electricity system. Eight out of the 16 DNSPs are currently offering DOE services in a trial capacity, with other DNSPs currently in the planning stage. Most DNSPs have a timeframe to incorporate DOEs in their connection agreements to their wider customer base within the next five years.

Figure 12: Summary of the timeline to offer small-scale DOEs



Some of the initial findings of the report will include:

- Service offerings: The key features of DOE implementation have yet to be determined by DNSPs.
- Technical characteristics: DNSP responses on the technical characteristics of DOEs were mostly aligned.
- Reporting and compliance: DNSP responses were quite variable on how DOE outcomes should be reported and how compliance should be verified and enforced.

The report will recommend that ongoing consultation between DNSPs, market bodies, key industry bodies and customers will be necessary to optimise DOE implementation across the network.

APPENDIX D: SMARTER HOMES FOR DISTRIBUTED ENERGY

ARENA contracted the consultancy ENEA to deliver a report on the market readiness of home energy management systems (HEMS) for DOEs as they exist today. HEMS are used to coordinate behind-the-meter (BTM) devices, such as rooftop solar, electric vehicles, home batteries, hot water systems and other smart devices.

As one emerging model for DOE implementation is for the envelopes to be located at the customer connection point, it is important that HEMS are able to comply with DOEs by orchestrating export and/or consumption from one or more energy device. The report will help to understand the challenges and opportunities associated with implementing DOEs at the residential customer connection point.

The report addresses four key objectives:

1. Review the current state of HEMS and if these can comply with DOEs.
2. Outline the readiness of HEMS to meet DOEs at the connection point.
3. Identify gaps and barriers in capability, market dynamics, standards and regulation.
4. Highlight areas for future investigation.

The report identified that a range of suitable products and services exist to manage exports and that HEMS can be used to respond to and manage DOEs. However, there is benefit in further maturing device communications standards and there are limitations on what types of energy-using devices can be realistically controlled.

The full report can be accessed at: arena.gov.au/knowledge-bank/smarter-homes-for-distributed-energy