THE DISTRIBUTED ENERGY RESOURCES REVOLUTION

A ROADMAP FOR AUSTRALIA'S ENORMOUS ROOFTOP SOLAR AND BATTERY POTENTIAL

CLEAN ENERGY COUNCIL

AUGUST 2019

TABLE OF CONTENTS

This report represents the collective vision of the Distributed Energy Leadership Forum (DELF), which is the Clean Energy Council's key advisory committee for strategy and priorities in support of distributed energy. The CEC thanks Marchment Hill Consulting (MHC) for drafting and refining the document and the following members of the DELF for shaping it according to its vision: Neil Gibbs (MHC and DELF chair), Simon de Bell (ABB Australia), Emma Fagan (Tesla), Jenny Paradiso (SunTrix), Warwick Johnston (SunWiz), Scott Partlin (SMA-Australia), Mark Paterson (Strategen) and Dr Penelope Crossley (University of Sydney).

INTRODUCTION

Most of Australia is about to reach ‘socket parity’ according to the Australian Energy Market Commission (AEMC) and Bloomberg New Energy Finance. This means that in future, more households and businesses will realise that a grid-connected rooftop solar and battery system produces electricity more cheaply than what they can buy from the grid.

Millions of Australians have already reduced their electricity bills and lessened their dependence on the grid using clean, renewable solar power. We have embraced rooftop solar so enthusiastically that we have the highest penetration of residential rooftop solar in the world. In Queensland, about 33 per cent of all dwellings have solar installed on their roof[1]. South Australia (32 per cent) and Western Australia (28 per cent) are not far behind. There are now more than 2.1 million Australian solar homes[2]. By 2050, the AEMC expects more than half of all houses will have solar PV systems and about a third of residential buildings will have energy storage.

It will be challenging to integrate that much solar generation onto the grid. Electricity distribution networks were not originally designed for it.

We need to change the way we manage solar and battery systems and how they interact with the grid. We’ll need new rules to mandate technological capability and new markets to make best use of the capabilities already at our disposal.

The next generation of solar and battery systems will be intelligent, with advanced communications capability, cybersecurity and an interface to markets. This will massively increase the solar hosting capacity of networks.

Policy makers need to establish markets for the grid services that will be required by future energy networks. They include markets for grid support, incentives to avoid unnecessary investment and support for dynamically balancing supply from millions of variable energy systems.

Progress will require a naturally sustaining support base to avoid being derailed as inevitable challenges emerge. It will need the characteristics of a democratised ‘movement’. It is our hope that this document will contribute to building a movement to revolutionise the way we transform and use energy.

This is a societal challenge. The changes will take place over decades. Households, businesses and governments will need to work together to make this a success. No single entity can make this change happen.

[1] SunWiz (2019), *Insights – July 2019*, subscription publication by SunWiz Solar Industry Intelligence
[2] ibid.

RECOMMENDATIONS

In order to facilitate and unlock the enormous potential for distributed energy resources (DER), the Clean Energy Council (CEC) proposes the following recommendations:

Distribution network service providers

- Distribution network service providers (DNSPs) should require inverters to have Volt-Watt and Volt-var response capability as a condition of grid connection for new DER systems.
- DNSPs that have already adopted static zero-export limitations should invest in network intelligence and move toward dynamic export limitations so that they can utilise DER on their networks more effectively.
- The CEC supports the development of multi-sided trading platforms as a means of enhancing system optimisation and customer benefits of DER uptake.
- DSNPs should move toward more cost-reflective network tariffs, which could include time-of-use or demand-based charging.
- Connection agreements should allow for the dynamic engagement of DER in the power system, and energy customers should have a right to initiate a review of their connection agreement and the opportunity to receive a better deal.

Standards

- Volt-Watt and Volt-var response should be a mandatory requirement in the Australian standard for inverters (AS 4777.2).
- Common standards, protocols and application programming interfaces (APIs) for communication with and between DER are being developed and should be supported and adopted.

Australian Energy Regulator

- The Australian Energy Regulator should recognise the customer value and the important role of dynamic network intelligence for managing high levels of DER on the grid and should approve expenditure required by networks to enable this.

State and territory governments

- Government rebate programs for batteries should include virtual power plant (VPP) capability requirements in their eligibility criteria.

- State and territory licensing and other regulatory frameworks should be developed and strengthened to ensure that microgrids can proceed with protections for customers in place and barriers to community energy projects are removed.

- State and territory governments should review their planning and development approvals systems to remove any barriers to developers of new suburbs aiming for very high DER penetration and minimal grid impacts using grid-connected microgrids and embedded networks.

Policy makers

- Policy makers should establish market frameworks that will enable DER to supply new energy services. This could include new markets to support grid function, system optimisation (avoiding unnecessary investments) and system balance.

- The Australian Energy Market Operator (AEMO) and the Australian Energy Market Commission (AEMC) should consider how aggregation of DER can be optimised using a single asset classification. Third-party aggregators should be able to provide wholesale demand response, export and frequency control ancillary services (FCAS) under a single classification.

- DER should have the same market access as utility-scale assets. Where this market access is prevented by regulatory barriers, this should be reviewed by AEMO and/or the AEMC.

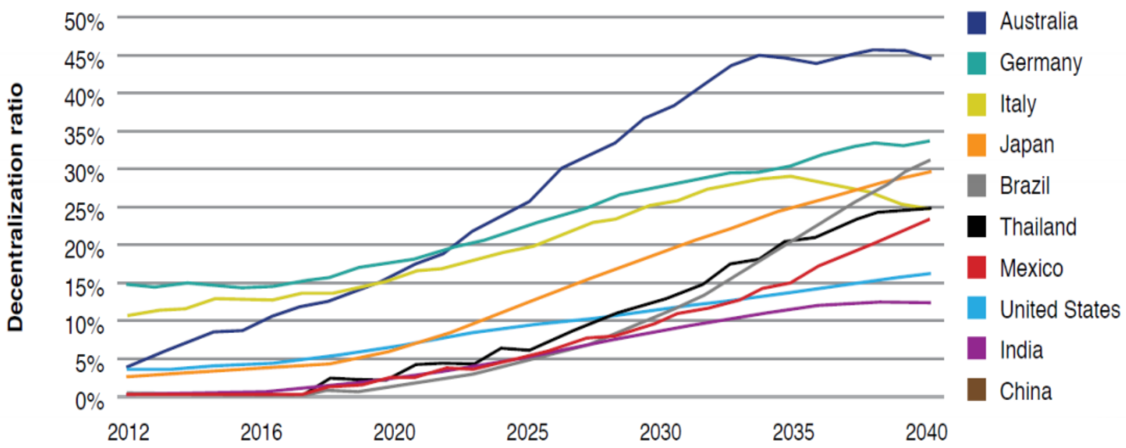
- Policy makers should adopt alternative network revenue models and tariff structures and supporting retailer reforms that would enable increased grid-enabled value exchanges such as peer-to-peer (P2P) trading, network service provision by DER and VPP activity.

- Policy makers should ensure that the distribution market operator (DMO) role (which would be a commercial role) is separated from the distribution system operator (DSO) role in electricity distribution market reform options being considered.

SECTION 1: A SOCIETAL CHANGE

Australia's electricity system is undergoing the most remarkable transformation. We lead the world in the decentralisation and digitalisation of electricity.

Figure 1 – Decentralisation ratio of electricity generation by country[3]



Rapid DER uptake poses technical challenges for the grid, including limited visibility of DER generation and maintaining voltage within operating parameters.[4] There are also challenges related to issues of access and equity.[5]

While electric vehicles (EVs) are still an infant market, they are expected to reach 615,000 vehicle sales by 2030. Following the popularity of solar PV systems, EVs will be the next major class of DER deployed at scale, with forecasters expecting their uptake to eclipse static batteries. The main inhibitor is price and charging facilities.[6]

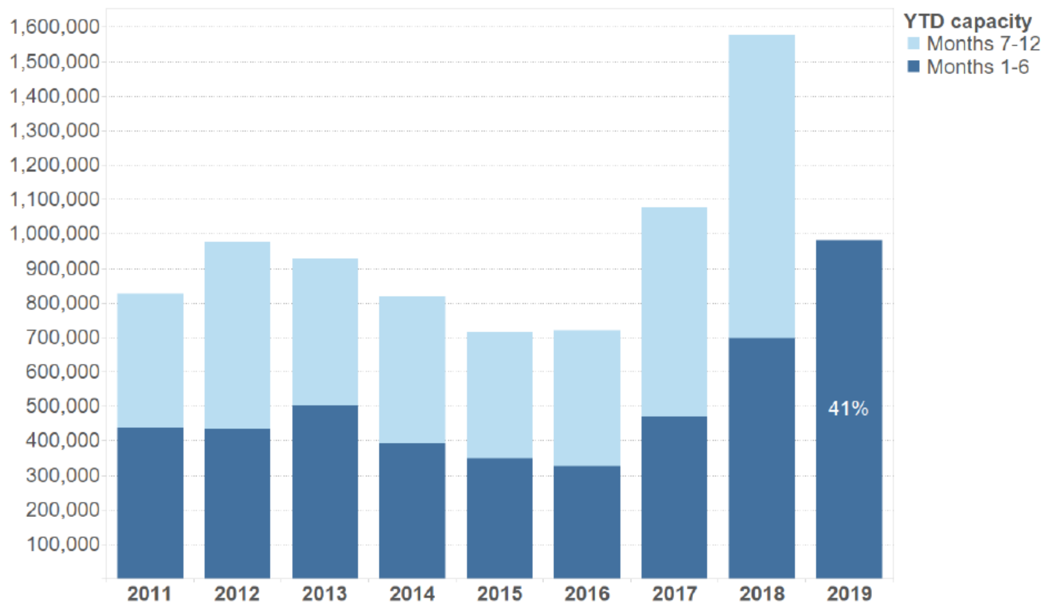
Australia has positioned itself as a global leader in the incubation and development of DER technologies and product services[7], prompted by rapid DER innovation in response to customer concerns around reliability, flexibility and the cost of electricity from the main grid. This creates opportunities to export DER technologies (both hardware and software).

---

[3] Bloomberg New Energy Finance, New Energy Outlook 2018, https://about.bnef.com/new-energy-outlook/
[4] https://www.researchgate.net/publication/326242449_Future_Challenges_and_Mitigation_Methods_for_High_Photovoltaic_Penetration_A_Survey
[5] https://www.aemo.com.au/-/media/Files/Media_Centre/2018/AEMO-observations_operational-and-market-challenges-to-reliability-and-security-in-the-NEM.pdf
[6] https://arena.gov.au/assets/2018/06/australian-ev-market-study-report.pdf
[7] https://www.navigantresearch.com/news-and-views/australia-is-positioned-as-an-incubator-laboratory-for-distributed-energy-resources-opportunities

Australia is also a pioneer in DER integration approaches with distribution networks, regulators and consumers. The skills acquired can be exported as advisory services, similar to Australian companies that export advisory services for the resources sector.

Figure 2 - Annual installed capacity of solar PV systems under 100 kW[8]



The unprecedented scale of change demands that we develop and implement new decentralised markets and a fundamentally different system architecture. This future should support and enable DER[9] monetisation (new markets that support grid function), system optimisation (to avoid unnecessary investment in centralised generation, transmission and/or distribution) and system balance (dynamically balancing supply from millions of intermittent DER).

The complexity of this transformation cannot be underestimated. Designing every aspect of these secondary or transactive energy markets that enable DER to be optimised in the power system and integrating them with the existing National Electricity Market (NEM) is a task of similar magnitude, but arguably greater complexity, than building the NEM. This is critical new national infrastructure. It will likely embrace new market rules, codes and licences, systems, processes, data protocols and communications hubs.

[8] SunWiz (2019), *Insights – July 2019*, subscription publication by SunWiz Solar Industry Intelligence

[9] 'Distributed energy resources' refers to often smaller generation units that are located on the consumer's side of the meter, including solar PV systems, battery storage, electric vehicles and other resources that facilitate demand response. Many of these technologies are not exclusively found 'behind the meter'. 'Distributed generation' is the term used when electricity is generated from sources, often renewable energy, near the point of use instead of centralised generation sources from power plants.

1.1 BENEFITS FOR CONSUMERS

The AEMC has identified the emergence of 'a new type of energy entrepreneur', the consumer who works with global battery providers such as Tesla and sonnen to combine their batteries in a VPP.

The advent of market for services from DER offers the potential for consumers to participate in managing grid constraints, reducing system costs and electricity prices and improving their return on DER investment. Superior investment returns may be available where consumers are able to access and stack new revenue streams to improve the economics of DER investments for their homes and businesses. Stacking revenue may be facilitated by commercial platforms such as those developed by Reposit[10] and Greensync[11]. A Reposit trial in Canberra reported that:

"These customers were able to make significant savings on electricity bills, with one customer saving up to $3,000 per annum on their electricity bills. These savings were through a combination of solar (for those that did not have it before the trial commenced), solar-charging of the battery, smart-charging of the battery at off peak times, through market operations and through behavioural change."[12]

New business models are seeking to attract and retain customers by removing complexity and providing broad energy services, including installation and maintenance of DER, as well as information, monitoring and communication services.

1.2 RISKS

Rooftop solar exports can adversely affect the voltage on the grid, taking it outside prescribed limits. There is a limit to how much electricity a low voltage line can take from rooftop solar systems exporting to it. As this limit is approached, it has often been the case that a DNSP will impose a zero-export policy or other constraint, meaning that less rooftop solar energy can be exported to the grid. In Hawaii, for example, the grid operator has imposed a zero-export policy on all new residential and commercial rooftop solar. Even in the absence of such polices, connection backlogs may arise over time as increasing numbers of consumers endeavour to connect DER and DNSPs seek to determine how much new capacity they can connect.

Exports from DER place downwards pressure on wholesale electricity prices, benefiting all customers, not just those who own DER. These benefits are lost when customers are constrained to zero export. These network constraints can be introduced by networks as a result of a range of factors, including their inability to control DER to achieve network security and

10 https://repositpower.com/how-it-works/
11 https://greensync.com/audiences/community-and-precincts/
12 https://arena.gov.au/assets/2017/06/20160922_4_PublicReport_LHO.pdf

insufficient reactive power controls that are cost effective for networks and customers.[12] Zero-export policies significantly reduce the size of a solar system that is economically viable for commercial and industrial sites and in many cases undermines business cases to install solar.[13]

The overwhelming majority of inverters sold in Australia are 'smart', meaning that they can support grid management by autonomously sensing grid conditions and providing more or less power (including reactive power) when the grid needs it. The Clean Energy Regulator has estimated that approximately 96 per cent of all inverters installed in 2019 have this capability, which is sometimes referred to as Volt-Watt and Volt-var response. This means that customers' exports are automatically constrained when the grid is unable to take all the electricity on offer. This capability is estimated to enable up to twice as much DER to be hosted on the grid. Widespread uptake of this inverter technology standard will help to avoid the need for zero-export limitations. The majority of Australian DNSPs require Volt-Watt and Volt-var response capability as a condition of connecting an inverter to their network. It is mandated either through rebate eligibility and/or grid connection rules in South Australia, Western Australia and Victoria. The CEC supports this approach, provided there is enough advance notice for manufacturers to address issues of legacy stock and allowance for continuing to honour warranty obligations using like-for-like replacements.

Recommendations

- Distribution network service providers (DNSPs) should require inverters to have Volt-Watt and Volt-var response capability as a condition of grid connection for new DER systems.

- Volt-Watt and Volt-var response should be a mandatory requirement in the Australian standard for inverters (AS 4777.2).

---

[12] https://www.aemo.com.au/-/media/Files/Electricity/NEM/DER/2018/OEN-Submissions/500-Planet-Ark-PowerENAAEMOresponse-v510-Aug-2018.pdf

[13] ibid.

SECTION 2: OPTIMISING THE SYSTEM

2.1 MODERNISE THE GRID TO SUPPORT DISTRIBUTED RESOURCES

Context

DER offers the potential to reduce total system costs by over $101 billion through network service platforms that enable DER to participate in increasingly dynamic electricity markets.[14] However, DER penetration is posing technical issues in some parts of the NEM, and there are concerns around a lack of DER visibility and the adequacy of planning for DER within the DNSPs' 2020-2025 plans.[15]

Challenge

Many DNSPs lack visibility of DER installations and behaviour behind the meter due to limited monitoring data from the low voltage network. This is especially the case in states where the rollout of advanced metering infrastructure has been slow. Lack of visibility presents technical challenges as DNSPs are not able to properly forecast when the physical limits of the network might be exceeded. AEMO is establishing a DER Register in 2019 to address the issue of DNSPs and their lack of monitoring data and visibility of the low voltage network.

In some parts of the grid, the presence of DER has revealed high voltage issues that had been present but unnoticed. In some cases, DER systems contributed to voltage rise on the low voltage network, especially older or incorrectly installed systems.

Networks with high solar penetration can deal with grid management challenges, such as voltage rise and thermal constraints, by imposing static zero-export limitations, strengthening their networks (i.e. building more assets) or investing in the capability to utilise dynamic network intelligence.

Building more poles and wires is expensive. Static zero-export limits are crude and short-sighted. The best solution is to incorporate dynamic network intelligence to enable dynamic management of DER, allowing exports when the network can accommodate it and limiting exports when necessary. This approach requires relatively modest network investment to actively manage the integration of rooftop solar PV, battery storage and VPPs. An independent cost-benefit analysis commissioned by SA Power Networks[16] has demonstrated that the benefits of this approach would exceed the costs for all customers, not just those who own solar and batteries.

[14] https://www.energynetworks.com.au/sites/default/files/entr_final_report_summary_april_2017.pdf
[15] AEMO's DER Register aims to redress the issues of visibility; https://www.aemo.com.au/Stakeholder-Consultation/Consultations/NEM-Distributed-Energy-Resources-Information-Guidelines-Consultation
[16] https://www.aer.gov.au/system/files/SAPN%20-%20Presentation%20-%204%20April%202019.pdf

Dynamic management of solar and batteries, which may include using and limiting exports in certain locations at certain times, is in the long-term interests of all customers. It will enable better use of batteries and VPPs to support the network management and reduce electricity prices, benefiting all customers. The CEC strongly supports this approach.

Recommendations

- DNSPs that have already adopted static zero-export limitations should utilise dynamic network intelligence and move toward dynamic export limitations so that they can utilise DER on their network more effectively.
- The Australian Energy Regulator should recognise the customer value and the important role of dynamic network intelligence for managing high levels of DER on the grid and should approve expenditure required by networks to enable this.
- Government rebate programs for batteries should include virtual power plant (VPP) capability requirements in their eligibility criteria.

2.2 COORDINATE AND OPTIMISE THROUGH MARKETS

Context

As distribution networks are currently unable to utilise dynamic management approaches to signal physical limits or constraints to DER-owner consumers or their aggregators, DNSPs impose crude solutions to technical challenges (e.g. export limits through connection agreements). Generally, the phases are limited to 5 kW per phase or the requirement for export-limiting technology within the inverter (e.g. SA Power Networks imposes an export limit of 5 kW per phase).[17]

Challenge

Static export limits reduce the value for consumers and limit the value for the power system as they are not able to capture the full value of DER. Various emergent technologies and business models – including micro-grids, P2P trading and VPPs – offer ways of improving the utilisation of DER to the benefit of their consumer owners as well as the grid, such that connection delays and export limits will be limited or redundant.

The role of the DSO is emerging in Australia, and in comparable jurisdictions, as a means of addressing the challenges of high DER penetration. The Open Energy Networks consultation that is being jointly conducted by AEMO and Energy Networks Australia (ENA) intends to identify the system requirements that must be addressed in the optimisation of DER connected

[17] https://www.solarchoice.net.au/blog/solar-system-size-limits-by-network; https://www.solarquotes.com.au/blog/sa-power-networks-inverter-limits/

to the distribution system and obtain a better understanding from traditional and new market participants as to how, from both a technical and commercial perspective, it will be possible to reduce barriers to entry into the system and best facilitate innovation and competition at the grid edge.[18] The Distributed Energy Integration Program (DEIP) that is being facilitated by the Australian Renewable Energy Agency (ARENA) consists of different workstreams to enhance the effectiveness of DER, customer, markets, frameworks and interoperability. The core aims of the DEIP are VPP enablement and demand-response integration.[19] Appropriate inverter standards and communication protocols will be essential to the viability of DER coordination and optimisation.

Recommendations

- Common standards, protocols and application programming interfaces (APIs) for communication with and between DER are being developed and should be supported and adopted.

- DER should have the same market access as utility-scale assets. Where this market access is prevented by regulatory barriers, this should be reviewed by AEMO and/or the AEMC.

2.3 DEVELOPING AND OPERATING MICROGRIDS

Context

DER have the potential to improve the efficiency of the energy system by deploying supply closer to the point of demand, and this could reduce the need for network augmentation to maintain the reliability of these areas. Energy consumer engagement can also be enhanced in community-based microgrids.

For example, the Narara ecovillage is an ARENA-funded project that involves 50 homes with community sharing of energy on NSW's Central Coast.[20] The Huntlee Microgrid, which was also funded by ARENA, is a greenfield development near Newcastle that will cover a new residential development of 5600 homes.[21]

Challenge

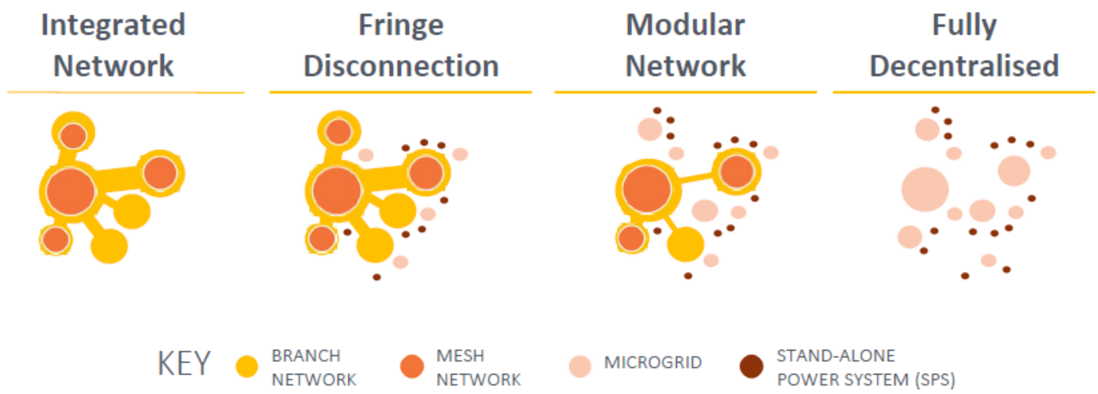
Microgrids are autonomous grids that can operate off-grid or be connected to existing grids and which can combine different assets and loads. As more countries incorporate renewable

18 https://www.energynetworks.com.au/sites/default/files/open_energy_networks_workshop_slidepack.pdf
19 https://arena.gov.au/assets/2018/11/deip-overview.pdf
20 https://nararaecovillage.com/nev-power/
21 https://arena.gov.au/assets/2015/04/Delivering-higher-renewable-penetration-new-land-housing-developments-microgrids.pdf

sources into their energy systems, microgrids are becoming increasingly important. Microgrids can be more cost effective, add resiliency and enable greater penetration of renewable generation within the energy mix. Microgrids readily lend themselves to P2P trading and VPP coordination arrangements.

Stand-alone power systems (including microgrids) are electricity supply arrangements that are not physically connected to the national grid. They can supply customers at the fringe of the grid more cheaply, safely and reliably than 'poles and wires'. Under the current market rules, remote customers are cross-subsidised by the rest of the electricity system to fund thousands of kilometres of poles and wires.

Figure 3 – A vision for evolution and decentralisation of distribution networks[22]



The AEMC has recommended that distribution networks should be allowed to use stand-alone power systems for remote customers, potentially delivering huge savings on the network investment needed to service them. The changes flagged by the AEMC mean a mix of solar, batteries and diesel back-up could be used, delivering savings for all customers and making the remote areas more resilient to natural disasters. While distribution networks will continue to cross-subsidise their existing customers, new connections will be competitively sourced.

States and territories need to review the way they license or otherwise regulate microgrids so that they can proceed with protections for customers in place.

Recommendation

- State and territory licensing and other regulatory frameworks should be developed and strengthened to ensure that microgrids can proceed with protections for customers in place and barriers to community energy projects are removed.

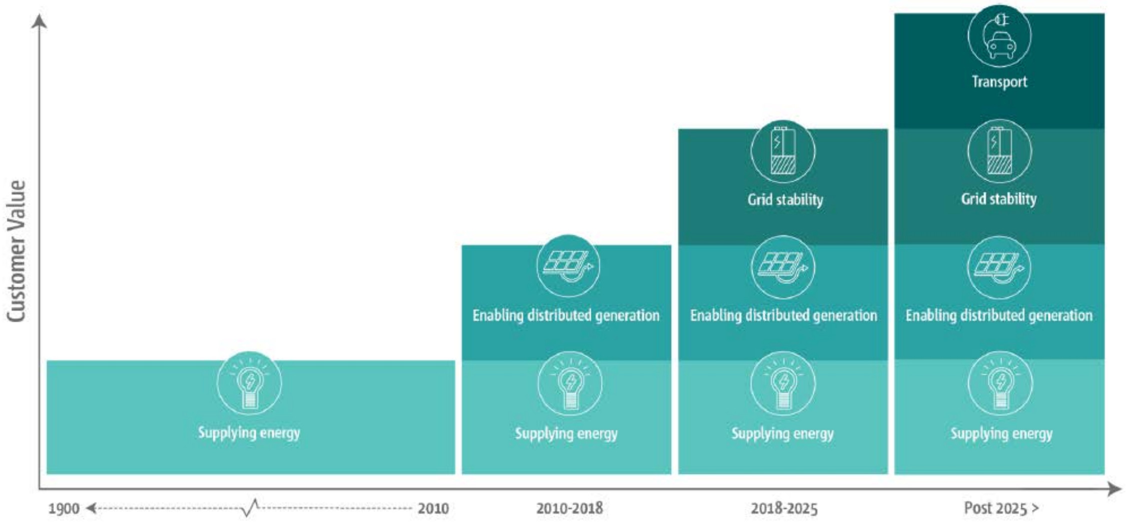
[22] Western Power, presentation to CEC's Energy Storage Directorate, 5 September 2018

2.4 IMPACTS OF E-TRANSPORT

Context

The advent of e-transport presents challenges and opportunities for the energy transition. While Australia currently lags comparable countries in the uptake of EV transport, electrification of transport represents a significant opportunity for DER, provided that grid impacts can be managed. Australian DNSPs do not anticipate significant effects of EVs on the electricity grid until after 2025.

Figure 4 – The evolving role for distribution networks[23]



Challenge

The impact of EVs on the grid will vary depending on the transition path to e-transport, the presence of factors such as shared vehicle arrangements and the persistence of internal combustion vehicles and/or alternative clean transport fuel, such as hydrogen.[24]

In Australia, EVs currently make up 0.08 per cent of new vehicles sold. This slow uptake is a function of the lack of policy support or incentives, higher upfront cost, limited choice of EVs for sale in Australia, a lack of public vehicle charging infrastructure[25], a globally low turnover rate of passenger vehicles and cultural inertia.

[23] https://www.aer.gov.au/system/files/SAPN%20-%20Presentation%20-%204%20April%202019.pdf
[24] http://www.infrastructurevictoria.com.au/sites/default/files/files/AVZEV/Advice%20on%20automated%20and%20zero%20emissions%20vehicles%20-%20October%202018.PDF
[25] https://www.climatecouncil.org.au/wp-content/uploads/2017/09/FactSheet-Transport.pdf

SECTION 3: MAXIMISING CUSTOMER BENEFITS

3.1 DER CONNECTIVITY AND CONTROLLABILITY

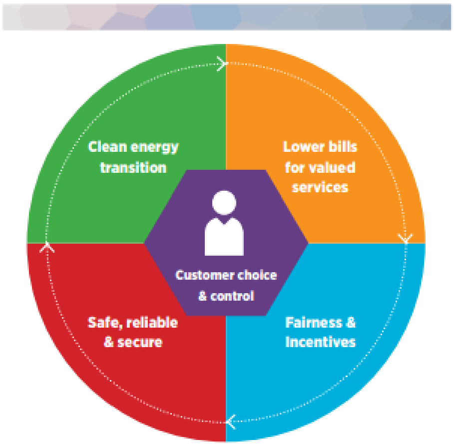
Context

The advent of connectable and controllable appliances and the ‘Internet of things’ presents an opportunity for load shifting so that customers can optimise energy supply arrangements and make a return on their DER investment. Many technical and regulatory issues remain, and these are likely to be resolved in an iterative way.

Opportunity

There are various ways in which customers stand to benefit by the advent of DER and the applications that they offer. Maximising customer benefits will involve harnessing technologies and new business models to provide efficient options and real choice. A customer-oriented transition must focus on carefully balancing key customer outcomes.[26]

Figure i: Balanced Scorecard of Customer Outcomes



DER connectivity and controllability have the potential to encompass a diverse range of DER assets, far beyond solar PV and battery systems. Future DER aggregation and orchestration will likely encompass a diverse range of controllable loads and potentially most connectable appliances within homes and businesses. This diversity of assets poses challenges in terms of connectivity standards,[27] protocols and interfaces. Related to these are the necessary imposition

[26] https://www.energynetworks.com.au/sites/default/files/entr_final_report_summary_april_2017.pdf
[27] Core connectivity standards are IEE 2030.5 formed in the US. SA Power Networks is currently running a program to adapt these standards to Australian conditions.

of new standards for cyber security.[28]

Platforms to support distribution-level energy trading markets, such as those considered by the AEMO/ENA Open Energy Networks consultation, pose challenges in terms of architecture and interface with the centralised energy markets operated by AEMO. AEMO is currently considering minimum requirements for VPP participation, which will be the first step in mandating the requirements for connectivity between DER assets[29].

In November 2018, AEMO launched a VPP demonstration program in collaboration with the AEMC, the AER and members of ARENA's DEIP program to lead the charge nationally on aggregation and connectivity of DER assets.[30] A proposed rule change would extend demand response to a broader range of devices, making for more inclusive VPPs.[31] If adopted, the rule would allow third-party aggregators and large energy users to bid into the wholesale market by creating a new class of market participant – the demand response service provider (DRSP). The CEC supports the introduction of the DRSP. The proposed change follows similar attempts in 2015 and 2016 that ultimately did not proceed. The proponents of the rule change consider that demand response remains greatly underutilised relative to its potential.[32]

Fundamentally, the rule change is about expanding the role of demand response across the NEM and increasing competition in retail energy markets. The creation of the new market participant will mean new service providers, more options for consumers and increased competition among retailers from new entrants. Educating customers and building confidence in demand response as a product will be central to customer acquisition campaigns in the initial stages of the marketplace.

Recommendations

- Policy makers should establish market frameworks that will enable DER to supply new energy services. This could include new markets to support grid function, system optimisation (avoiding unnecessary investments) and system balance.
- The Australian Energy Market Operator (AEMO) and the Australian Energy Market Commission (AEMC) should consider how aggregation of DER can be optimised using a single asset classification. Third-party aggregators should be able to provide wholesale demand response, export and frequency control ancillary services (FCAS) under a single classification.

---

[28] The cyber security challenges flowing from the advent of DER has been compared to the impact of bring-your-own-device for workplace cyber security; https://www.smh.com.au/business/cyber-security-threat-is-australias-power-grid-safe-from-hackers-20171103-gze2qd.html
[29] https://www.aemo.com.au/-/media/Files/Electricity/NEM/DER/2018/NEM-VPP-Demonstrations-program.pdf
[30] ibid.
[31] https://www.aemc.gov.au/rule-changes/wholesale-demand-response-mechanism
[32] http://www.tai.org.au/sites/default/files/WDR%20rule%20change%20request%2030%20August%20FINAL.pdf

3.2 PEER-TO-PEER TRADING

Context

There is strong customer interest in peer-to-peer (P2P) trading arrangements for commercial, social and community reasons. Developments in distributed ledger technology are ongoing; however, without change in other areas of the regulatory and market arrangements, these business models are unlikely to be adopted at scale across the NEM.[33]

Challenge

The major impediment to P2P trading is network tariffs. These challenges were revealed in an ARENA-funded P2P distributed ledger technology assessment involving AGL and IBM[34] and are currently being explored further through AGL's solar credit trading scheme,[35] as well as through Power Ledger's blockchain trial in Western Australia.[36]

Reform of network tariffs is likely to require an overhaul of revenue structures and would represent a significant reform project. There are other reforms that may incentivise P2P trading, such as changes to building standards within residential development complexes. Within the NEM, reform to the retail arrangements would also be needed before customers could trade energy in a P2P model without the involvement of a licensed retailer. As a result of these barriers, such models have not yet emerged at any material scale, despite the strong interest of customers and the increasing maturity of the enabling technology.

New precincts that are energy self-sufficient, manage electricity distribution and are not (or only lightly) connected to the grid could be the most promising area for P2P trading arrangements.

Recommendations

- Policy makers should adopt alternative network revenue models and tariff structures and supporting retailer reforms that would enable increased grid-enabled value exchanges such as peer-to-peer (P2P) trading, network service provision by DER and VPP activity.

- State and territory governments should review their planning and development approvals systems to remove any barriers to developers of new suburbs aiming for very high DER penetration and minimal grid impacts using grid-connected microgrids and embedded networks.

33 https://www.thefifthestate.com.au/energy-lead/business-energy-lead/australia-blockchain-energy-trading/
34 https://arena.gov.au/projects/peer-to-peer-trading/
35 https://thehub.agl.com.au/articles/2018/12/trading-sunshine-with-agl-solar-exchange
36 https://reneweconomy.com.au/australia-first-rooftop-solar-trading-trial-kicks-off-in-wa-97187/

3.3 ENERGY SERVICES ARRANGEMENTS

Context

Most customers are not interested in buying energy. They would prefer to pay for energy services. DER offer the opportunities for energy supply companies to become energy services companies, transitioning the energy sector away from commodity supply and towards genuine product differentiation.

Challenge

In the future, energy services companies will likely manage the risks and complexity of energy markets and enable customers to optimise the use of their DER to achieve the most affordable energy supply. The scope for trading energy within an increasingly diverse range of forums, including new distribution-level markets and P2P trading arrangements, will increase the range of product offerings that new energy services companies can provide. An ARENA-funded trial by Reposit in Canberra illustrates the scope for new energy service[37], while Powershop, sonnen and DC Power are already offering innovative energy services.

Revenue stacking will be an important part of new energy services offerings. Possible commercial examples of revenue stacking include Reposit,[38] Greensync,[39] sonnen[40] and DC Power's[41] platforms. The advent of e-transport will further enhance the scope for revenue stacking due to the size of vehicle batteries relative to home batteries, although vehicle-to-grid is at this time an immature market segment.

Recommendation

- The CEC supports the development of multi-sided trading platforms as a means of enhancing system optimisation and customer benefits of DER uptake.

[37] These customers were able to make significant savings on electricity bills, with one customer saving up to $3000 per annum on their electricity bills. These savings were through a combination of solar (for those that did not have it before the trial commenced), solar-charging of the battery, smart-charging of the battery at off peak times, through market operations and through behavioural change; https://arena.gov.au/assets/2017/06/20160922_4_PublicReport_LHO.pdf
[38] https://repositpower.com/how-it-works/
[39] https://greensync.com/audiences/community-and-precincts/
[40] https://www.theaustralian.com.au/business/technology/germanys-sonnen-offers-free-grid-power-deal-to-solar-users/news-story/9b8f9fd7af1279f9dd49f6d226bc7a34
[41] https://www.dcpowerco.com.au/

3.4 EVALUATION OF THE CONNECTION AGREEMENT

Context

Connection agreements are too rigid and unnecessarily restrictive on customers. In order to transform energy markets to optimise the use of DER, it will be necessary to evaluate the connection agreement and consider ways in which it may be improved and continue to evolve as the energy ecosystem evolves.

Challenge

The connection limitations put forward by Australian DNSPs vary considerably.[42] Generally, the phases are limited to 5 kW per phase or the requirement for export limiting technology within the inverter, for example the 10 kW inverter system export limited in Queensland as compared to the limit of 5 kW per phase imposed by SA Power Networks in South Australia.[43]

ENA has been working toward making grid connection rules more transparent and consistent across DNSPs for several years. Progress has been slow. A recent survey of the 16 DNSPs conducted by the CEC on behalf of its members demonstrated that:

- there is significant variation between DNSPs in grid connection rules
- several DNSPs' grid connection rules are still not published on their websites
- five DNSPs do not require inverters to demonstrate compliance with Australian Standards using the CEC Approved Products List as verification
- six DNSPs have not yet mandated Volt-Watt and/or Volt-var capability as a condition of grid connection and do not currently have dates or plans to do so.

Connection agreements need to evolve to enable the dynamic participation of metered sites, and therefore DER, in the energy system. Static connection limits will be increasingly seen as counterproductive as DNSPs adopt a dynamic approach to grid management.

Recommendation

- Connection agreements should allow for the dynamic engagement of DER in the power system, and energy customers should have a right to initiate a review of their connection agreement and the opportunity to receive a better deal.

[42] https://www.solarchoice.net.au/blog/solar-system-size-limits-by-network
[43] https://www.solarquotes.com.au/blog/sa-power-networks-inverter-limits/

SECTION 4: REGULATION AND GOVERNANCE

4.1 EVOLUTION OF NETWORK PRICING

Context

The current distribution network pricing regime is based primarily on volume-based tariffs applied to electricity flowing from the network to the customer with a relatively small element of fixed charge. Distribution networks receive no revenue when energy flows from customer assets into the network. Similarly, large electricity generators do not pay for their use of transmission and distribution networks.

Challenge

Current arrangements do not allow a distribution network to send time- and location-specific price signals to DER owners in order to minimise network augmentation costs. Alternative tariff structures are required, but at the same time customers are seeking less complexity not more. Some networks have adopted demand-based tariffs to address future expenditure on network augmentation in response to the growth in peak demand. Other networks are adopting time-of-use charging to encourage consumption during daylight hours, when solar PV systems generate an excess of zero marginal cost electricity.

The introduction of cost-reflective network tariffs is supported in principle by the majority of market participants. However, in contrast, the adoption of cost-reflective network tariffs has proved contentious, with limited progress made.

Recommendation

- DNSPs should move toward more cost-reflective network tariffs, which could include time-of-use or demand-based charging.

4.2 INTRODUCTION OF DSO FUNCTION

Context

The development and implementation of the distribution system operator (DSO) function in Australia will be an important step in optimising the use of DER.[44] Comparable markets (the UK, California, New York, Japan and Western Europe) are progressing towards adopting the DSO function. AEMO and ENA have more recently embarked on a formal (Open Energy Networks) consultation process, which is making progress in developing the DSO function for the Australian context.

Challenge

There are varying interpretations of DSO. However, at its simplest, the DSO model recognises an important transition of distribution networks from a simple one-way flow of energy to a more complex system of bi-directional flows.[45]

The transformation from the one-way flow distributed network operator (DNO) to the two-way flow DSO will require significant transformation on the part of each DNSP.[46] A market into which DER can sell services will be an instrumental element of any reform. This market would be delivered by a distribution market operator (DMO) and would enable the services on offer from DER to be available to the highest bidder, within the technical or physical limits of the distribution network (as defined dynamically by the DSO). This would allow DER owners (or their aggregators) to 'value stack' at the system level and help to ensure that DER assets contribute to a least-cost system. Given that distribution businesses (as DSO) could also be a buyer of network services from DER, it would be a conflict of interest and inappropriate for them to also manage the market as a DMO.

Recognising and establishing the DMO role is critical to ensuring the delivery of least-cost energy services, customer choice and ongoing market reforms (e.g. moving to a 'balancing market' model where AEMO has the visibility of priced, flexible response from the grid edge to use in balancing the variability of an increasingly renewable energy system).

Recommendation

- Policy makers should ensure that the distribution market operator (DMO) role (which would be a commercial role) is separated from the distribution system operator (DSO) role in electricity distribution market reform options being considered.

44 https://www.energynetworks.com.au/news/energy-insider/are-we-there-yet
45 https://www.energynetworks.com.au/news/energy-insider/smooth-operators-great-britains-transition-open-networks
46 https://blog.schneider-electric.com/utilities/2014/11/27/transformation-dno-dso/

SECTION 5: ABBREVIATIONS

AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
ARENA	Australian Renewable Energy Agency
CEC	Clean Energy Council
CER	Clean Energy Regulator
DEIP	Distributed Energy Integration Program
DER	distributed energy resources
DMO	distribution market operator
DNO	distribution network operator
DRSP	demand response service provider
DSO	distribution system operator
ENA	Energy Networks Australia
EV	electric vehicle
NEM	National Electricity Market
P2P	peer-to-peer
VPP	virtual power plant