The Electricity Journal 33 (2020) 106838

Contents lists available at ScienceDirect

The Electricity Journal

journal homepage: www.elsevier.com/locate/tej

Optimising the value of distributed energy resources

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ARTICLE INFO

keywords:
Distributed energy resources
Network services
Consumer engagement
Consumer incentives

ABSTRACT

The uptake of network-connected and consumer-owned distributed energy resources (DER) represents a transformational change to the energy mix, structure and operation of our power systems and markets. If DER can be successfully integrated into our electricity networks and markets, there is potential for all electricity system users to benefit. This paper discusses some of the important technical, economic and social opportunities and challenges of optimising the value of DER integration into electricity networks and markets.

1. Introduction

Global energy systems are transitioning from fossil fuel-fired generation to renewable generation and this trend is set to accelerate over coming decades (Fig. 1). It is vital to ensure that we decarbonise our energy system to limit dangerous climate change to below 2 degrees (IPCC, 2018) and preferably below 1.5 degrees.

One dimension of this transition is the increasing adoption of distributed energy resources (DER) such as solar PV, small-scale energy storage, demand response mechanisms and electric vehicles (EVs). As DER adoption increases, global electricity systems will demonstrate increasing levels of decentralisation, with this change currently occurring faster in Australia than any other nation as seen in Fig. 2.

The impacts of DER adoption will be transformational:

- From a technical perspective, DER will upend the traditional behaviour of electricity networks. The historical one-way energy flows that result from largely centralised, synchronous generation to distributed demand will change in a high-DER electricity system. Instead, electricity networks will be managing bidirectional, dynamic energy flows.
- From an economic perspective, the adoption of DER is challenging the traditional role of largely passive consumers. Prosumers purchasing DER assets, software and services are now active investors in the electricity system with the ability to operationalise their investment for private gain, public good or both.
- From a social perspective, DER can reduce energy costs and increase energy equity for individual prosumers and for energy consumers more broadly, including those who may not be able to directly invest in DER. However, the distribution and extent of beneficial outcomes is highly dependent how well the energy sector engages consumers, establishes markets or procurement of DER services and how consumers respond. In particular, DER incentives and technical capabilities will not realise their full potential without consumer trust in the electricity market, in electricity regulators and in the process by which the system is being transformed.

Given these perspectives, the widespread adoption of DER will require complementary technical, regulatory and market reforms in order to realize greater benefits for DER owners and the broader electricity system.

This paper draws on presentations and discussions from the Future Electricity Markets Summit in Sydney, 2019. The paper begins with some preliminaries to clarify what we mean by DER, to identify the key stakeholders, and to outline two system-wide challenges that frame the subsequent three sections. These subsequent sections focus on the details of the discussions that took place at the summit, grouped into social, economic and technical aspects of the transformation. In the closing sections of this paper we highlight some key recommendations from the summit, including the key no-regrets activities, trials and decisions that are needed.

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https://doi.org/10.1016/j.tej.2020.106838

Available online 10 September 2020

2. Preliminaries

2.1. DER

It is clear that DER includes technologies like solar PV and residential battery storage, but it is important to recognise that we are referring to all of the changes to generation, storage and demand being deployed at a distribution network level. This includes rooftop solar PV and battery storage, but also electric cars, buses and other vehicles; community or suburb scale battery storage; controllable loads like hot water and pool pumps; and a plethora of energy efficiency hardware and software.

In addition to these technological changes, DER also includes voluntary demand response, where consumers manually, or through the use of automated systems, modify their energy consumption in response to technical or economic signals provided by the network or market. Indeed, such voluntary demand response may act as a catalyst to increase the awareness, and signal the importance of such capabilities to consumers. The consequence of this might be to accelerate the uptake of more automated or autonomous demand response capabilities, particularly as DER technologies reduce in price over the coming decade.

2.2. Value

In considering the question of how the value of DER can be optimised, it is important to agree on a definition of value. Given that DER assets are connected into the electricity system, the authors believe that the most appropriate measure of value is how DER can support national electricity objectives. In Australia, this is captured in the National Electricity Objective as outlined in the National Electricity Law (South Australian Government, 1996).

In recommending this measure of value, the authors note that it is vital that national electricity objectives represent a measure of value for which there is broad consensus. In this way, a national electricity objective should provide a measure against which all technology, policy, regulations and opportunities for enhanced consumer participation can be assessed, rather than requiring a DER specific measure of value. The authors, and the forum attendees, noted that in the Australian context it may be necessary to revisit the definition of the National Electricity Objective to ensure that the attributes of DER value can be adequately captured.

2.3. Key stakeholders

There was a general consensus at the Summit that consumers are at the core of this transition as they are both the owners of DER technology and have the potential to receive much of the benefit, not just through reduced bills, but also quality-of-life improvement. The energy sector needs to better understand the various types of prosumers and consumers: residential, commercial and industrial, and the different motivations and opportunities for these newly active participants in the electricity system.

Distribution network service providers, market regulators and operators, retailers and aggregators, DER technology manufacturers and service providers are also stakeholders in this transition, and they, like consumers, have the opportunity to significantly benefit from DER. However, these benefits are by no means guaranteed. If the transition is not handled well, then there is also a lot of potential for harm, for example, through disrupted revenue streams, a reduction in system security (AEMO, 2019b) and the need for more costly network augmentation.

3. Fundamental challenges

The social, technical and economic dimensions of the DER transition are united by two overarching power systems challenges.

3.1. Scale

The first of these overarching challenges is scale. Australia is quickly moving from a system that has of the order of hundreds of large central generators, to millions of consumer-owned DER that may want market access. In this context, the technical and market forecasting and operation of the system may need to change significantly to maintain high levels of reliability and security. At-scale integration of DER will also require managing the communications, computation and data-access challenges of millions of devices operating at system and market timescales of seconds to minutes. This shift of services to the edge of the network will mean that the distribution network will need to change from a largely set-and-forget approach, to being actively managed to cope with dynamic, two-way energy flows.

While considering this scale transformation, it is worth noting that not all system participants agree that it is worth pursuing DER services at scale due to this complexity in integrating potentially millions of small-scale DER assets. Clearly, this tension will be answered definitively over the decade ahead, as consumer actions and spending determine how significant the uptake of DER will actually be.

3.2. Consumer engagement

The second overarching challenge is consumer engagement. With the transition to high-uptake DER, there is the opportunity, which will likely become a need, to rely on consumer-owned devices to provide system-critical services including energy balancing, frequency response, and voltage and capacity management. The system has not historically engaged or relied on consumers, or their retailer and aggregator intermediaries, to provide these services. Contributing to this challenge is an inherent tension between what some consumers may prioritise, e.g., consuming energy when convenient, and the desirable outcomes for the

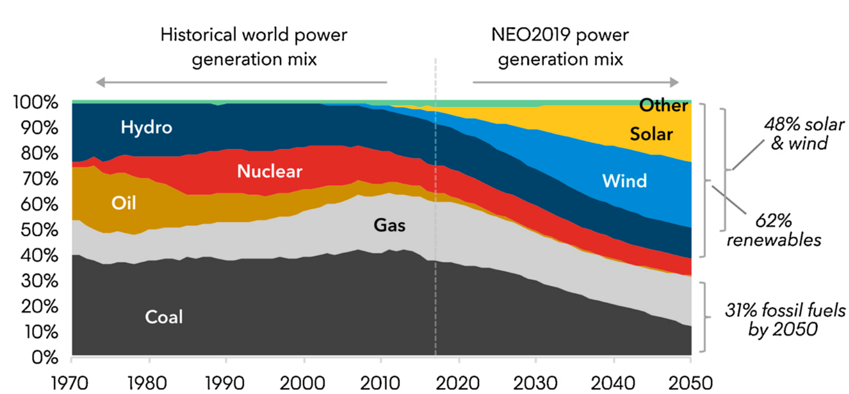

Fig. 1. Historical and forecast share of global electricity generation by source (*Source*: BNEF (2019)).

system as a whole. In this context, aligning the desires and incentives for consumers, system and network operators is a critical challenge for ensuring that consumer-owned DER assets can meaningfully and dependably contribute to the operation of the electricity system.

4. Social

Two strong social themes that emerged from the summit were consumer engagement and energy equity.

4.1. Consumer engagement

The transitioning energy sector has considerable expectations—that consumers should engage with electricity sector issues, respond to demand management initiatives, and allow their DER to be used for services that benefit the whole system. Meanwhile, many sector participants doubt that consumers are willing to respond—particularly if they do not receive immediate financial or social benefits. There was agreement that consumers lack trust in the electricity sector with the doubling of retail electricity prices in less than ten years, market complexity and conflicting messages being contributing factors (Essential Research, 2019). There was also agreement that it is the industry's responsibility to rebuild trust in order to optimise the contribution of consumer investments in DER technologies for electricity system benefits.

Dr. Larissa Nicholls presented Monash University research highlighting current consumer engagement with the energy system via new energy technology adoption and participation in demand management programs. The research proposed a national, coordinated engagement strategy to consistently communicate energy system and technology issues and encourage households to contribute to beneficial grid outcomes. The research recommended that consumer engagement would ideally be led by a central body or organisation, but despite interviewing stakeholders from a range of key sector organisations, no organisation was currently well positioned and widely viewed as suitable to perform the role.

One of the challenges to better engage consumers is for the energy sector to identify and use language that aligns with consumer understanding and interests. For example, the acronym DER itself is a power systems term that consumers do not use or know, and likely will not want to. 'Demand response' and the language of control and optimisation may be threatening to consumers. Communicating the value of more complicated concepts such as power systems security, and how consumer investment decisions and control of their DER assets can help or harm this, will be near impossible without a common language and understanding of the changing nature of the system.

The point was made that consumer behaviour may be perceived as 'crazy' or 'inefficient' from the perspective of the technical needs of the system, and that the industry might need to allow for a certain level of inefficiency, and avoid overly controlling and prescriptive solutions in order to build trust with consumers. In the end, a balance between system and consumer needs and priorities will need to be found.

4.2. Energy equity

Over recent years, consumers have experienced rapid electricity and gas price rises and concerning increases in households facing difficulty paying energy bills and being disconnected. Equity in access to affordable electricity, including via the use of new energy technologies, is an important issue as investment in DER continues and the markets evolve-but views on the scale of the problem and how to address it vary. Some stakeholders have concerns that focusing solely on technical optimisation and economic least-cost outcomes will widen the gap between those that can afford to invest in DER and low-income households, renters and those that are in unfavourable locations for DER. Others expect that more economically efficient utilisation of DER and other network assets will lower the energy costs for all users-and therefore a continuing or even wider gap in access to DER may be socially acceptable.

Recent research has identified that the majority of household rooftop solar has been installed in outer suburban and regional areas (typically not high income), and the least investment has been in the wealthiest city suburbs (APVI, 2020). This data indicates strong demand for DER technologies in mid-lower income households seeking lower energy costs. While battery storage and electric vehicles currently remain out of reach of most consumers, falling battery prices mean this trend could carry over to other forms of DER, the lowest income households and renters will likely still face substantial difficulties accessing technologies to reduce energy costs.

A debate continues within the energy sector as to what extent this inequity should be addressed inside or outside the electricity market, such as through the social welfare system and through housing policy. Complementary programs, for example, subsidising solar on social housing, have been implemented in several Australian jurisdictions. Existing inequities in the electricity market in terms of costs and ability to purchase DER technology and services will need to be considered alongside the potential financial impacts for consumers from emerging incentives and pricing mechanisms intended to encourage more efficient utilisation of distributed energy resources.

5. Economic

5.1. Price signals and incentives

DER has the potential to participate in markets for energy, ancillary and network services, but well-defined markets, regulation and other clear and quantifiable incentives are needed to encourage participation. Longer-term, clear pricing signals and incentives are needed to provide consumers with enough confidence to make DER investment decisions, without exposing them to undue financial risk. Ideally price signals should also be cost reflective, so that DER operation aligns with the optimal system-wide utilisation of assets both short and long-term. However, understanding cost-reflectivity is becoming more complex, especially given the fundamental changes in the operation of the electricity system.

The global transition to electricity systems powered by renewable

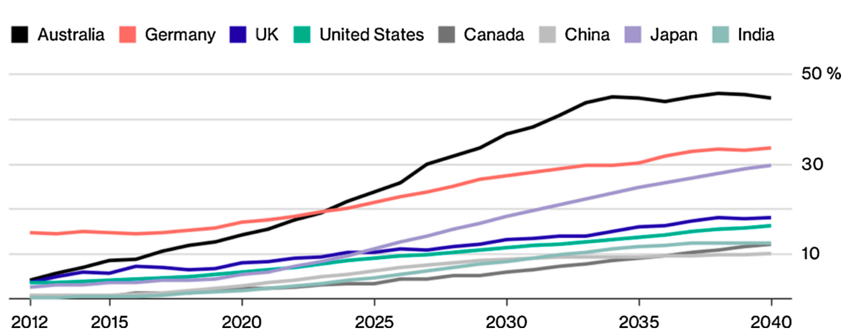

Fig. 2. Forecast ratio of behind-the-meter electricity capacity to total installed capacity in the coming decades (*Source*: BNEF (2017)).

generation will also mean a transition towards zero marginal cost energy production. In this context, there may be an increase in the volume and value of power quality services, including services that differ from those currently included in existing energy and ancillary service markets. This will create a further opportunity for DER to participate in markets and provide services that will create valuable revenue streams for consumers who own DER assets.

There was little support at the Summit for more traditional capacity markets, particularly because in practice they tend to exclude most flexible demand, including DER. However, there was generally good support for operating reserves, such as those used in the existing Frequency Control and Ancillary Services (FCAS) markets. DER could be a natural source of these operating reserves, particularly given the benefits of using consumer DER assets only when needed to maintain energy reliability and energy security. One incentive that was currently observed to be missing was for the provision of reactive power for voltage regulation and balancing purposes, particularly in the distribution network.

Summit participants agreed that it will be highly preferable to have a market that jointly accounts for energy, reserve and reactive power, that factors in the physical realities of the transmission and distribution network, and co-optimises the use of all assets, including DER, that provide these services. There are, however, several ways in which this outcome can be achieved.

One option is a combinatorial market where each bid is a take-it-or-leave-it offer to provide a discrete combination of each service (energy, FCAS, reactive power) to the market. A second approach represents an extension of the existing National Electricity Market (NEM) design that requires bids to consist of a continuous operating range for each service, with simple constraints that capture the operating limits of the assets. The former combinatorial market approach provides participants with the most freedom to express their costs and internal constraints, at the cost of a much more difficult computational challenge to clear the market, and a likely loss of transparency and interpretability.

There was also significant discussion about who these incentives and markets should be structured for, in particular if they should be simple tariffs for human consumption, so that consumers can choose to respond more manually if they wish, or if they should be more complicated machine tariffs, consumed by automated aggregation capabilities that control DER assets. Dr. Doug Arent, from the National Renewable Energy Laboratory (NREL), presented a talk that compared the trade-offs between simple and dynamic forms of tariff, looking at the value they can unlock in DER, and the risk they can impose on consumers. Group discussions indicated a preference to avoid the natural compromise position resulting in moderately complex incentive structures which are too complicated for consumers to react to and which do not support the more dynamic operation of the electricity system.

Getting these market changes right at the outset is unlikely due to how dynamically the system is evolving and the need to experiment with pricing concepts before they can be fully understood and implemented. For these reasons, it may be beneficial to encourage an iterative approach to the design, implementation, and evaluation of new markets or incentives as the operating environment continues to evolve.

While these market changes might need to be incremental and ongoing rather than a step change, it should not prevent us from thinking big and experimenting with different ideas. Sandboxing some of the more ambitious or disruptive design choices could be a low-risk way of learning about new regulation and market choices before committing these changes into the rules. Having the ability to fail in a low-risk manner and fail fast will be critical to facilitate the innovation that needs to happen.

5.2. Consumer representation in markets

Consumers are already investing in DER, particularly rooftop solar, but we are yet to see at-scale business models of aggregation and retail that provides consumers the representation they are looking for. With a few notable exceptions, retailers in Australia do not offer consumers an installation service for rooftop solar, and demand response programs to date have been limited. Overall, incumbent retailers who represent consumers in markets are not yet moving to keep pace with, or capture some of the market in, DER investment.

This consumer investment in solar means that they are consuming fewer kilo-watt-hours from the network. Dr. Fereidoon Sioshansi, from Menlo Energy Economics, presented on how this is changing the traditional relationship between the consumers and utilities, and some of business models and tariff changes we might see emerge over time. With heavy investment in DER, we could begin to see consumers that treat the network mainly as a backup and balancing service, which would require a radical change in how services are valued and how costs are recovered.

6. Technical

Dr. Jenny Riesz, from the Australian Energy Market Operator (AEMO), presented on the system-wide operational impacts in a high-uptake DER future. Operating an electricity system with millions of DER assets can expose significant challenges for both network and system operators. Overwhelmingly, these challenges are not reflective of the behaviour of the DER itself, but are indicative that new operational capabilities and paradigms are needed to manage power systems with millions of distributed assets, where dynamic two-way flows of energy are commonplace.

In particular, DER adoption requires greater system and network visibility. In current systems there is full visibility of the large centralised generation and transmission network behaviour. The move to DER requires visibility of both the DER current operating state and forecasted behaviour, and the behaviour of the distribution network it is typically connected to, something system operators have never had.

A common theme from the Summit was a recognition that to support DER visibility, and long term network and market integration, it is important to develop or adopt appropriate technical and interoperability standards for DER. It is well accepted that such standards adoption is an urgent requirement, due to the timeline for implementing such changes within DER devices, and given it will often be challenging or impossible to retrofit once the device is installed.

Further, standards will only work so long as manufacturers and installers comply with them. As indicated in the AEMO (2019b) report into DER integration, compliance is an existing problem for DER, with up to 30 per cent of monitored inverters in South Australia estimated to be non-compliant with respect to the over frequency droop response standards. Correcting this requires suitable testing and visibility over DER hardware and software, as well as the ability and resources to enforce compliance.

Standards are important not only for safety and system security, but also to ensure adequate interoperability between different manufacturers, aggregators and retailers. Without such interoperability, DER may not be able to appropriately integrate and deliver services to markets for energy, ancillary and network services. Such an outcome could considerably reduce opportunities for consumers to be financially rewarded for their uptake of DER assets. Furthermore, if closed proprietary standards are used for communication and control of DER, there is a significant risk consumers will be locking themselves into one aggregator or retailer at the time of purchase, reducing the competition that is likely to yield desirable outcomes for consumers in the medium- to long-term.

For network and system operators some of the key technical challenges of DER integration are outlined in what follows.

6.1. Voltage management

Two-way flows of energy, high-penetration solar PV, and large new loads, (i.e. EV fast charging) are all contributing to an increasing dynamic range for voltage (as demonstrated in Fig. 3). This contributes to making voltage management in distribution networks more difficult. The development and implementation of new capabilities to manage voltage in a high-DER future are thus an active area of focus for network operators. Note, in the NEM, current voltages in the low voltage (LV) networks are already high so this is not just a rooftop PV issue (Heslop et al., 2020).

6.2. DER behaviour during system disturbances

The behaviour of DER during system disturbances (e.g., the frequency disturbance in Fig. 4) needs to be well understood, otherwise DER could contribute to a recoverable disturbance becoming a much bigger system-wide problem. In the future, it may also be important to require "behavioural certification" of DER in response to significant system events. Such certification could be an important way to ensure that energy security is not threatened in a high-uptake DER future.

6.3. Minimum loads

Due to the highly correlated behaviour of solar PV during the day, there are concerns about the potential for negative minimum demand at particular times and in some regions of the Australian electricity system (e.g., South Australia as seen in Fig. 5). Negative minimum demand will require changes to how energy reliability and energy security are assessed and maintained, and this is a pressing issue especially in South Australia which has over 30 per cent household solar PV penetration and high levels of large-scale solar PV and wind resources as well.

In the context of these challenges, it is widely appreciated that there are challenges to be overcome in operating a high-DER electricity system and that new operational capabilities and paradigms are needed to manage power systems with millions of distributed assets, where dynamic two-way flows of energy are commonplace. In this context, what is needed is better evidence of exactly where the key problems lie and how significant they could be if not directly addressed.

7. Conclusion and next steps

It is clear that DER represents a major component of the broader electricity and energy system transformation. In reflecting the presentations and discussions at the Future Electricity Market Summit, the authors would like to emphasise that it is imperative to find a way to be courageous about making technical, regulatory and market reforms that allow the full value of DER to be captured and shared for the benefit of all electricity and energy consumers.

Clearly such reform is broad in scope and will take time to fully realise. In this context, it will be important to avoid reform that seems politically palatable or achievable in the short term but which does not fully unlock the value of DER in the medium- to long-term. To that end, achieving the ambitious reform agenda required here is going to require three key steps over the years ahead:

1. A clear vision for a future electricity system that understands and values DER (CSIRO, 2017). While challenging, achieving a consensus vision amongst all stakeholders including electricity consumers, would be highly advantageous (Kuiper, 2019). Achieving consensus amongst consumers is going to require a strategy for building consumer and prosumer trust and engagement, something that itself will require a recognition of the segmented aspirations of different consumers and prosumers.
2. Agreeing on the no-regrets activities and reforms that can be implemented in the short-term to underpin the transition to our vision of a high-DER future. Several of these initiatives have been outlined in the preceding sections that outlined the key social, technical and economic aspects of transitioning to a high-DER future.
3. Implementing a cross-disciplinary, socio-techno-economic work program that will provide an evidence-base for implementing the necessary medium- to long-term reforms that will achieve our vision of a high-DER future. Such a work program will require collaboration amongst all stakeholders including the market and regulatory bodies, consumers and consumer advocates, and industry. Alongside, and supporting the reform agenda will be the systems and technology capabilities that will underpin the technical integration of DER in networks and markets. In the Australian context, there are many technology trials already under way so this technical program of work must grow beyond these trials and seek to implement these solutions at scale.

The potential for the beneficial impacts of DER is very broad and the discussions and presentations at the Future Electricity Markets Summit

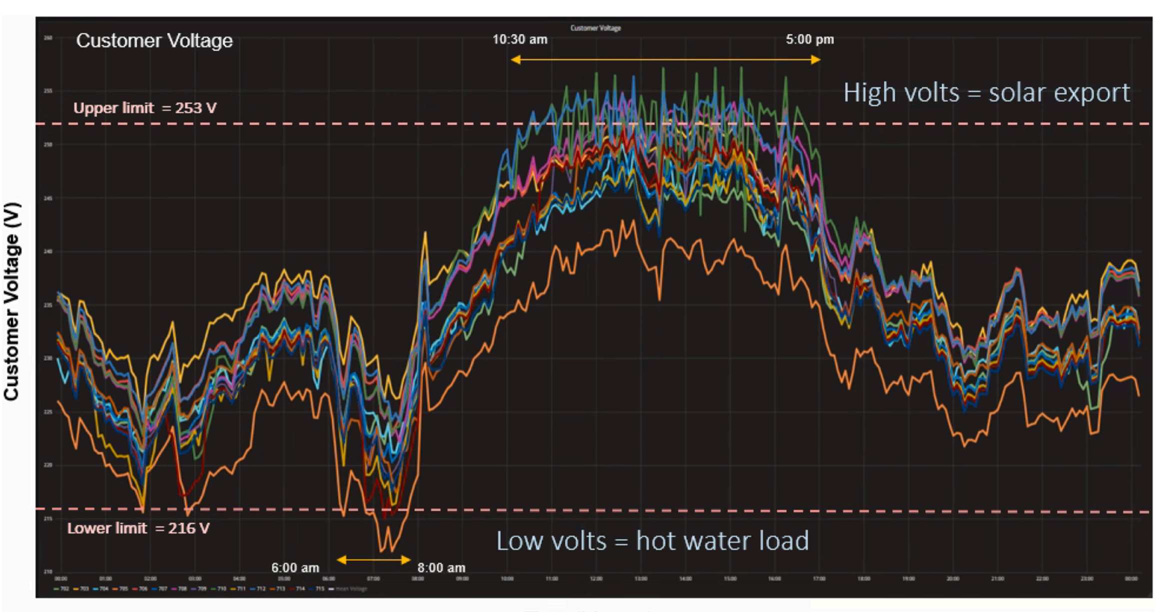

Fig. 3. Voltage observations from the Networks Renewed project in the AusNet Services network, Victoria (*Source*: ARENA and UTS (2018)).

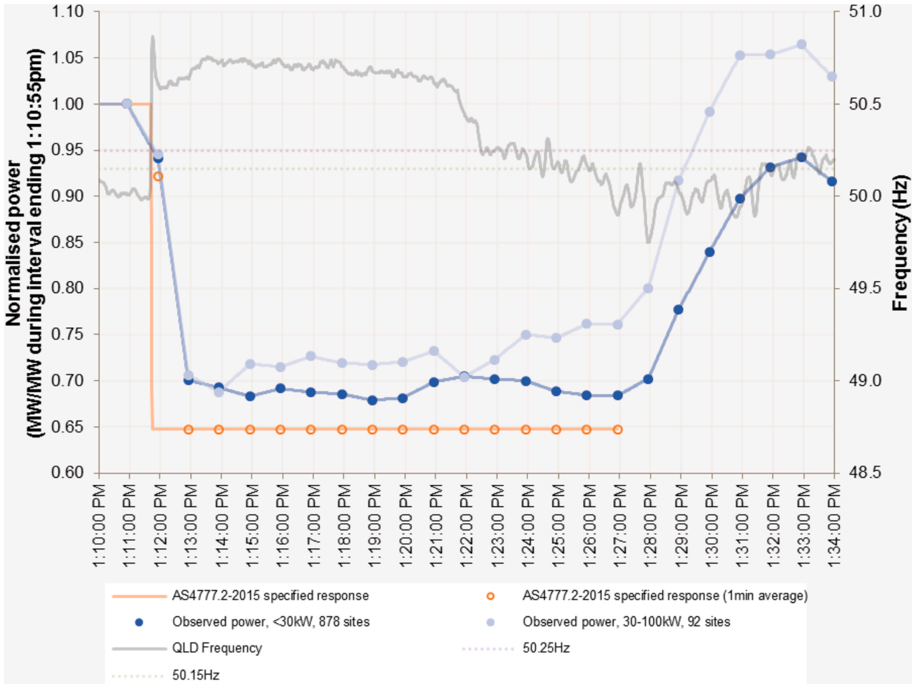

Fig. 4. Understanding the behaviour of DER, in this case solar PV, due to system disturbances is vital to ensuring that DER assets can adequately maintain energy reliability and energy security (*Source*: AEMO (2019a)).

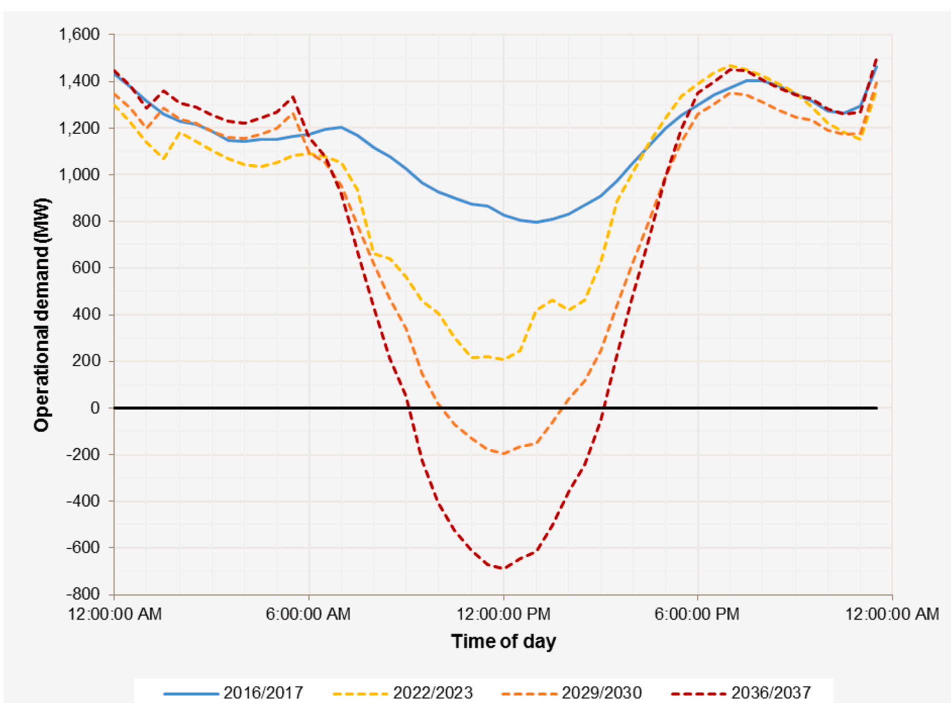

Fig. 5. Understanding how to maintain energy reliability and energy security is an increasingly urgent challenge as several locations in Australia, in this case South Australia, are headed towards negative minimum demand over the coming decade (*Source*: Riesz (2019)).

2019 were an important opportunity to not only reflect on work already underway, but also to chart a course toward a high-DER future that delivers on the promised benefits to all electricity system users.

Declaration of Competing Interest

The authors report no declarations of interest.

References

AEMO, 2019a. Queensland and South Australia System Separation on 25 August 2018. Technical Report. Australian Energy Market Operator.
AEMO, 2019b. Technical Integration of Distributed Energy Resources. Technical Report. Australian Energy Market Operator.
APVI, 2020. Solar PV Maps and Tools (accessed March 2020). https://pv-map.apvi.org.au/.
ARENA, UTS, 2018. Networks Renewed Project Customer Forum.

BNEF, 2017. New Energy Outlook 2017. Technical Report. Bloomberg New Energy Finance.
BNEF, 2019. New Energy Outlook 2019. Technical Report. Bloomberg New Energy Finance.
CSIRO, E.N.A., 2017. Electricity Network Transformation Roadmap: Final Report. Technical Report. Energy Networks Australia (ENA) and Commonwealth Scientific and Industrial Research Organisation (CSIRO) (accessed May 2020). https://www.energynetworks.com.au/assets/uploads/entr_final_report_april_2017.pdf.
Essential Research, 2019. Energy Consumer Sentiment Survey December 2019. Technical Report. Essential Research and Energy Consumers Australia (accessed March 2020). https://energyconsumersaustralia.com.au/wp-content/uploads/Energy-Consumer-Sentiment-Survey-Report-December-2019.pdf.
Heslop, S., Stringer, N., Yildiz, B., Bruce, A., Heywood, P., MacGill, I., Passey, R., 2020. Voltage Analysis of the LV Distribution Network in the Australian National Electricity Market. Technical Report. University of New South Wales (UNSW) for the Energy Security Board (ESB) (accessed May 2020). https://www.dropbox.com/s/8rdvthjsg9ntats/ESBReportVoltage_Master_040520_Final.pdf.
IPCC, 2018. Global Warming of 1.5°C. Technical Report. Intergovernmental Panel on Climate Change.
Kuiper, G., 2019. The Future of Electricity Distribution Networks. Technical Report. The Winston Churchill Memorial Trust (accessed May 2020). https://www.churchilltrust.com.au/media/fellows/Kuiper_G_2017_Regulation_of_clean_smart_customer-centric_energy_networks_1.pdf.
Riesz, J., 2019. Integration of DER: Operational Impacts, Future Electricity Summit 2019, Sydney.
South Australian Government, 1996. National Electricity (South Australia) Act. https://www.legislation.sa.gov.au/LZ/C/A/NATIONALELECTRICITY(SOUTHAUSTRALIA)ACT1996.aspx.

Dr Lachlan Blackhall is Entrepreneurial Fellow and Head, Battery Storage and Grid Integration Program at The Australian National University. Previously, Dr Blackhall led the development of capabilities to monitor, optimise and control residential solar generation and battery storage, as well as the development of virtual power plant technology to aggregate energy storage to deliver services to energy networks, markets and utilities. Dr Blackhall holds a BE, BSc and a PhD in engineering and applied mathematics, is a Senior Member of the Institute of Electrical and Electronics Engineers (IEEE) and a Fellow of both the Institution of Engineers Australia (IEAust) and the Australian Academy of Technology and Engineering (ATSE).

Dr Gabrielle Kuiper is the DER Strategy Specialist with the Energy Security Board and a 2017 Churchill Fellow. In late 2018 she visited North America, the UK and Europe investigating the regulation of clean, smart, customer-centric energy networks. Dr Kuiper is an energy, sustainability and climate change professional with over twenty years experience in the corporate world, government and non-government organisations and academia. Since 2010, she has held positions as the Head of Environmental Sustainability at ANZ bank; Senior Advisor, Climate Change, Energy and Environment to the Australian Prime Minister, the Hon Julia Gillard MP; Senior Policy Officer, Energy and Water Consumers Advocacy Program at the Public Interest Advocacy Centre (PIAC) and Director, Climate Change, Resources and Energy at the NSW Department of Premier and Cabinet. Among other awards, she was a U.S. Department of State Climate Change Professional Fellow in 2011 and a Hermon-Slade Foundation Chevening Scholar with the British Council in 1999.

Larissa's human–computer interaction research includes smart home, distributed electricity generation, and other digital technologies. Her applied research projects involve in-home ethnographic research to explore interactions between energy (technologies, usage, pricing, communications) and social, physical and financial wellbeing. Larissa specialises in bringing deeper understandings of household practices and concerns into Australia's ongoing policy debates about energy affordability, sustainability and reliability. The impacts of energy policy and emerging technologies for vulnerable and disadvantaged households are a key research focus. Her industry research supports consumer advocacy and energy organisation decision-making towards better outcomes for households.

Paul is a research fellow in the Research School of Computer Science at ANU, researching how optimisation and intelligent systems can enable the integration of distributed energy resources (DER) and renewable energy into our electricity networks. He was a contributor to the ARENA funded CONSORT project, which successfully demonstrated in live trials the distributed optimisation of network support from residential DER. More recently his attention has turned to getting more value out of DER through wholesale market participation, focusing on the challenge of enabling the greatest possible flexibility for DER owners, without overloading distribution networks.