Submission to Select Senate Committee into the Resilience of Electricity Infrastructure in a Warming World

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by

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About CEEM

The UNSW Centre for Energy and Environmental Markets (CEEM) undertakes interdisciplinary research in the design, analysis and performance monitoring of energy and environmental markets and their associated policy frameworks. CEEM brings together UNSW researchers from the Australian School of Business, the Faculty of Engineering, the Institute of Environmental Studies, the Faculty of Arts and Social Sciences and the Faculty of Law, working alongside a number of Australian and International partners. Its research focuses on the challenges and opportunities of clean energy transition within market oriented electricity industries. Key aspects of this transition are the integration of large-scale renewable technologies and distributed energy technologies – generation, storage and 'smart' loads – into the electricity industry. Facilitating this integration requires appropriate spot, ancillary and forward wholesale electricity markets, retail markets, monopoly network regulation and broader energy and climate policies.

CEEM has been undertaking research into these challenges for more than a decade, with a focus on the design of markets and regulatory frameworks within the Australian National Electricity Market, and State and Federal energy and climate policy. More details of this work can be found at the Centre website – www.ceem.unsw.edu.au. We welcome comments, suggestions and corrections on this submission, and all our work in the area. Please contact Associate Professor Iain MacGill, Joint Director of the Centre at i.macgill@unsw.edu.au.

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1 Introduction

CEEM welcomes the opportunity to contribute to the work of the Senate Select Committee into the Resilience of Electricity Infrastructure in a Warming World.

The committee's inquiry ".. *into the role of storage technologies and localised, distributed generation to provide Australia's electricity networks with the resilience to withstand the increasing severity and frequency of extreme weather events driven by global warming; recommend measures that should be taken by federal, state and local governments to hasten the rollout of such technologies; and any other relevant matters*." is extremely timely for many reasons. These include:

- the growing severity and number of extreme weather events being experienced in Australia
- the very adverse impacts some of recent events have had on the operation of the Australian National Electricity Market (NEM),
- the extraordinary progress over the past decade in the technical performance and costs of key distributed energy technologies including photovoltaics (PV), 'smart' end-user equipment and buildings and, more recently, small battery energy storage systems
- the growing limitations of current retail market arrangements and network regulation to appropriately facilitate greater energy user engagement with distributed energy options, and
- an Australian climate and energy policy discussion, particularly Federally, which has focussed far too much on the direct costs of emission reduction actions, while largely ignoring the far higher societal costs associated with unchecked warming, including reduced electricity network resilience.

To summarise, the increased severity and frequency of extreme weather events in a warming world, are creating new challenges for the resilience of the Australian electricity system – an industry that is also in the early stages of a low-carbon transition that will be essential to avoiding every worsening climate change impacts.

Note that large utility-scale renewables deployment raises both challenges but also opportunities for electricity industry resilience. The highly variable and only partially predictable output of key renewable technologies, notably wind and photovoltaics (PV), certainly raises challenges for secure electricity industry operation. These impacts will depend significantly on the appropriateness of industry arrangements (IEA, 2016) particularly wholesale spot markets and frequency control ancillary services (Riesz & Milligan, 2015). However, renewables can increase resilience in some key ways as well, including reducing the risks associated with future gas prices and carbon policies in a low carbon global energy future (Vithayasrichareon, Riesz & MacGill, 2015).

However, as highlighted in this committee inquiry, our distributed energy options have a particularly important role to play in future electricity industry resilience; both in decarbonising electricity generation to mitigate climate change impacts on the electricity system, and in optimising, localising and increasing redundancy to improve resilience of energy service delivery to energy consumers. In particular, distributed storage and generation can be located deep in the distribution network near, or even on the site of energy users, and hence provide resilience where it is really matters.

Our submission first briefly discusses the broader context for distributed energy technologies and resilience, highlighting some possible limitations in the framing of the committee's inquiry. It then specifically addresses these terms of reference. We particularly highlight work undertaken by CEEM in relevant areas. We would, of course, welcome the opportunity to engage further with the Committee and further discuss any of the points raised here in our submission.

2 A broader context for distributed energy and resilience

Distributed energy covers a wide range of technologies:
While the committee particularly notes the role of storage and distributed generation, it is useful to take a broader view of distributed energy options. In particular, a growing range of 'smart' end-use equipment with communications and control capabilities also offer opportunities to improve resilience. Hot and chilled water systems, space heating and cooling and a range of other end-use equipment all have inherent energy storage of some form, that can assist in more flexible equipment operation, while still delivering desired energy services as required. In many cases, the costs of this 'storage' are effectively already largely paid for, with just minor communications and 'smarts' costs to be considered. At a higher level, 'smart' building control systems can coordinate a range of such equipment within particular buildings and precincts. More broadly again, energy efficiency offers improved resilience as well, by reducing the amount of energy that must be delivered to provide desired energy services.

Focus on resilience in energy services delivery:
The formal objective of the Australian National Electricity Market is to "*... to promote efficient investment in, and efficient operation and use of, electricity services for the long term interests of consumers of electricity with respect to price, quality, safety, reliability and security of supply of electricity; and the reliability, safety and security of the national electricity system.*"

Network resilience has a vital role to play in this, but note that the objective revolves around the delivery of energy services to consumers. Distributed energy technologies certainly offer opportunities to improve the resilience of networks, but in particular contexts they may also offer opportunities to improve the resilience of energy services delivery to consumers in the absence of a functioning network. Home and commercial distributed energy systems, with PV and battery storage, that can continue to operate when the grid fails are an example of this.

As such, distributed energy options can partner with, but also in some circumstances compete with, existing electrical networks for energy service delivery (MacGill and Smith, 2017). Given Australia's extensive, and highly subsidised rural grids that face particular resilience challenges in a warming world, the Committee could usefully consider this broader resilience opportunity from distributed energy technologies.

3 Committee Inquiry terms of reference

(a) *the role of storage technologies and localised, distributed generation to provide Australia's electricity networks with the resilience to withstand the increasing severity and frequency of extreme weather events driven by global warming;*

Distributed energy technologies have proven capabilities to improve the resilience of networks in some contexts and energy service delivery more generally, as evident by the demonstration and trial programs undertaken by a range of distribution network service providers here in Australia (eg. Ergon Energy, 2016; Energex, 2016; Ausgrid, 2017) in Australia and elsewhere. These trials have, however, also highlighted some of the complexities and challenges involved.

The future role of distributed energy technologies in providing resilience against extreme weather events remains unclear. In large part, this reflects ongoing uncertainties about the type, severity and frequency of extreme weather events Australia is likely to experience. The recently announced ARC Centre of Excellence for Climate Extremes, involving a number of research partners including UNSW, is an important initiative in this regard. Still, the fundamental limitations of climate modelling suggest that there will be ongoing uncertainties regarding our 'extreme weather' future. As such, the roles of distributed energy towards greater electricity industry resilience must themselves be resilient to such uncertainties. These roles include of course helping to ensure ongoing energy service delivery during extreme events that damage electricity industry infrastructure. However, they also include potential contributions to reducing the likelihood of infrastructure failure or binding constraints, be they reducing peak network demand, or longer-term issues such as reducing cooling water requirements of the industry in times of drought.

A range of studies by CEEM and others has highlighted the wider potential of distributed energy technologies including in reducing network peak loads and hence improving its ability to accomodate extreme 'peak' events through distributed PV (Haghdadi, Bruce & MacGill 2017), managing specific household loads that drive peak demand during extreme events (Fan, MacGill & Sproul 2015), and providing flexibility, which reduces the costs of providing reliable generation capacity in both conventional and high variable renewable energy systems (Hungerford, Bruce & MacGill 2016).

The technical performance and costs of our distributed energy options also adds to the uncertainties of their future roles. The past decade has seen remarkable progress in both performance and costs, and this seems likely to continue. Still, their contribution to resilience requires assured performance under extreme weather events. Again, improved modelling tools for distributed energy, and particularly their integration into electricity industry arrangements will have value. There are also interesting opportunities for integrated modelling across extreme weather events and distributed energy options such as, for example, the impact of widespread distributed PV deployment on reducing the urban heat island effect (Ma et al, 2017).

The final, and likely key, uncertainty regarding the future role of distributed energy is the policy, commercial and regulatory arrangements within which these technologies will be deployed. There are options other than distributed energy technologies for improving network resilience including expenditure on hardening the existing network, and creating greater redundancy through network augmentation. Which options, or mix of options, will be deployed will depend on these governance arrangements, as discussed further below.

(b) recommend measures that should be taken by federal, state and local governments to hasten the rollout of such technologies in order to:

The first policy imperative is to do no harm. Unfortunately, recent energy and climate policy developments and some formal rule change processes (discussed further below) might actually reduce the deployment of appropriate distributed energy technologies.

Beyond doing no harm, and while many distributed energy technologies promise to be highly cost effective and/or are well aligned with emerging consumer preferences, rapid rollout will require significant deployment support. Such support (e.g. via Feed in Tariffs and the RET) has been instrumental to the success of PV, reducing new entrant barriers by building economies of scale and facilitating learning by experience (both technical and institutional). Such support for distributed energy technologies would also be justified by the societal value of the abatement associated with a clean energy transition. Where possible, this support should be targeted at strategically important capabilities (e.g. flexibility/storage), rather than specific technologies (batteries), allowing a range of stakeholders to innovate and cost effective solutions to emerge.

While a range of regulatory reform processes are underway, a number of new types of transaction and ownership structures are not permitted under current arrangements (Roberts, Bruce and MacGill 2015; Bowyer, Bruce and Passey 2016). In addition to support for deployment, strong resolve to progress market and regulatory reforms will be required in the face of disruption to incumbent business models. While incumbents such as network businesses have the resources and regulatory scope to run pilots and technology trials, the creation of 'safe spaces' to innovate outside of the regulatory envelope, yet within time and locational constraints, would permit a wider range of potential market participants to experiement on key value opportunities with distributed energy

In addition to support for deployment, new models and approaches to integrate these new technologies into network planning and operation (Haghdadi, Dennis, Bruce et al. 2015, Hungerford, Bruce and MacGill 2015), generation investment (Vithayasrichareon, Mills and MacGill 2015) as well as appropriate market design, regulation and incentive structures (Riesz and Milligan 2014, Marshall, Bruce and MacGill 2016, Young, MacGill and Bruce 2016) will all be an important part of ensuring greater future energy servce resililence. Given the public value of this type of research, it would be best supported by targetted R&D funding.

As financing is a significant fraction of the cost of implementing capital intensive projects such as renewable and distributed energy projects, risk is the key cost factor factor for investors, and hence governments can play a valuable role in reducing risk to reduce costs. Policy stability and rigor is a key part of this risk reduction, beyond specific policy measures.

(i) create jobs in installation, manufacture and research of storage and distribution technologies,

Renewable and distributed energy technologies, due to their relatively small scale, modularity and distributed deloyment are more employment intensive than conventional large scale generation. As just one example, there are already more renewable energy jobs in the US than in coal mining there (Martin 2017). Particularly in the Australian context, the majority of distributed energy jobs are not likely to be in manufacture, but within potentially many SMEs engaged in deployment, including design and installation, O&M, financing, consulting, and innovative new businesses that harness ICT for energy management. The key driver of job creation will therefore likely be the level of local deployment, rather than just seeking to develop and sell distributed energy systems into international markets.

(ii) stimulate household and business demand for storage technologies,

Households and commercial buildings represent key stakeholders and potential investors in distributed energy options. They are, of course, very well placed to implement distributed energy systems that improve the resilience of their energy services.

However, they face a challenging investment context, and broader difficulties in effectively engaging with the electricity industry. The value of distributed energy options hinge, critically, on the commercial framework within which deployment resides; retail market arrangements and network tariffs. These arrangements need, of course, to balance prosumer preferences against the wider economic impacts of deployment. However, policy makers and regulators would also seem to be struggling to reconcile their stated objectives of greater demand-side participation with the realities of its potentially transformative impacts. In the Australian NEM, recent developments, notably with supposedly more cost reflective tariffs, may actually reduce opportunities for energy user engagement, or perhaps direct that engagement in ways that reduce overall electricity sector effectiveness and efficiency through grid defection. Certainly, they present and possible future tariffs don't provide a means for securing longer-term investment certainty for energy users (MacGill & Bruce, 2015; MacGill & Smith, 2017).

More generally, the focus on more cost reflective tariffs may adversely impact policy and regulatory efforts to more directly assist energy users to engage effectively in our shared energy future. Energy users need assistance as well as appropriate price signals to capture the distributed energy opportunities on offer. Unfortunately, existing retailers and network business models aren't offering the customer centric 'energy services' focus required for this. A greater focus on enhancing retail market competition in desired 'energy services' instead of measuring it through price spreads and customer 'transfer' rates would assist.

(iii) *anticipate the rapid deployment of localised distributed generation through changes to market rules,*

Australia certainly provides an example of rapid deployment of distributed generation, with its world leading PV penetration that was achieved in only a little more than half a decade. In some ways, this was actually facilitated by relatively slow rule and policy change processes, that are in some ways now being used to try and reduce PV uptake.

The key governance challenge is to facilitate appropriate distributed energy deployment by both energy users and other stakeholders such as the network businesses. Focussing key governance institutions on this task would be aided by changing the National Electricity Objective to explicitly support technology and business model innovation to address our urgent climate energy challenges.

There are good reasons for thoughtful, transparent and carefully sequenced rule and policy change processes. However, Australian arrangements have proved slow in managing some emerging challenges and opportunities. An important rule design objective is universality in terms of the rules for different participants. The implications of rule changes can never be fully known in advance, and hence warrants suitable caution. One approach to supporting technology and business innovation in this circumstance is to provide a framework for supporting locationally and temporally constrained experimentation while providing time to incorporate learnings from such trials and managing adverse impacts.

(iv) *drive the reduction in technology costs through economies of scale,*

There are certainly options to reduce technology costs through economies of scale. These economies do not only arise in manufacturing, but also in supply chains and, particularly, in the design, installation, operation and maintenance links of the supply chain. For example, Australia has amongst the worlds' lowest prices for home PV systems despite having almost no local manufacturing (APVI, 2016).

More generally, most distributed energy options are highly capital intensive, meaning that the key cost driver is the cost of finance. And the key cost driver of finance is risk. Hence, policy makers should focus on reducing the risks of distributed energy deployment. While the importance of investor certainty is well appreciated for large-scale electicity industry infrastructure investment, there has been far less focus on providing greater investor certainty for distributed energy options deployed by energy users including households and commercial organisations. It is difficult for energy users to lock in long-term contracts around electricity pricing or network tariffs. Hence, their investments in distributed energy are at risk from changes to retail contracts and network tariffs, with few options for securing longer-term arrangements.

Finally, the focus should really be on value maximisation rather than cost reductions – resilience is not generally aided by excessive focus on the lowest cost technology options. Instead, resilience benefits from assessment frameworks that focus on broad delivered benefits as well as costs.

(v) seize on the opportunities to be a global leader in deploying storage technologies because of Australia's high fixed electricity tariffs and significant penetration of rooftop solar; and

Australia is certainly uniquely placed to capitalise on the knowledge and experience gained through widespread deployment of distributed generation here. It has the highest household penetration of PV in the world (MacGill and Bruce, 2016), and has been identified as an early market opportunity for storage, largely because of the net metering arrangements now in place for PV that mean self-consumed PV generation saves the household the retail tariff, while exported PV generation is paid at a much lower rate, or not paid for at all. Australia's high retail tariffs are part of this commercial opportunity. However, the structure of the tariffs is key. High fixed costs (eg. $/day) and lower consumption charges (eg. c/kWh) reduce the value of both PV and storage compared to present NEM residential tariffs with primarily volumetric charges (Oliva & MacGill, 2016). High retail electricity costs, abundant sunshine and high household PV penetrations will not, alone, necessarily deliver the desired storage deployment unless appropriate commercial and regulatory frameworks are in place (MacGill & Smith, 2017).

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