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A Framework to Assess the Ability of Network Regulatory Arrangements to Facilitate Appropriate Investment in Distributed Energy

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Abstract

The planning and operation of electricity industries has traditionally been highly supply-side focused, with electricity demand often treated as entirely exogenously driven. As such, efforts to manage the demand side have generally been limited to relatively minor amounts of network and market-driven demand response and energy efficiency programs. Interest in, and the ability to manage, what is happening on the customer side of the utility meter has increased in recent years, facilitated by a range of new technologies including real-time metering and control, distributed photovoltaic systems and battery storage systems. Beyond energy, a number of potential benefits associated with distributed energy (DE) have been identified, including increased system flexibility to match demand and supply (which is likely to have more value in the future with higher penetration of variable renewable energy), peak load reduction and other network services such as reactive power control, as well as more amorphous societal benefits including increased consumer engagement, improved energy security, increased safety and resilience and reduced emissions. However, the direct economic benefits to consumers of their distributed energy resources is determined by the regulatory environment and retail market arrangements within which they reside.

While there are still some challenges associated with appropriately managing high DE, energy consumers have demonstrated their interest in such options, and these wider potential benefits would present a major opportunity for the electricity industry. Given that many of the benefits of DE relate to the present investment in and operation of distribution networks, substantial investment in DE poses particular opportunities yet also potential challenges for distribution network service providers.

It is therefore worth investigating to what extent the current network regulatory and commercial arrangements are suited to facilitate appropriate investment in DE by consumers, and potentially other stakeholders. This paper presents an assessment framework to consider the benefits provided by DE, and evaluate the alignment of present regulatory arrangements for DE and financial incentives for different stakeholders with these benefits. Using this framework, potential challenges and areas for improvement are identified.

1. Network services and distributed energy

The Australian National Electricity Market (NEM) has a formal National Electricity Objective (NEO) to 'promote efficient investment in… electricity services for the long-term interests of consumers of electricity'. The NEO provides a basis for reviewing the success or otherwise of NEM governance. Recent years have seen a particular focus on network arrangements, given their role in the doubling of retail electricity prices over the past seven years. A number of inquiries (Productivity Commission, 2013, AEMC, 2012a, AEMC, 2014) have focused on the significant expansion in network investment driving this price increase (ESAA, 2012) to meet reliability standards (Simshauser, 2014) and peak demand increases that have yet to eventuate (AEMO, 2013)(Sandiford, Forcey, Pears, & McConnell, 2015). The Productivity Commission (PC) in particular has questioned the efficiency of these investments by distributed network service providers (DNSPs) (Productivity Commission, 2013). This period of growth in network investment has been paralleled, in surprising ways, by the growing capabilities of, and consumer interest in, a range of distributed energy (DE) options including PV systems, smart metering and controllable loads and, now, battery energy storage systems. There was, however, a significant disconnect between these two developments, despite the potential of many DE options to contribute towards network service provision without additional traditional 'poles and wires' network investment.

This seems highly unlikely to represent efficient investment in the long-term interests of consumers, and raises further questions regarding network governance in a rapidly changing electricity industry context.

An obvious starting point for serving the long-term interests of consumers, is to give those consumers a central role in industry planning arrangements. As noted by the Productivity Commission, consumers have not had a meaningful role in key industry investment processes, which is particularly significant with regards to network investment, recovery of which makes up to half of a typical household electricity bill. There have been recent efforts to improve engagement with end-users including the establishment of Energy Consumers Australia, set up by COAG to advocate in the interests of consumers. However, the primary means by which consumers voice their preferences is through their own investment choices. In the 2015-2016 financial year, there was close to \$2.8bn of private investment in PV and storage in Australia[1]. This does not include any of the energy efficiency measures that were also implemented by energy consumers, or other distributed energy opportunities that consumers will have invested in, which would add considerably to the total. Energy efficiency measures pay for themselves quickly, and more affordable efficient appliances and fixtures are rapidly coming onto market (US-DoE, 2016). 'Self-consumed' PV reached socket parity in Australia some years ago (Australian PV Association, 2013), and the cost of energy from PV continues to decline, while electricity storage options are also rapidly declining in cost, with substantial price reductions expected in the near to mid future (Reedman, 2015).

And what of the parallel investment of some \$8.742bn[2] by the distribution networks over the same year, despite opportunities for DE investment to potentially offset at least some of this?

[1] Calculated from total PV capacity installed at \$2.37/kW installed (Johnson & Egan, 2015) and known Tesla and Enphase orders and pricing as at August 2016

[2] According to the AER, current electricity distribution network determinations (not including transmission) total \$43.712bn over the five year period

Current network investment plans suggest that consumers can expect their electricity prices to continue to rise in the next regulatory period. Electricity price increases serve to make distributed energy (DE) an even more appealing investment for consumers. How should these DE and network investments be seen in the context of the NEM objective of efficient investment in electricity services for the long-term interests of consumers?

Networks invest in augmentation on the basis of predicted locational constraints at times of peak demand. These predictions rely on assumptions about user consumption. However, where consumers are investing at the same time to reduce their own costs. This could create unnecessary duplication or, worse, decision making that works against shared interests, which would be an inefficient outcome. The Australian Energy Market Operator (AEMO) Statement of Opportunities for generation is now considering distributed generation (DG) investment by consumers (AEMO, 2016b) but a similar concept for network investment does not yet seem to exist, despite opportunities for efficiency improvements, particularly through the management and reduction of peak demand.

The focus of this paper, then, is the issue of more coherent decision making across network businesses and energy consumers, and across traditional network investment and our growing DE options, to deliver the long-term interests of consumers. The paper is structured as follows. Section 2 introduces the key participants and potential decision makers, and their objectives. Section 3 examines the investment options available to achieve the desired outcomes. Section 4 discusses the potential investors in the electricity industry. Finally, Section 5 makes a start on discussing what would be required to make future investment as efficient as possible.

2. Objectives of participants

2.1. Consumers

The focus of consumers is primarily on reliable and affordable energy services. A diverse range of additional, usually secondary, objectives might include cleaner energy, and some measure of grid independence. The influences on consumer decision-making will certainly include some mix of price, the risk of price increases, the services they can receive for a given amount of energy or money, and the source of the energy (usually secondary to the services it can provide). The level of engagement of different consumers is another complexity. Australian, particularly residential and commercial, energy demand was once considered to be near inelastic (Graham, 2006) suggesting little interest in or motivation for consumers to engage with their energy utility. However, rapid price increases in recent years (ESAA, 2012) have coincided with a decline in demand that cannot be wholly attributed to PV installations (Sandiford et al., 2015, Saddler, 2013). This suggests that there is a limit to consumer tolerance to price increases (Fan & Hyndman, 2011). Having breached this tolerance, consumers are now investigating other means to obtain their desired services. Consumers are also likely to place additional utility on subjective matters such as the source of their electricity (and opportunities to 'punish' their retailers).

2.2. Electricity supply industry

Electricity industry arrangements are meant to be guided by the national electricity objective (NEO), which is as follows:

"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"

However actual outcomes are influenced by how the NEO is interpreted and which elements of the NEO are prioritised over others. As an example, a series of outages in the early 2000s led to a strong emphasis on reliability (Simshauser, 2014), that required major investment in networks. Current reliability standards are regarded by some as excessive (Mountain & Littlechild, 2010, Productivity Commission, 2013), adding insignificant benefit to the consumer, though coming at a large cost. The required investment for reliability resulted in a doubling of prices for consumers, which seems to indicate that the consumer 'price' objective of the NEO has been subsumed by the reliability objective (Mountain, 2014). Essentially, reliability has come at the expense of consumers.

Beyond these possible regulatory tradeoffs, market-oriented decision making by private participants is expected to play a key role in delivering the NEM objectives. The majority of the electricity supply industry is now privately owned and operated. These private participants are motivated by commercial returns, which may create a conflict between the NEO requirement to keep prices at efficient levels for consumers, and private company objectives of profit creation. Generator revenues are set largely by wholesale spot (and associated derivative) prices earned by the capacity they can bring to market (Riesz, MacGill, & Gilmore, 2014). Retailer revenues are primarily determined by the margin between the retail tariffs they charge their customers and these wholesale prices across their customer base (meaning customer retention is key). By contrast, network businesses operate under monopoly economic regulation intended to provide returns appropriate for 'efficient' network investment and operation (Mountain, 2014).

The nature of competition for each of these sectors varies. Generally, generator profits are adversely impacted by new entrant generation and falling demand. Retailers focus particularly on customer retention and acquisition, while network businesses have been viewed as natural monopolies and haven't traditionally been subject competition, with guaranteed returns for approved investment. Regulation of natural monopolies is intended to replace the role of competition in keeping prices low and serving the interests of consumers. This involves restricting the ability of the network business to extract monopoly profits or deliver poor service, creating a set of incentives for the regulated business to act efficiently, and setting prices and revenues to reflect costs incurred by an 'efficient' business. However, in the case of electricity networks, regulatory arrangements appear to be failing to protect the interests of consumers.

New DE entrants are now changing the nature of competition in the electricity industry. DE generation effectively competes against large-scale generation and opens up opportunities for different, more engaged, retailer models. DE can now provide both an alternative to network augmentation and provide network power quality services in the short term, and in some areas might replace networks in the long term. DE therefore represents a new form of competition in what has been traditionally viewed as a monopoly. For instance, a growing number of companies aim to assist energy consumers in deploying DE generation, and better manage their demand in order to deliver their desired energy services at lower costs. New offerings are now being created by non-traditional industry participants, from the installation of private generation systems to the creation of energy independent housing precincts by property developers. These new players are meeting the 'utility' requirements of consumers in a way that the electricity retailers are not perceived to. Existing retailers are responding and have developed new product offerings to help with this including fixed bills and solar leasing (AGL, 2016). Of course DE uptake is likely to reduce the amount of energy a customer will draw from the grid. Such declining volumetric consumption will reduce revenue from consumers, which will reduce economies of scale in providing networks, and ultimately place at risk the viability of some network businesses, an outcome that may not be in the best interests of consumers, considering the high cost of stand-alone power systems. These risks require a rethink of suitable network business models and market and regulatory arrangements that can find the right balance in the interests of consumers.

3. Investment options for the electricity industry

3.1. Centralised Generation

Within the NEM, large-scale utility generation investment has been largely handed over to private, commercially focused, large utility participants. The Australian Energy Market Operator (AEMO, 2016b) makes forward looking projections of future supply requirements, however, it is intended that market participants make utility scale generation investments. Such generation investments involve long-time frames and considerable risk including potentially 4-8 years of planning and construction before they begin operation (BREE, 2012). This lead time, coupled with the size of the necessary investment and the long payback period (BREE, 2012), mean that only very large companies are able to invest in this generation. If projected demand increases do not eventuate, it may take many years to have a positive return on investment. The construction of centralised generation also requires substantial corresponding investment in the transmission and distribution networks to allow generators to participate in the NEM.

3.2. Network

Network businesses are expected to be able to be able to supply electricity to meet demand at all times and locations across the network, and this is enforced by stringent reliability standards (AEMC, 2012b). As such, network investment is dominated by having the ability to supply the necessary energy to meet peak demand events when they occur (AEMC, 2012a; Productivity Commission, 2013). These peak demand events may vary in time, location and duration across the network, depending on local circumstances (AEMC, 2014), and are the subject of forecasts that are primarily used to identify necessary network augmentations.

The regulatory investment test for distribution/transmission (RIT-D/T) testing provides one of few opportunities for non-network solutions to be considered by network companies (AEMC, 2012a). Tests such as the RIT-D/T are supposed to assist in finding alternatives to network augmentation, but there is a strong preference to follow the default option of network augmentation, because the NSP is responsible for identifying the non-network opportunity and classifying it appropriately as a non-refurbishment/replacement, the test only applies to large (>$5 million) investments, non-network stakeholders need to be engaged, and the revenue benefits associated with expanding the regulated asset base provide strong incentives for the NSP against non-network investments. If there is likely to be any slight impact on reliability, the network option will be used, even if it is not the most economically beneficial outcome for other stakeholders. This preference is reinforced by the assurance that any reasonable investment in augmentation will be covered by a guaranteed return on investment (RBA, 2011)(Mountain, 2014). Other attempts to improve incentives for NSPs have thus far not proved effective at overcoming these barriers. This appears to be a failure of the regulatory arrangements to provide suitable incentives for the regulated business to act efficiently.

3.3. Distributed Energy

Returning to the consumer objective of convenient and cost effective energy services, while electricity has been the dominant provider of these services, how much electricity is needed and where it is sourced from is now increasingly at the consumers' discretion. In terms of investment, the options that are now available to consumers are very wide-ranging and far more affordable than they were ten years ago (US-DoE, 2016; Sandiford et al., 2015). Interest in more efficient energy consuming devices has been growing rapidly, made up of everything from housing types, air conditioning and hot water options, appliances and fixtures, without considering distributed generation such as PV. Because this distributed energy is comprised of many disparate parts, its growth has not been immediately obvious – it is only when cumulative impact is considered (Saddler, 2013) that the effect becomes evident.

Consumers increasingly also have choice about where they source their electricity from. Ten years ago, this wasn't even a question for most consumers. In most states, electricity prices were regulated (RBA, 2011), and prices were cheap, so the retailer choice was not significant. As electricity prices from retailers have continued to rise, PV prices have continued to fall (Johnson & Egan, 2015; (Watt, Passey, Noone, & Spooner, 2014), making PV an increasingly attractive investment under current retail market arrangements. Batteries provide an additional set of capabilities including the ability to shape the timing of demand from the grid, and teamed with PV to reduce purchases from the grid and sales to the grid markedly. There are two key network implications to consider at this point: the use of PV generation will cause a decline in volumetric sales, ultimately affecting network tariffs. In addition to this, both PV and storage have the potential to shift or decrease local network peaks, changing the investment required, and potentially rendering some augmentation unnecessary.

Consumer distributed energy services can be arranged directly by the consumer, or alternatively by a service provider. This has led to the development of new types of investors in the energy industry. For instance, property developers have begun to create new products that meet some of the utility values held by consumers. One immediate example is the Mirvac "House with no bills" (Mirvac, 2016), but other developers targeting the zero net energy market are also using lessons learnt overseas to engage consumers in Australia. There are also new trials peer-to-peer energy trading, and Australia's first community-based energy retailer started business in 2016. All of these new business models do not engage with network companies in the standard manner, suggesting that network business models – and how networks engage with consumers – would benefit from further review, with a greater emphasis on consumer engagement.

4. Investors – who's going to build this?

Investment in centralised electricity generation and distribution requires large companies with access to sufficient financial resources, and the capacity to finance investments with long lead times and long payback periods. Network companies in Australia are large publically regulated monopolies. While appropriately located distributed energy could potentially mitigate the need for some forms of network augmentation, it is not currently incentivised (Kelly, Rutovitz, Langham, & McIntosh, 2016), so network companies have largely invested in traditional network assets. Locational information regarding current or future constraints has not readily been available to other potential participants, which has tended to contain network investments to the traditional large network companies.

Early studies into DE saw electricity industry participants, particularly DNSPs, as the primary investors into DE (Dunstan, Boronyak, Langham, & Ison, 2011), as they would derive the most benefit from DE in the form of avoided investment. Issues with the incentives in the regulatory system for NSPs to invest in DE have been discussed in section 3. However, the disaggregated nature of distributed energy investments make them accessible to any willing market participant, with a very low investment requirement threshold. The dominant small scale 'electricity industry investor' in Australia has turned out to be the consumer. This is reflected in both declining overall energy use per household (Australian Energy Regulator, 2013) and the high penetration of household PV systems (APVI, 2016; Johnson & Egan, 2015) seen in Figure 1. DE could thus be characterised as 'democratised generation', allowing consumers to have a say in investmentsthat will feed back into the electricity industry.

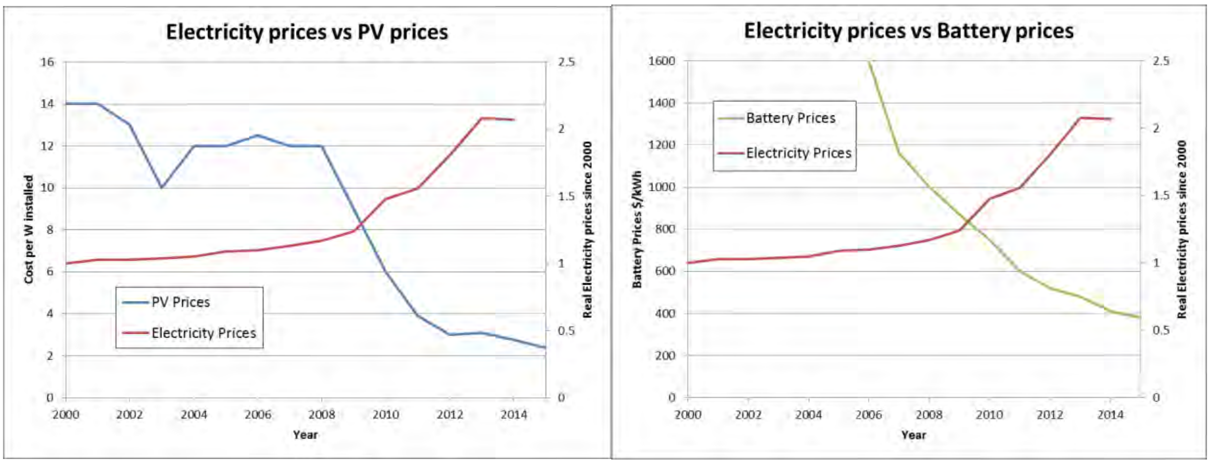

Figure 1: Increasing Electricity Costs and declining DE technology costs. Graphs developed from IPART data (IPART, 2013) **and APVI PV Pricing** (Johnson & Egan, 2015) **and battery forecasts** (Nykvist & Nilsson, 2015)

Electricity retailers are also investing in DG as a means of maintaining their customer base. Origin, AGL and others are now offering solar and storage products to attract and keep customers. There are other product retailers who are tapping into consumer preference, including solar, battery and energy management system retailers. Community energy organisations and property developers are a new category of 'retailer' that are targeting other consumer utility values: electricity price security, clean energy, and independence from the conventional power companies. The early expectation that networks were best placed to and would therefore be the first to invest in DE has not thus far eventuated, likely a result of incentives in the regulatory system that do not necessarily align network companies' interests with those of consumers. Interesting questions remain regarding what mix of network business, retailer/third party and consumer investments would deliver efficient DE investment, and of course, what regulatory arrangements would be suitable to achieve this.

5. Making investment efficient

5.1. Consider all investors

The NEO does not directly specify what comprises efficient investment, making it a matter for interpretation (AEMO, 2016a). However, given that electricity tariffs are projected to continue to rise and DE prices continue to fall (Nykvist & Nilsson, 2015), the economic imperatives that drive consumer investment into DE will continue to strengthen. The role that consumers and other third party service providers should therefore be considered in industry planning and decision making processes. While we are now starting to see DE considered by NSPs and AEMO in load forecasting, consumer investments in DE are largely treated as negative load. These investors could take a more active role in efficient network investment, given the right information and incentives.

5.2. Coordinate future investments

5.2.1. Locational coordination

The benefits of DE have been known for some time (Dunstan et al., 2011), but some of these benefits can only be realised if the DE is sited where and operated when it is needed. Out of the Power of Choice Review, outcomes included a rule change that requires DNSPs to provide load data at zone substation level to assist DE proponents better target their investments, as well as new guidelines for forecasting and consumer engagement as part of the better regulation reforms (AEMC, 2012a). In particular, the Distribution Annual Planning Reports (DAPRs) are intended to provide non-network providers with a better understanding of the potential for alternatives to current and forecast network limitations. In addition, the Network Opportunities Map developed by the Institute for Sustainable Futures (CSIRO, 2016), and funded by ARENA publishes data provided by DNSPs on temporal and locational constraints faced by the networks at times of peak demand. If implemented, an AEMC alternative rule recommendation coming out of a proposal for Local Generation Network Credits would also make it mandatory for networks to provide this data. Nevertheless, at present, any DE demand management would need to be sold to the network via individually negotiated contracts, while the data available on constraints does not extend to detailed half-hourly data at different levels of the network, data below substation level, nor opportunities for a wider range of network services, beyond peak load reduction.

5.2.2. Flexible planning

Currently, networks submit their plans to the regulator in advance of the 5 year determination periods (AER, 2016). Non-network investments in areas of constraint may reduce the requirement for network investment, and DE can be very rapidly installed, as exemplified by the installation of nearly 5GW of PV in less than 5 years (APVI, 2016). DE options would provide options for rapidly deployable, modular demand response that would avoid potentially unnecessary investments. However, long lead times for network augmentation planning, including investment triggers at only 80% of capacity, may constrain adaptation to rapid changes in demand and generation.

5.2.3. Appropriate incentives

As discussed throughout this paper, incentives for network businesses through the current regulatory arrangements discourage DE investments. In the case of networks, it is worth considering whether a quality of service component such as that employed in the UK (Ofgem,

2010) may assist to diminish the emphasis on capital expenditure, and provide a beneficial incentive to network companies. For non-network participants, in a limited number of cases, third parties may sell network services to DNSPs, but the main investors in DE are consumers, for whom the primary incentive is tariff price signals. Recognising that current tariffs incentivize often inefficient investment in loads and DE technologies, a Distribution Network Pricing Rule Change was introduced, which requires network tariffs to be cost reflective. However, at present, there are a range of factors that may limit their effectiveness. Firstly, more cost reflective tariffs require the rollout of advanced metering equipment (Productivity Commission, 2013; AEMC, 2014). Secondly, retailers are not obligated to pass on network tariffs in their exact form to consumers. An example is the fixed price electricity bills from Origin Energy, where the customer pays the same price, regardless of their consumption, negating the price signal from the networks. Thirdly, design of cost-reflective tariffs is extremely challenging and complex, so there is significant discretion afforded DNSPs in the design of these tariffs and opacity around their design. Ultimately the tariffs that have been proposed to date after this rule change do not appear to be well aligned with the costs the consumer is imposing on the network (Young, MacGill and Bruce, 2016), and therefore cannot act as an efficient price signal. Other proposals to encourage efficient DE investments according to their location. Include proposals to facilitate peer-to-peer trading which would align local generation and loads, and LGNCs which would provide a price signal regarding the temporal and location network value for DE feeding into the grid. The regulatory arrangements that can appropriately incentivise investment in DE are still not settled.

6. Conclusion

The economic imperatives driving DE investment are likely to encourage further investment for some time. As such, it is critical to consider DE in industry planning. Despite significant reform in the area, investment planning, coordination and incentives for networks, consumers and third parties are not coherent, and are leading to unnecessary duplication and investments that are not in the long term interests of consumers. Exactly what form coordination would take, how flexible planning would be managed, and how best to structure appropriate incentives are all future matters to be investigated and decided.

References

AEMC. (2012a). *Power of Choice Review*. Sydney. Retrieved from http://www.aemc.gov.au/Media/docs/Final-report-1b158644-c634-48bf-bb3a-e3f204beda30-0.pdf

AEMC. (2012b). Reliability Standards. Sydney: AEMC Reliability Panel. Retrieved from http://www.aemc.gov.au/getattachment/f93100d9-72d2-46fb-9c25-ac274a04ae58/Reliability-Standards-(to-apply-from-1-July-2012).aspx

AEMC. (2014). *Final Determination: Distribution Network Pricing Arrangements - Cost reflective pricing*. Sydney.

AEMO. (2013). National Electricity Forecasting Report 2013. Retrieved from https://www.aemo.com.au/-/media/Files/PDF/NationalElectricityForecastReport2013pdf.pdf

AEMO. (2016a). AEMO National Electricity Law. Retrieved October 27, 2016, from https://www.aemo.com.au/Datasource/Archives/Archive137

AEMO. (2016b). *Electricity Statement of Opportunities*. Retrieved from https://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/NEM_ESOO/2016/v2/2016-Electricity-Statement-of-Opportunities-Report_V2.pdf

AER. (2016). Our role in networks. Retrieved November 3, 2016, from https://www.aer.gov.au/networks-pipelines/our-role-in-networks#aer-network-revenue-determination-engagement-protocol

AGL. (2016). The value of Solar Power. Retrieved October 28, 2016, from https://aglsolar.com.au/the-value-of-solar-power/

APVI. (2016). Australian PV Market since 2001. Retrieved October 30, 2016, from http://pv-map.apvi.org.au/analyses

Australian Energy Regulator. (2013). State of the Energy Market, 1–149. Retrieved from https://www.aer.gov.au/node/29372

Australian PV Association. (2013). PV in Australian 2012 Executive Summary - Prepared for the Internation Energy Agency.

BREE. (2012). *Australian Energy Technology Assessment*.

CSIRO. (2016). Australian Renewable Energy Mapping Infrastructure. Retrieved October 30, 2016, from https://nationalmap.gov.au/renewables/

Dunstan, C., Boronyak, L., Langham, E., & Ison, N. (2011). *Think Small: the Australian Decentralised Energy Roadmap*. Sydney.

ESAA. (2012). Electricity Price Growth-Fact Sheet. Retrieved from www.esaa.com.au

Fan, S., & Hyndman, R. J. (2011). The price elasticity of electricity demand in South Australia. *Energy Policy*, *39*(6), 3709–3719. http://doi.org/10.1016/j.enpol.2011.03.080

Graham, P. (2006). *The Heat is on: The Future of Energy in Australia*. Canberra.

IPART. (2013). Spreadsheet - FAQ Model - Electricity price changes to 2013 - August 2013. Retrieved November 2, 2016, from https://www.ipart.nsw.gov.au/Home/About-IPART/FAQs/Energy/Electricity-Where-can-I-find-information-about-historical-prices/Spreadsheet-FAQ-Model-Electricity-price-changes-to-2013-August-2013

IPART. (2015). Review of the performance and competitiveness of the retail electricity market in NSW. Report, Sydney: IPART. Retrieved from https://www.ipart.nsw.gov.au/files/sharedassets/website/trimholdingbay/final_report_-_review_of_the_performance_and_competitiveness_of_the_retail_electricity_market_in_nsw_-_november_2015.pdf

Johnson, W., & Egan, R. (2015). *PV in Australia 2015*. Sydney. Retrieved from http://apvi.org.au/wp-content/uploads/2016/07/PV-in-Australia-Report-2015.pdf

Kelly, S., Rutovitz, J., Langham, E., & McIntosh, L. (2016). *Economic Impact Analysis of Local Generation Network Credits in NSW*. Sydney.

Mirvac. (2016). House with no bills. Retrieved October 28, 2016, from http://www.mirvac.com/Sustainability/House-with-No-Bills/

Mountain, B. (2014). Independent regulation of government-owned monopolies: An oxymoron? The case of electricity distribution in Australia. *Utilities Policy*, *31*, 188–196. http://doi.org/10.1016/j.jup.2014.09.011

Mountain, B., & Littlechild, S. (2010). Comparing electricity distribution network revenues and costs in New South Wales, Great Britain and Victoria. *Energy Policy*, *38*(10), 5770–5782. http://doi.org/10.1016/j.enpol.2010.05.027

Nykvist, B., & Nilsson, M. (2015). Rapidly falling costs of battery packs for electric vehicles. *Nature Climate Change*, *5*(April), 329--332. http://doi.org/10.1038/nclimate2564

Ofgem. (2010). RIIO: A new way to regulate energy networks, 58.

Productivity Commission. (2013). *Electricity Network Regulatory Frameworks*. *Inquiry Report* (Vol. 2).

RBA. (2011). How are electricity prices set in Australia? Reserve Bank of Australia. Retrieved from http://www.rba.gov.au/information/foi/disclosure-log/pdf/101115.pdf

Reedman, L. (2015). *Future Energy Storage Trends*. Newcastle. Retrieved from http://www.aemc.gov.au/Major-Pages/Integration-of-storage/Documents/CSIRIO-Future-Trends-Report-2015.aspx

Riesz, J., MacGill, I., & Gilmore, J. (2014). Examining the viability of energy-only markets with high renewable penetrations, 1–5. http://doi.org/10.1109/PESGM.2014.6939818

Saddler, H. (2013). Power Down. Why is electricity consumption decreasing? *The Australia Institute*, (14).

Sandiford, M., Forcey, T., Pears, A., & McConnell, D. (2015). Five Years of Declining Annual Consumption of Grid-Supplied Electricity in Eastern Australia: Causes and Consequences. *The Electricity Journal*, *28*(AUGUST), 96–117. http://doi.org/10.1016/j.tej.2015.07.007

Shaikh, S. (2016). Utility: Meaning, Characteristics and Types | Economics. Retrieved November 1, 2016, from http://www.economicsdiscussion.net/utility/utility-meaning-characteristics-and-types-economics/13594

Simshauser, P. (2014). Policy Forum : Energy Markets From First Place to Last : The National Electricity Market ' s Policy-Induced " Energy Market Death Spiral ," *47*(4), 540–562.

US-DoE. (2016). *Revolution ... Now: the future arrives for five clean energy technologies - 2016 update*. Retrieved from http://energy.gov/sites/prod/files/2016/09/f33/Revolutiona%CC%82%E2%82%ACNow 2016 Report_2.pdf

Watt, M., Passey, R., Noone, B., & Spooner, T. (2014). National Survey Report of PV Power Applications in Australia 2013.

Young, S., MacGill, I., Bruce, A., (2016) *Electricity network revenue under different Australian residential tariff designs and customer interventions,* IEEE Power And Energy Society AGM, Boston, 2016