Citizen Utilities: The Emerging Power Paradigm

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The emergence of citizen-based power systems in an integrated grid has been anticipated for decades. We can reveal how this is emerging in practice due to the significant uptake of solar photovoltaics (solar PV) and now battery storage in Perth, Australia. The high cost of electricity, high radiant energy levels and easy access to cheap Chinese technology, has led to dramatic buying during Perth’s recent boomtown years. The traditional uni-directional power system is rapidly disrupting and this paper assesses where this may head and what it means for the grid. Results of monitoring in a solar powered house along with the impact of a battery storage system show the impact on the traditional grid is substantial but it will still be needed and must therefore adapt to the new distributed, bi-directional energy system. Surveys and price trajectories reveal how the trends to solar power storage will continue and how a citizen utility paradigm will emerge as the future grid building block.

Keywords:
Solar Power; Battery Storage; Distributed Power; Grid; Citizen Utilities

1 Introduction

The idea of distributed generation for power has been well known for many decades (Lovins, 1979, 2002; Alanne and Sari, 2006). Lesser understood are the downstream impacts on centralised electricity grids (Sioshansi, 2014) and the social acceptance of the transition processes that flow from widespread adoption of small-scale technologies like rooftop installations of solar PV (The Economist, 2013; Nadel and Herndon, 2014). Now an emerging demonstration city, Perth, the capital of Western
Australia, enables us to see some of the first signs of this new economic and social phenomenon.

Perth became one of the wealthiest cities in the world in the past decade as its population passed 2 million with the last 400,000 people moving to the city in the previous 7 years (Australian Bureau of Statistics, 2015). The city’s growth spurt was based on a boomtown flow-on from new iron ore mining and natural gas developments created to feed the growing Chinese and broader Asian markets to the near north (Committee for Perth, 2012). Part of the new wealth has been used to purchase solar PV on suburban rooftops at remarkable growth rates (The Clean Energy Regulator, 2015), with them being present on more than 22.5 per cent of homes resulting in no new large-scale energy installations being required for the next several decades (AEMO, 2016). Perth’s largest power station is now rooftop installed solar PV, transforming the electricity system.

This paper will outline how this dramatic growth in solar PV has happened in Perth with limited government involvement, how it is expected to continue along with the emerging deployment of battery storage, and thus how the city is becoming a test case for the new distributed solar city, with its associated disruption of the traditional grid system and in particular the creation of citizen utilities.

2 Global Solar

2.1 Solar Uptake

In the last 25 years, the amount of renewable energy installed around the world has increased by 81 per cent and in the past decade by almost 40 per cent (IEA, 2015).
Renewable energies in off-grid or mini-grid systems are being presented as a solution to improve the welfare of developing countries, and these systems have already provided many remote communities with energy independence, allowing them to bypass the need for a transmission network and therefore remove the associated costs of installing and maintaining a network (Nature, 2004; Neves et al., 2014). Hawaii has already reached grid parity for solar power and battery storage on a commercial level due to the high cost of importing fuel, and retail parity is expected by 2022 (Bronski et al. 2014).

Strategies for small-scale decentralised projects are now being implemented around the world (Ozgur 2015; Araujo 2014). In February 2015, Deustche Bank modelled solar PV pricing in 60 countries and found that 30 had regions in which rooftop installed solar PV electricity was at grid parity (Shah and Booream-Phelps, 2015). Germany reached grid parity at the end of 2012 and had the strongest solar PV take-up in the world with 24.8GW of installations by 2011 (Zhang 2013a). Based on Germany’s pioneering feed-in tariffs, Hungary has subsequently taken this system a step further by altering the tariff based on the time of day delivery of the electricity to the grid, a system that has also been implemented in other parts of the world (Klein et al. 2008). For jurisdictions that are reforming electricity tariffs towards time-of-day cost-reflective pricing, if protectionist policies of incumbent generators are not being pursued, it is expected also that time-of-day feed-in tariffs would be put in place to incentivise batteries providing electricity during peak periods and averting the need for expensive peak generation capacity.

2.2 Investments and Cost Reductions
Solar PV installations were, until recent years, prohibitive due to their manufacturing costs. The E.U, Japan, USA and emerging countries have long provided broad funding for research and development to provide affordable, sustainable energy (Shah, 2006). In 2004, investment in renewable energy technology for electricity generation became greater than fossil fuels, and has continued to outstrip them ever since (World Bank, 2013; U.S. EPA, 2014). By 2040 investment in solar power worldwide is predicted to reach US$3.7 trillion, accounting for 35 per cent of capacity additions and resulting in a total of US$8 trillion spent on all forms of renewable energy (Henbest and Giannakopoulou, 2015). It is now virtually impossible to obtain commercial financing for coal energy projects across the E.U., the United States or when using World Bank finances (World Bank, 2013). Since 2008, renewable energy uptake in Europe has wiped off more than half a trillion USD from the value of traditional energy companies with the largest utility in Germany, E.ON, having a three-quarter share price drop since 2010, and the second largest utility, RWE, seeing its recurrent net income fall by a third since 2010 (The Economist, 2013; Gottfredson et al. 2012).

In China, the huge increase in demand by European countries for solar PV has led to a rapid growth in solar PV in all areas of the domestic supply chain. Since 2008, China has become the world’s largest producer of solar PV, providing approximately one third of total cell shipments globally. With the increasing output there has been a corresponding improvement in production technology, in the quality of the solar PV components and a subsequent decrease in the overall cost (Zhang and He, 2013a). In addition to these hard costs, several countries, including Australia, are streamlining processes to reduce soft costs such as permit fees, supply chain costs and
commissioning associated with solar PV production and installation as a method of further reducing overall cost. The Sunshot Initiative in the US has calculated that soft costs comprise between 52 and 64 per cent of the overall production costs of photovoltaics in the US (Friedman et al., 2013). The strategies outlined in their paper are forecasted to reduce solar PV production and installation soft costs by up to 79 per cent by 2020. Further improving upon the value of solar PV installation, in April 2015, the founder of technology-company Tesla, Elon Musk, announced the launch of Tesla’s home battery storage system, which will sell for US$350/kWh. This has set the retail price for solar power storage batteries substantially lower than forecasts had predicted. Prior to this, the Rocky Mountain Institute estimates suggested this would not be reached until beyond 2025, which is also within the predicted range of Nyqvist and Nilsson (2015). Due to the costs of batteries declining faster than predicted, they are expected to reach parity with grids in Australia by 2020 and even earlier in Perth, as discussed below (The Climate Council, 2015). This will allow storage of excess solar power to be used during peak electricity times when the cost of producing electricity is higher and solar electricity generation is lower.

3 Perth

3.1 Perth: Solar Central

The number of households in Perth with rooftop installed solar PV is now in excess of 22.5 per cent, with more than 200,000 systems having been installed since 2010, translating into more than 550 MW of generating capacity (AEMO, 2016). The purchase of solar PV is continuing to grow at over 20 per cent per annum (The Clean Energy Regulator, 2015). Australia in general has been growing rapidly in its adoption of solar PV with more than 1.5 million households with rooftop installed
solar PV, representing around 15 per cent of households, and projected to rise to over 18 million kW by 2031 (Flannery and Sahajwalla, 2013).

The reasons that Perth’s rooftop solar PV has grown even faster than the rest of Australia include:

- More than 300 days of full sunshine are enjoyed every year in the Perth region.
- Electricity prices in the regional grid have risen more than 85 per cent since 2008 and are determined by the sole retailer, Synergy, who also owns much of the generation capacity (Wood and Blowers, 2015). See below in Figure 1.
- Perth has had an economic boom over the past decade that raised income levels to some of the highest in the world (World Bank 2014), resulting in a doubling of the amount of solar PV installers between 2009 and 2014 (REC Agents, 2014).
- Chinese exports of cheap solar PV and now battery storage systems are easily shipped to Perth (in the same time zone and with shipping routes well developed for the export of Western Australian minerals).

3.2 Electricity Price Rise

The price of electricity across Australia has risen substantially above the Consumer Price Index (CPI) over the past decade. Electricity prices in Australia are set within six states and two territories, and four of the eight jurisdictions have among the highest electricity prices in the OECD world, second only to Denmark and Germany (CME, 2012). In the Eastern States of Australia, the National Energy Market is responsible for the transmission of energy across five states (AEMO, 21 April 2016).
The market is made up of generators that produce the electricity, and multiple transmission and distribution network providers that purchase and on-sell electricity as retailers. These companies are a combination of privately owned, state owned or both. In the South-West of Australia, the South-West Interconnected System provides electricity for over 900,000 residential customers, and over 90,000 businesses. The transmission network is operated by Western Power and household electricity is supplied to consumers by the sole retailer, Synergy, both of which are owned by the state (Western Power, 21 April 2016). In Perth, electricity is subsidised by the government by around AU$250 million per annum but the price to consumers remains high.

![Australian CPI vs electricity prices](image)

Figure 1 Australian and Perth electricity price rises compared to CPI. Author’s summary with price data and CPI data from ABS.

The adoption of solar PV has been mostly a feature of middle-income-households as the majority are being purchased in the less wealthy outer suburbs where people have large houses and higher electricity bills as a proportion of their income (Newton and
Newman 2013). Some suburbs already have over 50 per cent of houses with solar PV. The growth rates are therefore likely to continue as electricity prices are anticipated to keep growing owing to the government seeking to reduce the level of subsidy for electricity (Government of Western Australia, 2015).

3.3 Solar Storage
The next step in distributed energy is the adoption of solar power storage through the purchase of Lithium Ion battery energy systems that are growing in demand following the decline in prices as a result of mass production of battery electric vehicles (Nykvist and Nilson 2015). The price of solar power storage based on solar PV and Li Ion batteries is declining such that this combination is nearly at grid parity in Perth. Figure 2 below shows how the combination of rooftop installed solar PV with household battery storage systems is crossing over the price of electricity in Perth at around 2017/2018.
Figure 2: Electricity prices in Perth, Western Australia with solar PV and battery storage against the most commonly charged tariff. Grid parity will be reached around 2017/2018. Source: Authors with data explained in Supplementary Information.

As electricity from solar PV and battery storage becomes cheaper than grid alternatives, this new supply will flood the market, increasing supply and creating a lower market price for electricity. The further decline of battery and solar PV prices, the continuing rise of electricity prices and the expiration of state premium feed-in tariff programs, will encourage existing solar PV owners, who are looking to further reduce their electricity bill, to install a battery with market size expected to be double the size of the amount of the 1.5 million households who presently have rooftop solar (Koh et al. 2015). Perth therefore is an ideal case study to evaluate the emergence of solar power storage as a mainstream technology, the impact this has on consumers’ utilization of centralised energy, tariff reform and the economic and community opportunities that this new energy paradigm brings.

3.4 Overcoming Barriers

There has been some resistance, both within government and from the fossil fuel industry towards distributed energy generation. In Australia, the Expanded Renewable Energy Target legislation was passed in 2009 to replace the Mandatory Renewable Energy Target, specifically supporting the production and installation of small-scale solar PV. The object of the legislation was to ensure that at least 20 per cent of Australia’s energy was supplied by renewables by 2020, to be implemented by The Clean Energy Council, the peak body of the renewable energy industry in Australia (Simpson and Clifton, 2013; The Clean Energy Council, 21 April 2016).
In 2012, a review of Australia’s Renewable Energy Target was carried out by the Climate Change Authority. One hundred and sixty stakeholder submissions were reviewed with 14 per cent in support of a reduction of the original target of 20 per cent renewables by 2020 and 6 per cent in favour of abolishing the RET altogether. Of those in support of the reduction, only one submission was not from a corporation or industry group with a fossil fuel or mixed energy focus (Simpson and Clifton, 2013). After another review in June 2015, the Australian government legislated a change in the target for the renewable energy sector to produce 33 000GWh (33 billion KWh) by 2020, a significant reduction from the previous target of 41,000-45,000GWh. This was due to a reduction in the forecasted energy requirement in Australia, calculating that the new target would still provide 20 per cent of renewables by that year. Although the target will still be reached by this forecast, Simpson and Clifton note that the original legislation had clearly stated that 20 per cent was a minimum goal, and that this reduction in GWh is an indication of reluctance from the government to change the status quo.

Despite this policy setback to larger scale renewable energy projects, the rising number of small-scale solar PV installations in Australia, and especially Perth, has happened much faster than expected. A second survey conducted by Morgan Stanley Research (2016) of 1,600 households connected to the National Energy Market revealed that approximately 50 per cent of participants were interested in a household solar PV installation and battery storage product at a price point of AU$10 000 with a 10 year payback period. The initial research, in 2015, projected that by 2035 there would be a potential market of 2.4 million National Energy Market households, and
could even exceed 3 million by 2035. However this projection is likely to be exceeded without the introduction of policies that incentivised solar PV and battery storage installations or improved feed-in tariff rates. Thus, with the lowering cost of battery storage it is possible that household solar PV and battery storage installations could disrupt the energy market independent of policy reforms (Morgan Stanley Research, 2016). This paper looks at how this is beginning in Perth and what is emerging in response. The biggest questions that arise from these changes are: what is the role of the grid in a distributed system and what are the changes to the utility business model, especially in retailing electricity? To answer this, the research project has monitored and analysed a Perth home complete with solar storage.

4 Household Monitoring

4.1 Method

A house, called ‘Josh’s House’, with solar passive design was built with solar PV and set up later with a battery storage system. The house, containing a two adult two-child family, was fully monitored over a two year period. The case study for Josh’s House was undertaken using actual energy usage data for the period June 2014 to June 2015 of the household, which was collected at 30-minute intervals. The household is grid connected and had 3kW of solar PV system to supplement its energy needs. A battery of 10 kWh storage capacity was installed after this monitoring period to examine the impact on the household system. A simulation of the battery’s impact during that year was made based on three scenarios to gather how much electricity would be procured from various sources: solar panels, battery storage or the grid. The battery was sized to be 10kWh based on a realistic consideration of cost as well as expected demand.
To optimally maintain the battery, 20 per cent of its capacity should not be used, therefore 8kWh of useable power was modelled.

Historical electricity consumption data was used to simulate how much of grid electricity demand would be defected from installing an 8kWh battery. The limitations of this analysis are that large amounts of power drawn within 30-minute interval, greater than the size of the battery inverter, would result in the power being drawn entirely from the grid instead of the battery. The instances that would trigger this would be the utilization of household appliances such as kettles, hairdryers, and vacuum cleaners that are used for small amounts of time. This is expected to have a low level of impact on the results. As the historical usage data covers a one-year period this is not indicative of solar radiation in future years, which may vary to a greater or lesser degree as well as household energy consumption.

The change in the Australian Consumer Price Index (CPI) between 1980 and 2015 were compared against the rise in Australian electricity prices during the same time period. Both sets of data were sourced from the Australian Bureau of Statistics.

For the LCOE of electricity for solar storage, historic and future prices were sourced from Bloomberg New Energy Finance, the Australian PV Institute as well as Australian solar battery suppliers. Foreign exchange rates were built into the modelling and sourced from the Australian Tax Office. For the forecasted period of LCOE for solar and battery prices, we also sense checked market forecasts by undertaking a logarithmic regression. We used a logarithmic regression as it was
a better fit than a linear regression. The formula for the logarithmic regression $e^y=x$ where $y=$electricity prices, and $x=$years. This resulted in $y = -0.361(\ln)x + 1.1894$, that had the $r$-squared value of 0.95662.

The results indicated a future annual growth rate of 7.5 per cent, however, for conservative estimates we used a 5 per cent per annum growth rate.

4.2 Results

The house is highly energy efficient, using approximately 10 kWh of electricity per day with no air conditioning or heating. The results of monitoring show the household was sourcing 55 per cent of its electricity from the grid and 45 per cent from its solar panels. It has a lower peak demand than normal households and with the roof top PV, is making 75 per cent more renewable power than it is consuming – see Figure 3.
Figure 3: Household monitoring showing energy profile of case study house compared to average Perth household. Source: Author’s calculations with data from joshshouse.com.au.

Despite producing electricity surplus to demand, the family still use most of their power in the evening and hence still pay an electricity bill; in the reference period, the price of this electricity is around AU26 c/kWh compared to the AU7 c/kWh they receive back from the utility for the solar PV electricity they sell during the day. However, with a solar power storage system in place, some of the power collected from the sun during the day can be stored in the battery and then consumed during the evening instead of purchasing electricity from the grid.

Figure 4 shows the reduction in electricity drawn from the grid annually with 3 kW of solar PV, and then how this is reduced further with the installation of a battery system to store excess electricity from the solar PV system. The incorporation of a solar PV and battery system reduced this highly energy efficient household’s reliance on the grid from around 55 per cent to less than 10 per cent, whilst still uploading 75 per cent surplus electricity to the grid. The household would therefore only draw energy
from the grid during the few periods of consecutive cloudy days in winter, but this would still be significant if, for some reason, the house was not grid connected.

Figure 4: Results of Monitored Perth Household with 3kW solar panels and then impact of incorporating an 8kWh solar power storage battery. Annual energy usage between June 2014 and June 2015. Source: Author’s calculations with data from joshshouse.com.au.

Solar PV has facilitated a disruption in grid and grid based energy utilisation during the hours when the sun is shining and battery storage is emerging as an even greater disruption to utilisation for all hours in the day, as electricity production moves to household roof-tops and storage systems as well as selling surplus power to the utility.

If this case study is any way an exemplar of the 900,000 households in Perth, what is the impact on the utility and to consumers in this emerging new age of grid connected distributed power?

5 Disruption Impacts

The first main question from this research is how important is the grid in this unfolding world of solar-storage?

5.1 How economic is self-sufficient?

The first key conclusion from the disruption due to solar power storage is that the grid is unlikely to be abandoned by most consumers. Total grid defection is a disconnection of the household from the grid with a sole reliance on renewables and battery storage (Bronski et al., 2015). The evidence from above shows the solar power
storage system cannot carry the household throughout the year even in highly sunny
Perth. Instead, the option of load defection would allow consumers to be significantly
less reliant on energy from the grid while still being connected. Further modelling
was undertaken to analyse what upsizing of the solar PV and battery system would be
needed to see 100 per cent load defection from the traditional energy system. The
results showed that the household solar PV system would have to go from 3 kW to 5
kW, a 66 per cent increase, and the battery would have to be substantially increased
from 8 kWh to 14 kWh of usable storage, a 75 per cent increase. This additional
infrastructure would require a commensurate increase in capital investment and would
have a much longer payback period as the infrastructure would be used for a minimal
amount of time during the winter when there was limited sun, with the rest of the
power being sold back to the energy retailer at a low feed in tariff. The economics of
total grid defection outlined in this scenario are not as compelling as the more than 90
per cent load defection scenario with the smaller system. Achieving grid defection is
exponentially costly as the system approaches 100%. The economics of purchasing
extra solar and batteries to support a household for just a few days a year do not add
up. This suggests that households who optimise the size and cost of their system will
still rely on the grid in some periods throughout the year.

**5.2 Storage and the Grid: other reasons.**

There are many other reasons why the grid is likely to continue after solar PV and
batteries are mainstreamed:

1. The grid is needed for equity purposes, as lower-income earners will not
   always be able to afford solar PV and battery storage options in the transition
   period and after.
2. Operations and essential services that require access to constant and large amounts of power at all times of the day, such as hospitals, prisons and aged care centres, will also rely more heavily on the electricity network.

3. The grid is needed by customers if their systems break down.

4. Grids do go out when their main lines get cut due to extreme weather, fires and earthquakes and in the new world of solar and battery storage these breaks will be lessened in their impacts but a grid can enable those parts impacted to be quickly restored as adjacent parts that have not been impacted can feed into the area from their storage (Newman, Beatley and Boyer, 2009).

5. Grid systems will still be needed in densely populated areas with apartment blocks and cities where there is not enough roof space to layout sufficient solar PV panels, though lower-cost solar PV façades for buildings will go some way to lessen this situation (Frontini et al., 2015).

6. Grid connected households can feed back their excess generation into helping cities to become regenerative (Hes and du Plessis, 2015). In this case study, the household came off grid by over 90 per cent, and was still uploading 75 per cent of its surplus electricity to the grid. Within buildings such as apartments, the sharing of power between consumers will ultimately require less installed capacity on a per dwelling basis, and therefore cost, than if each household had its own stand-alone solar power battery system.

7. The grid can be used by households to procure power in the off-peak to hold in battery storage and then use during peak periods.

8. Household battery storage systems can be used optimally to assist a grid perform efficiently and reduce peak demand.
The second conclusion about solar power storage from this Perth case study is that no further growth in large-scale generation should be anticipated as rooftop solar is expected to rapidly replace all other sources (Moulton, 2015). The main impact of solar power storage is that bi-directional electricity flows are becoming mainstream very quickly. Utilities in the form of generators, network operators and retailers experiencing this disruption will need to adjust their commercial plans as Perth’s dramatic growth in solar PV was a market that was not anticipated. The boom-time in Perth was predicted to rapidly increase the need for peak power from the centralised system and hence an old coal-fired power station was recommissioned at a cost of AU$500m and returned to service the grid. However, it was never needed as the household solar PV reduced the demand on the grid so effectively that it led the Minister for Energy to conclude that the grid would never again need to build a power station. The growth of solar PV adoption to 70 per cent by 2025 was ‘inevitable’ he concluded (Moulton, 2015). Over time, the transmission network is likely to be utilised less and is therefore at risk of having some of its value written down.

The third conclusion from the emerging new energy systems associated with solar power storage is that consumers are likely to create their own way of managing the majority of their electricity needs and how they dispose of their excess electricity. This is because these households are no longer likely to sell their electricity to the grid network operator, and will instead choose to use it for their own domestic consumption by coupling it with energy storage and sell their surplus directly to other consumers. This will enable consumers to potentially become energy traders, only selling electricity back to the grid when the buyback price is what they desire (RepositPower, 2015). The process of managing these sales is likely to be through
local groups of buyers moderated through the internet (ref). We have called this emerging phenomenon ‘citizen utilities’. This will put downward pressure on electricity prices and bring with it new economic opportunities.

The evidence for these bottom-up responses to solar power storage is that already technology platforms are being invented to sell excess local electricity such as Reposit and Local Volts. Companies such as Grid Singularity, Solar Coin and Ethereum are using the Bitcoin’s underlying programming protocol, called ‘the blockchain’ to transact electricity (Extance, 2015). This is a distributed consensus-driven infrastructure enabling trust between counterparties. Using the blockchain, microgrids can become more resilient with a commonly used database for managing transactions. This can be used to both manage electricity and financial payments associated with it (Rutkin, 2016). The future would appear to be an integration of these smart city systems with sustainable city systems (Newman, Beatley and Boyer, 2009; Hargroves and Smith, 2005).

6 Group Housing Utilities

The use of solar in Perth and around the world has mostly been used on individual households where a simple rooftop system can be owned and operated by the household. The research project then shifted to see whether group housing could also join this transition to solar-storage technology and how a citizen utility could apply.

6.1 Strata Company Citizen Utility

For group housing (around one third of Perth’s households) there are new responsibilities being taken by residential building managers to act as a citizen utility.
A new profession of local energy managers is emerging to service this new market (Green and Newman, 2016a; The Clean Energy Council, 2016). An innovative new precinct development called WGV (stands for White Gum Valley, the suburb in which the development is set) is utilising a Federal Government ARENA research grant to establish shared solar PV and battery storage as a basis for the power system, covering around 60 households (Landcorp, 2015). Within the apartment buildings, the shared areas and infrastructure, called strata title areas, are handled by a strata management company. A scheme has been worked out to trial how the strata company can manage the solar PV and storage infrastructure. The strata company will manage electricity, electricity contracts, administer the electricity bills to the residents, and sell excess power to the grid and others in their locality. The strata will thus be making money for the dwelling owners. This is a citizen utility. Through transacting with each other, citizen utilities will utilise the local distribution network more, thereby increasing its utilisation and financial value (Seba 2014). This phenomenon counters some of the concern of the so called ‘death spiral’ whereby consumers go ‘off grid’ and bring utilities to bankruptcy.

Through the ARENA research project, we will know in a few years whether the WGV precinct will still need the grid based on the economics of precinct scale housing where considerably more capacity can be provided than in the individual household model. The utility, Western Power, is part of this project and will no doubt be watching with great interest.

The WGV project also has shared local water management (a community bore) and waste management that enable the strata company to have multiple utility
responsibilities and opportunities. One group of dwellings will have shared electric vehicles as part of their strata company. Such green technologies and features such as solar focused design, low carbon materials, biophilic walls and roofs, are increasingly being built into new developments in Perth. The governance, metering of end-use consumption has been trialled for the accurate measurement and data transfer of water and can similarly be used to measure electricity generation and use. There are applications for other utilities such as gas as well (Giurco et al. 2010).

6.2 Perceptions of Value in Green Technologies

The question of whether citizen utilities are likely to grow in the future depends on more than the price of solar power storage compared to fossil fuel power but also depends on consumer preferences. A survey was thus conducted on whether people in Perth were likely to want to buy into such green developments, especially the new multi-unit developments where developers create their product with or without green technologies and sell them to the market.

Twenty-seven new developments were surveyed to see what people were looking for in medium and high-density developments; a multi criteria analysis carried out by Green and Newman (2016a) showed that the usual criteria of affordability, location and size were now being joined by the need for ‘sustainability characteristics’ in 46 per cent of households. Thus citizen utilities are likely to become a major feature of future grouped housing, which makes up 25 per cent of existing housing in Australia (Australian Bureau of Statistics, 2011) and are growing their share of the new building market as cities densify (Newman and Kenworthy, 2015).
7 The Future of Network Utilities in the Light of Citizen Utilities

7.1 Electricity From Local Sources

A citizen utility system enables electricity to be created from local sources. In the above Perth case this was household rooftop solar PV and battery storage, and it seeks to generate a profit for the members of its group. This democratisation of electricity provision could be a major transformative force for sustainability in local economies (Muro 2015) and stretch into the provision of solar powered transport (Newman and Kenworthy, 2015). However, it still requires a grid to be maintained, albeit with smaller capacity, particularly in the transmission part of the network, and far less need for large-scale generators. So how will utilities face this emerging challenge?

Although large-scale solar PV projects have been encouraged and installed by governments and utilities in some countries, there are disadvantages to prioritising this type of installation, as exemplified by the issues that arose in China through large-scale solar PV subsidies. The Chinese government encouraged domestic solar PV installations (primarily large scale) with a series of policies, regulations and subsidies formulated in 2009 (Zhang et al., 2013b). Subsidies of up to 50-70 per cent were provided for large scale installations, however, the subsidy was provided for the installation of solar PV without any regulation of the quality of systems being installed, meaning there was no incentive for installers to use high quality solar PV resulting in performance and longevity issues. Furthermore, large-scale systems, due to land limitations, were mostly built in areas remote from demand centres. This resulted in higher costs, inefficiencies and other challenges to the transmission systems.
Distributed generation (rooftop) solar PV systems, as explored in this article, provide solutions to these problems. As the energy generation of the solar PV is provided directly to the occupants of the building, there is a direct incentive to invest in high quality systems. The installations require no additional land or additional transmission lines, and there is a significant reduction in energy lost during transmission compared to large-scale systems. Understanding these differences, China has since turned its focus towards distributed generation (Zhang et al., 2013b). Similar responses to the new distributed solar options are likely in all economies as is now happening in Western Australia. Thus the need to accommodate distributed rather than centralised power is a major policy agenda. So, what kind of responses can be expected from utilities?

7.1 Utility Responses

The growing threat of citizen-owned distributed renewables paired with batteries is pressuring utilities to engage with their customers in new ways, acknowledging them as potential generators as well as buyers of electricity, or ‘prosumers’. Potential responses for utilities are to ‘Fight’, ‘Flight’ or ‘Innovate’ as set out in Figure 5. These are not mutually exclusive, as an example, utilities may Fight and simultaneously Innovate.
Figure 5: ‘Fight’, ‘Flight’ or ‘Innovate’ options for businesses threatened by distributed energy business models (Authors created with some information from Bloomberg New Energy Finance) (Bloomberg, 2015).

7.1.1 Fight

If incumbent businesses ‘Fight’ against the market uptake of renewables, they can lobby for protectionist policies that maintain their market share. Utilities could insist that consumers continue to pay for infrastructure when they no longer utilise it, through the implementation of higher fixed charges. The increase in charges to customers will have a high elasticity effect on demand, and may result in further reasons for customers to defect from the grid entirely. Another fight response would be to restrict renewable technology uptake to certain proportions or times of the day and to try to limit battery sourced electricity being uploaded to the grid. Prohibition rarely works in the long term with disruptive innovations, as consumers will try and circumvent the system entirely, whereby incumbents choosing not to reform ultimately suffer more as a result. For example, traditional taxi drivers adopting Fight strategies have ultimately not stopped the deployment of Uber taxis and the impact it has had on the traditional market. ‘Fighting’ will still lead to asset write-downs and
stranded assets. In the case of the energy sector, the oversized parts of grid infrastructure, such as the transmission network, would be written down in value. Some large-scale generation assets will have their market share eroded by cheaper renewals and consequently be written down in value.

The ‘Fight’ response can be explained by Nobel laureate Daniel Kahneman’s theories of behavioural economics; he suggests that under certain conditions people and corporations do not behave in the way that economic models have traditionally assumed to maximize utility, instead the market is resistant and wilfully ignorant to the new paradigm that is emerging (Gilovich, Griffin and Kahneman, 2002).

### 7.1.2 Flight

The ‘Flight’ approach would see utilities taking no action or divesting investments in traditional energy markets altogether. Inaction leaves utilities exposed to the market changes. Not managing the transition effectively between the old and the new paradigm will likely lead to asset write-downs and stranded assets.

### 7.1.3 Innovate

Incumbent utilities can embrace this new reality and continue to play to their strengths as established brands with a wide customer base and technical experience. They can adapt their product offerings and services to this new market. ‘Innovate’ approaches take the form of deployment of new technologies with new business models that enable the transition to a distributed, market-based and fossil-fuel-free power system. This new market is attracting participants such as technology and software companies along with new, more agile financial institutions backing the industry. For example,
the new multi-unit WGV development outlined above will see the building’s multiple owners also act as the utility. Green and Newman (2016b) state that it is possible for a third party utility company to own all or part of the energy assets and also have contracts in place where they maintain them. Innovative strategies may therefore include incumbent retailers offering solar power and storage to consumers in various ownership and leasing arrangements. New technologies for power transactions such as the blockchain will be used in the transition from a centralised to a distributed energy system, facilitating equitable market pricing, even if regulators resist.

Although Innovation isn’t an assurance of survival, some utilities will survive by innovating, whilst others will be unable or unwilling to adapt. Regardless though, the citizen utility phenomenon will result in lower electricity prices for consumers as grid infrastructure is written down in value and generation costs are driven down from low cost solar PV and storage. Perhaps the biggest policy implication in a distributed electricity grid is that the retail functions of utilities will drastically change. Instead of collecting power from producers and selling it at a profit, the utilities main role will shift to providing ancillary services, ensuring a balanced grid can accommodate its various distributed producers through its own solar and storage systems, being asset owners of smaller scale generation assets, as well as charging for the grid under new pricing regimes.

8 Conclusions and Policy Implications

For the past century in Perth, consumers have been at the end of a very long production line of electricity. Notwithstanding, in less than a decade, with mass deployment of solar PV rooftop installations, they’ve moved from consumers to
consumer-producers, much like citizen journalists in social media. With middle-income rooftop-installed solar PV now the largest power station in the grid, there is significant disruption as householders seek to not only reduce their power bills, but to sell their excess power to other local users via micro utilities and enabling technologies such as the blockchain. Residential building managers and local communities are able to become citizen utilities, providing their groups of households with solar power and profits from the excess.

This paper has shown that the grid will still be needed in this new distributed system and that citizen utilities will need to be accommodated. This is a challenge to all conventional utilities, especially in their retail function. A coalescing of factors has resulted in the emergence of these citizen utilities. This is the first version of a new kind of energy market, operated by consumers, which will change the way we generate, consume and transact electricity.

Facilitating this transition can enable significant economic advantages to a city. The Perth transformation suggests that the change from an old economy orientation with fossil fuels and centralised power can rapidly shift to distributed, citizen-utility-based power on a foundation of new economic localism and the democratisation of power.

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