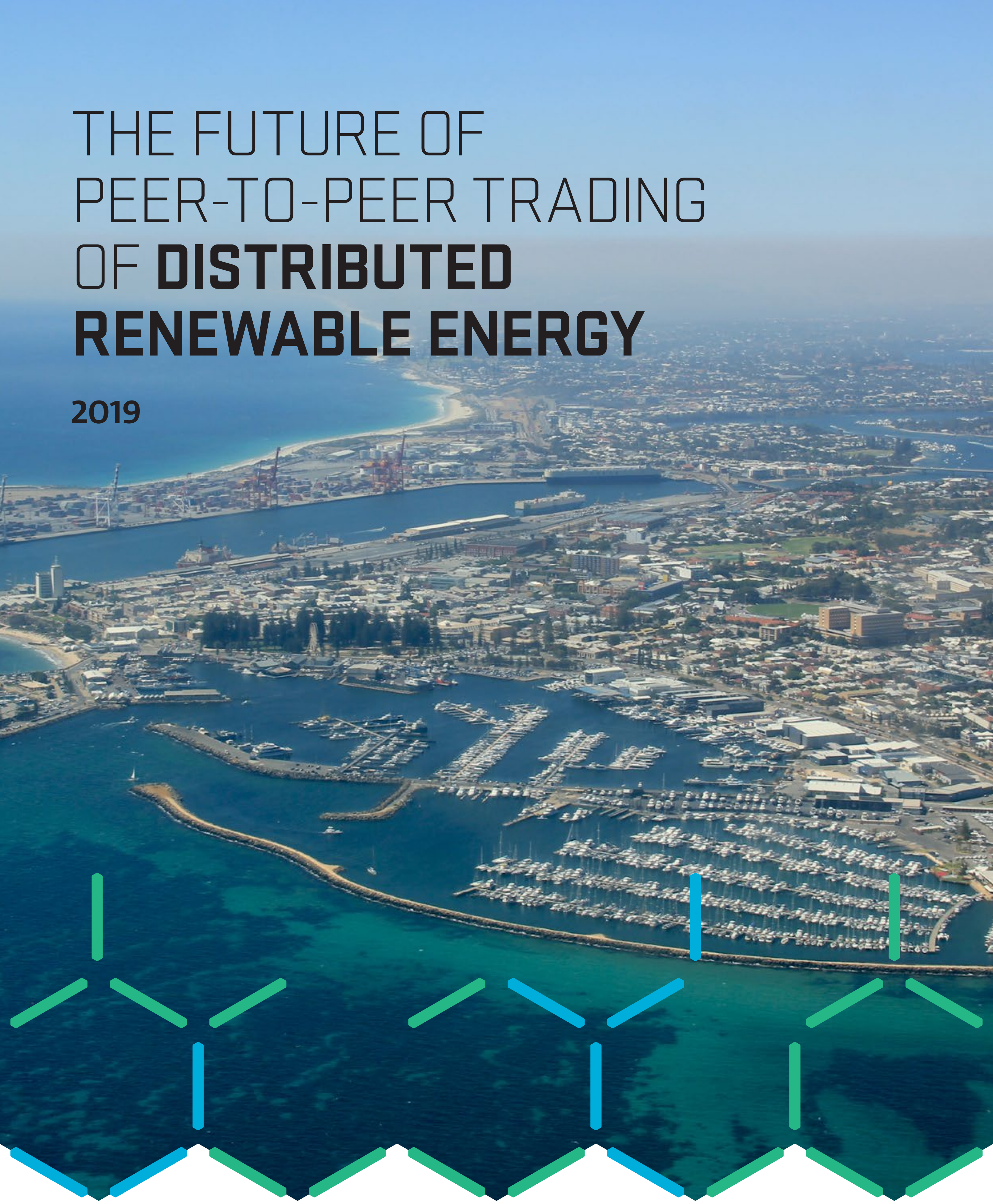
THE FUTURE OF PEER-TO-PEER TRADING OF **DISTRIBUTED RENEWABLE ENERGY**

2019



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EXECUTIVE SUMMARY

The energy industry is transforming. Advances in energy generation and storage, digital technologies and platforms, robotics, Internet of Things, artificial intelligence and autonomous vehicles are driving tomorrow's innovations, and enabling new business models to emerge. Unlike previous industrial revolutions, the digital revolution has no clear boundaries, and its development is likely to be ongoing, ubiquitous and rapid. In addition, accelerated adoption of new technologies and smart devices, especially among the tech-savvy digital natives, is increasingly empowering energy consumers of tomorrow to become 'prosumers' who generate as well as consume energy.

Globally, the cost of solar energy is comparable to that of fossil-fuel generated electricity. In addition, solar energy is leading the way and accounting for more than half of the newly installed renewable capacity.[6] These developments have been echoed here in Australia, with the average cost of installing a 5-kW rooftop solar system dropping from AU$12,290 in 2012 to only AU$5,530 in 2019.[8,9] Advances in technology combined with declining cost of rooftop solar are incentivising households to install distributed energy resources (DER) and generate their own electricity. In addition, growing consumer concerns about the environment, along with improving performance of new generation DER, could potentially see energy consumers and residential generators seeking new ways to create value for themselves in the future.

The emergence of new peer-to-peer (P2P) business models across many industries, coupled with increasing interest by Australians in the sharing economy, could see the P2P business model extend to the energy industry of the future. Over the next decade, new P2P energy trading platforms may emerge to allow prosumers to trade their excess electricity with consumers who want to purchase affordable renewable energy. However, how will P2P energy trading be integrated into the existing energy system? Will P2P energy trading provide a secure, reliable and cost-effective mechanism for monetising DER?

Today, most prosumers seamlessly sell excess electricity generated by their rooftop solar to electricity retailers, and are compensated via a feed-in tariff (FiT). In this report, P2P energy trading represents the monetised transaction of energy from households or businesses with small-scale DER to local residential and commercial energy consumers. This report supports the RENeW Nexus project that was established in the City of Fremantle to examine the value and efficiency of P2P energy trading in Western Australia, and explores the possibility of P2P energy trading operating as part of the energy system across the state over the next decade.

This report opens with the outcomes of a horizon scan of interconnected social, economic, geopolitical, technological and environmental trends driving transformation across the energy industry. These trends were categorised into four overarching themes (Figure 1).

Building on the analysed trends, the second part of the report presents future narratives describing how P2P energy trading may operate in 2030. With these insights, the government, energy and property industries, and consumers will be able to better navigate the uncertainties around P2P energy trading, and maximise the potential opportunities that this new energy system could bring over the next decade.

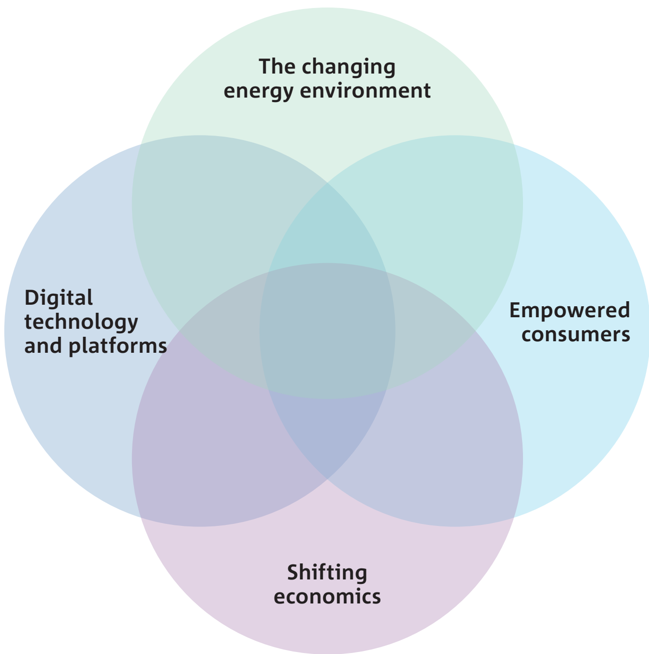
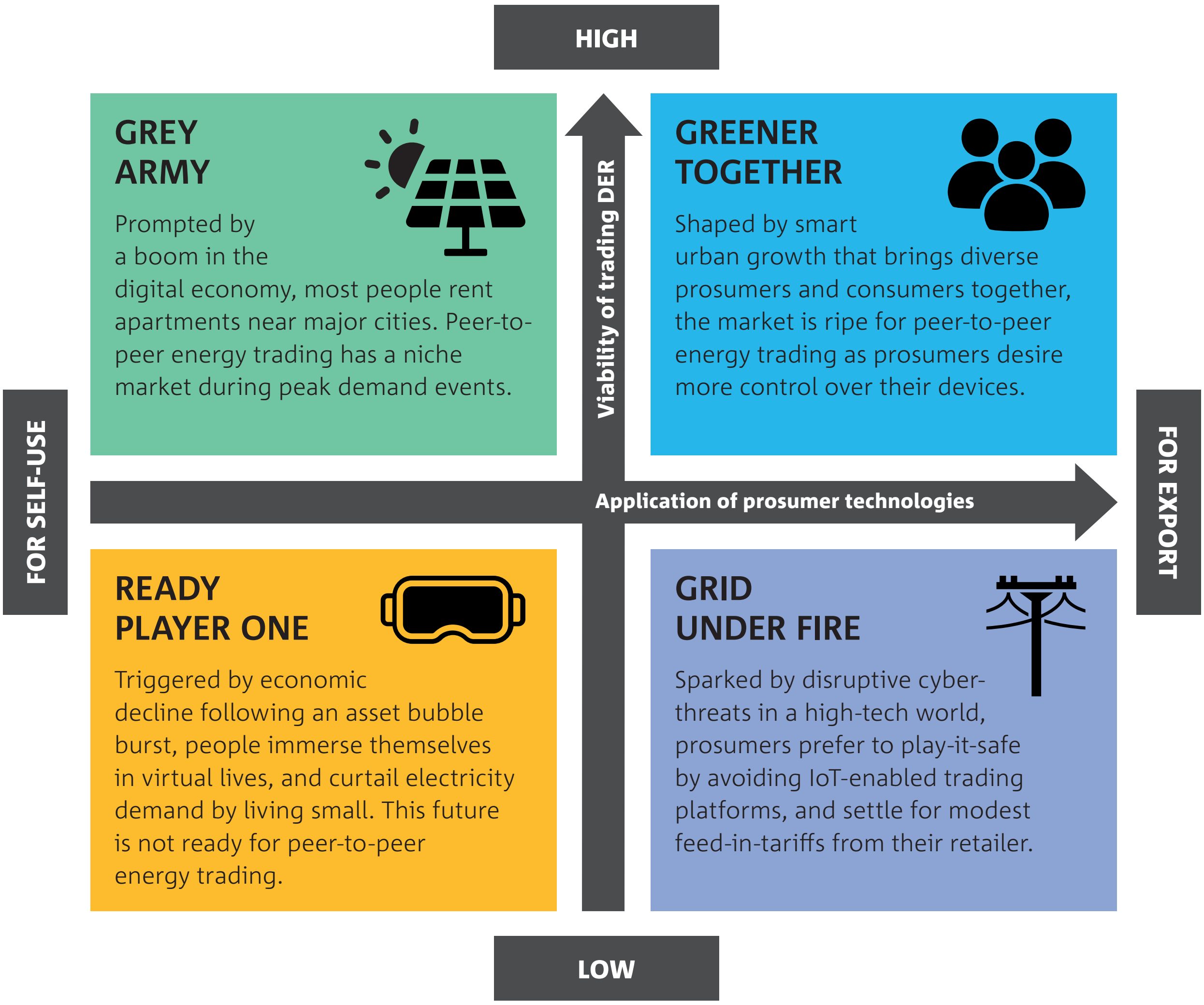


Figure 1. The four main emerging themes relating to the changing energy system out to 2030

FOUR SCENARIOS

The four scenarios have been developed based on the interconnected set of trends outlined in the first part of the report. Following an extensive literature review examining the plausibility of different areas of broad uncertainties, we consulted with a number of energy industry and government stakeholders to identify two key areas of uncertainty that could impact the operation of P2P energy trading in 2030. The first uncertainty and axis we identified related to how prosumers will use the energy they produce—will it be primarily for self-use, or will they aim to create a surplus for export. We named this first axis 'Application of prosumer technologies'. The second 'Viability of trading DER' axis examines how financially viable it could be for prosumers to trade their excess renewable energy. It describes the extent to which regulations, infrastructure and market conditions will enable prosumers to create financial value through trading their surplus DER. When combined, the two axes yield four scenarios that capture a range of plausible futures. The identified uncertainties gave rise to the following four scenarios:



FUTURE OPPORTUNITIES AND RISKS

Developing future scenarios describing how P2P energy trading may operate in 2030 will help identify a number of risks, challenges and opportunities for the consumers, government, and energy and property industries over the next decade. Informed through consultations with government and energy industry stakeholders, the following are some of the future opportunities and risks relating to P2P energy trading over the next decade:

- Enable prosumers to have more control over their excess solar energy, and potentially receive a higher return compared to future FiTs.
- Potentially offer consumers more affordable electricity compared to retail tariffs, and transparency on the exact source of the purchased energy.
- Engage more households on energy issues, and assist in the transition towards a cleaner energy mix.
- Network upgrades could be needed to enable high volumes of export-capable DER.
- Upgrading grid infrastructure to enable more export-capable DER will likely increase transaction costs and adversely impact on trading viability.
- Growing number of large-scale renewables combined with an increasing number of small-scale DER will likely drive down generation costs in the future. The price advantage in the generation cost of energy that P2P may offer could diminish in the future.
- Current flat tariff structures do not incentivise P2P trading. However, future market reforms, including more cost-reflective pricing, retail contestability and removal of current guaranteed renewable energy buy-back rates could affect trading viability.
- Regulations require P2P platforms to operate in cooperation with incumbent utilities.
- Customer engagement could be difficult due to complexity relating to the cost structure, management and regulation of the electricity system.
- Difficulties in accessing real-time meter data to collate accurate records of transactions.

Scenarios in this report provide a narrative about the possibility of P2P energy trading operating as part of the Western Australian energy system over the decade, and can assist in facilitating early strategic discussions around future energy management. As we move towards 2030, it will be vital to track development towards these scenarios, and establish timely strategic responses that prioritise future management of the existing grid to accommodate an increasing volume of renewable energy. This work is a positive first step towards informing decisions around future priorities and investments in distributed energy systems and technologies.

INTRODUCTION

As with many industries across Australia, the energy industry is undergoing a rapid transformation.[12]

Characterised by worldwide development in renewable energy generation and storage technologies, digital platforms, Internet of Things (IoT), Artificial Intelligence (AI) and autonomous vehicles, the speed and scale of today's technological change rivals the early 20th century transition to electricity. Likewise, adoption is increasing at a rapid rate. Today, technologies are enabling more efficient delivery of products and services that many of today's consumers find indispensable, such as ordering a ride, booking a flight, buying groceries, paying bills and listening to music, to name just a few. The emergence of new energy-related technologies and business models could potentially alter the way we generate, consume and distribute energy in the future. In addition, shifting consumer values and preferences coupled with changes to the energy mix are empowering energy consumers to increasingly become 'prosumers' who generate as well as consume energy.

Globally, 2017 saw the biggest annual increase in the generating capacity of renewable power. An additional 178 gigawatts of renewable energy was installed in 2017—increasing by around 9% from the year before to a total capacity of around 2,195 gigawatts.[6] Solar energy led the way and accounted for more than half of the newly installed renewable capacity, with wind and hydropower accounting for approximately 29% and 11% respectively.[6] Driven by declining cost of solar PV worldwide, more solar energy was added to the generation mix in 2017 than fossil fuel and nuclear generated energy.[6] Here in Australia, the average cost of installing a 5kW rooftop solar system dropped from AU$12,290 in 2012 to only AU$5,530 in 2019.[8,9]

Technology advancements and declining cost of rooftop solar are incentivising households to install their own distributed energy resources (DER). Today, households with rooftop solar are contributing to Australia's renewable energy transition, as well as saving money on household energy bills. These 'prosumers' are earning a small feed-in tariff (FiT) from their retailer for selling the surplus energy they produce back to the central grid. In addition, producing their own electricity during the day enables prosumers to directly use the electricity they produce—reducing their consumption of centrally generated electricity. However, new ways for prosumers to sell their surplus energy are emerging.

Over the past decade, we've seen the rise of new peer-to-peer (P2P) business models across many industries that use online technology to help connect strangers and enable them to do business online. There are over 1,000 P2P platforms operating worldwide (e.g. Uber, Airbnb and Airtasker)—with Australians becoming increasingly interested and engaged in this sharing economy.[13] The next decade could see P2P platforms extend to the energy industry, where prosumers trade their excess electricity with energy consumers who are looking to purchase renewable energy for an agreed price. Unlike the traditional form of DER trading where the electricity retailer pays households a FiT for their excess electricity generated by their rooftop solar, our definition of P2P energy trading relates to the monetised transaction of energy from households or businesses with small-scale DER to local residential and commercial energy consumers. P2P energy trading systems can be considered as a record of inputs and outputs of a common-pool resource. Analogous to a dam, the P2P platform supports the accounting for the resources that are added and subtracted from the common pool, rather than managing the direct transaction of physical electrons in the system. This form of P2P energy trading could potentially:

- benefit the prosumers by enabling them to have more control over their excess solar energy and receive a higher return compared to the FiT
- benefit the consumers by offering them more affordable electricity compared to retail tariffs, and transparency on the exact source of the purchased energy
- engage more households on energy issues and assist the transition to a cleaner energy mix

Although P2P energy trading could present many benefits to both prosumers and consumers, there are uncertainties around integrating P2P energy trading to the existing energy system. In addition, it's unclear whether or not P2P energy trading will provide a secure, reliable and cost-effective alternative to the traditional FiTs offered by retailers. Recently, the Australian Government supported the establishment of the RENeW Nexus project in the City of Fremantle Western Australia (WA) to examine the value and efficiency of P2P trading of renewable energy. Working with Power Ledger, the RENeW Nexus project operates a P2P trading platform that connect trial participants, the prosumers, to those who are consumers to transact energy trades according to pre-selected criteria for price and time-of-use.

Supporting the RENeW Nexus project, this report presents the findings from a strategic foresight exercise exploring the possibility of P2P energy trading operating as part of the energy system across WA over the decade.

This report opens with an outline of key trends relating to the changing energy system out to 2030. A 'trend' refers to a pattern of change impacting how energy is generated, distributed and consumed that may reshape the energy sector in the future. Trends can be social, economic, geopolitical, technological or environmental. In this report, the individual trends have been grouped into four overarching themes (Figure 2).

Based on how these trends are likely to play out over the next decade, the second part of the report presents future narratives describing how P2P energy trading may operate in 2030. With these insights, energy consumers, the government, energy and property industries will be able to better navigate the uncertainties around P2P energy trading, and maximise the potential opportunities that this new energy system could bring in the future. The final section of the report briefly explores the implications for community, government and industry organisations.

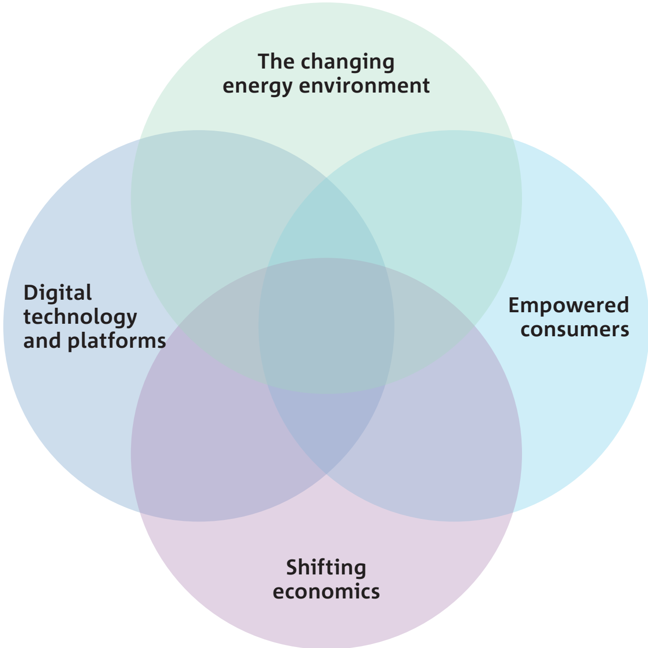


Figure 2. The four main emerging themes relating to the changing energy system out to 2030

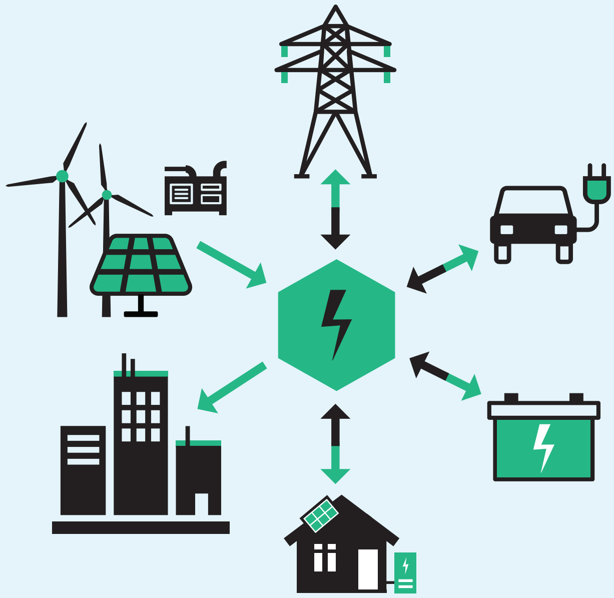
Capturing value from distributed energy resources

Today, prosumers can sell their excess solar energy to their retailer via a flat feed-in tariff (FiT). Across Australia, FiTs vary according to the geographical location of the solar system and the date the system was installed.

Over the past decade, another renewable energy business model has emerged that aggregates distributed energy resources (DER) and packages it into large bundles that can be dispatched to the wholesale market or used to support more efficient functioning of the grid. This aggregation model can be deployed by incumbent retailers or new energy companies. For this approach to work, aggregators must be able to remotely control customer (behind the meter) energy technologies, such as solar PVs and batteries. Some aggregators may also seek to control large energy-consuming devices such as air-conditioners, hot water systems and pool pumps. Controlling these devices enables aggregators to deliver full value for the energy system. For example, aggregators could potentially turn down air-conditioners across thousands of households during peak-demand periods when the grid is under pressure. Additionally, aggregators could unlock solar-battery energy when wholesale market demand (and prices) are high. As wholesale market prices tend not to peak during the middle of the day, when solar PV output is high, energy storage technology will be essential for storing excess electricity generated during the day.[4]

The DER aggregation model is also referred to as virtual power plants (VPPs) because digital technology is used to control huge fleets of devices and coordinate large amounts of DER to deliver a range of services that historically have been performed by large centralised power plants.[4] Some consider VPPs as operating exclusively within the domain of demand management (or demand response), such as turning down energy-consuming devices during a few annual peak demand events when the grid is under pressure. However, as the capacity of residential solar and battery systems increase, aggregators could potentially bundle up residential DER in large enough parcels to trade on the wholesale market. This report assumes that the aggregators (and VPPs) of 2030 will use DER to deliver a 'full value stack', including services that address grid efficiency and the opportunity to bundle and sell 'spare capacity' and renewable energy to wholesale markets.

VPPs are only now being trialled, and regulations are lagging behind the pace of technological and business model innovation. However, the Australian Energy Market Operator is collaborating with other national regulators to develop a VPP demonstration framework, and allow VPPs to establish their capability to deliver the full value stack and inform changes to regulations. The South Australian Government is working to form what could be the world's largest VPP project, starting with a trial including over 1,000 households and aggregating up to 250 megawatts of capacity.[7]



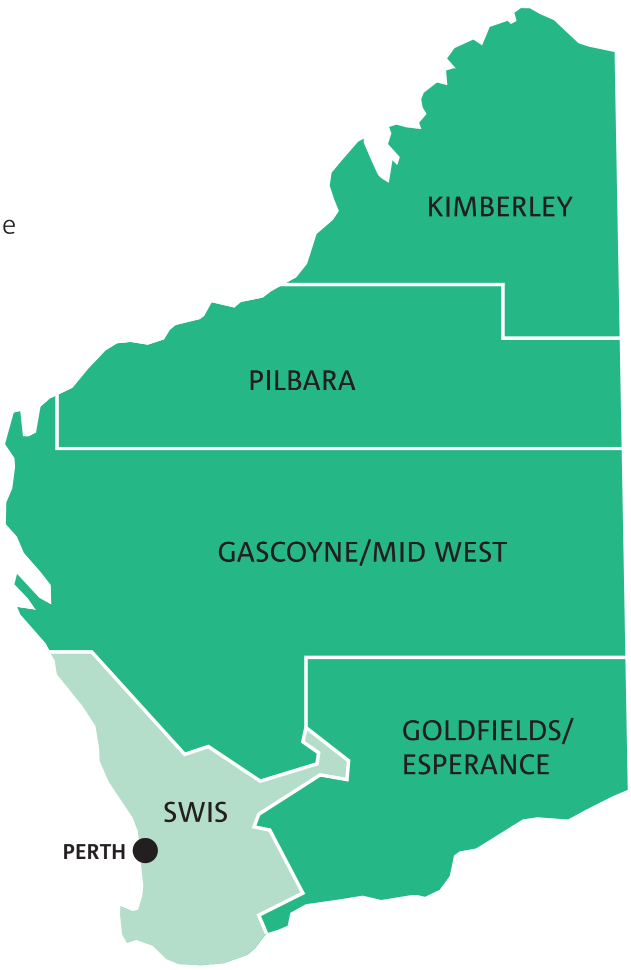
Moving into the future, the overall efficiency of DER is likely to be impacted by urban form and the design of electricity networks. Urban form relates to the density and land use in towns and cities. It determines to what extent locally generated renewable energy can meet local energy demands, and how effectively energy supply and demand can be balanced in local networks.[10] Urban form also determines how effective DER can be integrated into the energy system. For example, low-density residential neighbourhoods with large amounts of roof space have the potential to maximise solar energy production during the day, but lead to excessive supply relative to daytime demand of local consumers. Battery storage could address this issue, but will be costly in the foreseeable future. Alternatively, mixed-use development consist of residential and commercial properties and have the potential to bring together prosumers and consumers to the same local network, and enable more effective balance of energy supply and demand.[11]

CURRENT PROFILE OF **WESTERN AUSTRALIA'S ENERGY SYSTEM**

Disconnected from the National Energy Market, the energy system across Western Australia (WA) is divided into

FIVE GEOGRAPHICAL REGIONS

comprising the South West Interconnected System (SWIS), Goldfields/Esperance, Kimberley, Gascoyne/Mid-West and the Pilbara System.[14]



Around **92%** of Australia's natural gas reserves are located in WA and off the coast of WA.[15]

THE THREE KEY GOVERNMENT-OWNED ELECTRICITY MARKET PLAYERS

across WA are[16]:

Horizon Power
generates, distributes and sells electricity across regional WA outside of the SWIS

Synergy
generates and sells electricity within the SWIS

Western Power
provides transmission and distribution services within the SWIS

Demand for electricity is

HIGHEST DURING SUMMER BETWEEN 4PM AND 8PM,

when most WA residents arrive home and turn on their air-conditioners, TVs, lights and other household appliances.[17]

THE WA ENERGY SECTOR IS HIGHLY REGULATED

by the state government who owns a majority of the energy assets across the state, including generators, transmission and distribution lines, and retail operations.[16,19]

Government regulations ensure that the per kilowatt electricity cost is consistent across the state of WA, currently is

28 CENTS/KWH.[21]

The Western Australian Government is currently developing a

DER ROADMAP

to help efficiently integrate growing levels of DER into the existing energy system.[18]

ACROSS THE SWIS, RESIDENTIAL AND SMALL COMMERCIAL CONSUMERS ARE NON-CONTESTABLE

and are serviced by Synergy. Only large commercial consumers that use over 50-MWh of electricity per year can choose their energy retailer.[20]

In response to rising electricity prices, the Western Australian Government has begun implementing reforms to

REDUCE OVER-PROCUREMENT

of reserve capacity in the SWIS.[22,23]

THE CHANGING ENERGY ENVIRONMENT

Western Australia (WA) has vast renewable energy resources. The state is currently witnessing a dramatic rise in the number of households installing rooftop solar. Advancement in DER technologies have the potential to transform the electricity sector and create opportunities for new P2P business models to emerge.[24] At the same time, increasing frequency and severity of bushfires and storms across WA could potentially impact its energy system in the future.[25] As we move towards 2030, WA is likely to face a number of emerging challenges. Challenges include building grid resilience to mass outages, improving the ability of the grid to cope with the fluctuating nature of solar energy, and addressing environmental issues presented when rooftop solar and battery systems reach their end of life.

Increasing adoption of rooftop solar PV among WA residents. Households and businesses in WA are installing rooftop photovoltaic (PV) systems at record rates. Between 2016 and 2017, there was a 33% increase in the number of Western Australian households with rooftop solar.[26] During the same period, WA was home to 10 of the top 20 solar adopting suburbs in Australia.[26] Today, 27% of households across Perth are generating electricity through rooftop PV.[27] In 2017, these rooftop systems produced almost 50 times the amount of electricity they did a decade earlier (Figure 3).

Ideal conditions for generating solar energy. WA is home to the sunniest capital city in Australia, as well as the sunniest region. The sun shines across the city of Perth for nearly 9 hours on average each day (Figure 4), and across the Western Pilbara region for more than 10 hours a day.[29,30] The vast amount of sunshine across the state makes WA an ideal location for generating large volumes of solar energy. In addition, over 79% of private dwellings in WA are detached houses compared with 73% in the rest of Australia.[31] Perth has the second highest proportion of detached versus strata titles of all Australian capital cities (Figure 5). As it is more straightforward to install rooftop solar on detached homes than on strata title residences, such as apartment blocks, the large proportion of detached homes across WA is likely to drive future growth in rooftop solar.

An increasing need to accommodate two-way flow of electricity across the grid. On sunny days, high levels of electricity can flood the solar system—increasing the amount of solar electricity that is fed into the grid.[34] To prevent electricity surges and blackouts, inverters detect abnormal voltages across the grid and disconnect solar PV systems during times of high voltage. The sunny WA climate, combined with an increasing uptake of rooftop solar across the state, have seen the South West Interconnected System (SWIS) recently experience its lowest point of demand and negative electricity prices in the middle of the day.[35] High penetration of solar in the absence of high consumer demand has the potential to present new challenges for the grid.[35]

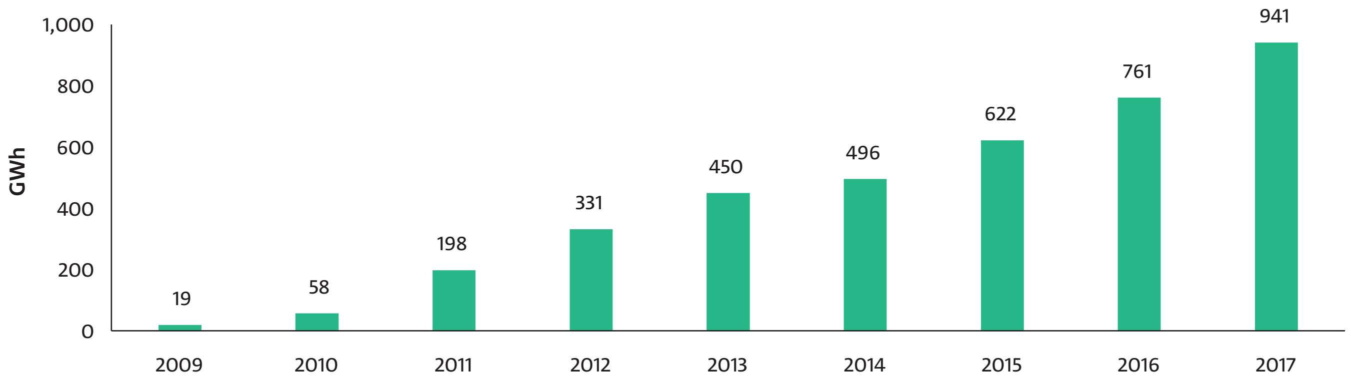


Figure 3. Small-scale solar electricity generation in Western Australia, Australian Energy Statistics[28]

The unpredictable and fluctuating nature of both solar output from DER and customer energy demands creates challenges to maintaining steady voltages in the grid. Moving into the future, effective infrastructure planning and orchestration of DER will be crucial to ensure efficient operation of the energy market. Without a solution, the viability of P2P energy trading may be impacted. If the grid is unable to manage the intermittent and fluctuating nature of solar energy generation efficiently, an increasing number of inverters are likely to disconnect from the grid—leading to large portions of redundant rooftop solar.

Climate change and extreme weather is causing more severe power outages. The frequency, intensity and duration of extreme weather events associated with climate change are likely to increase over the next decade.[36] We're already seeing extreme heat, storms, bushfires and floods occurring with growing intensity and frequency across Australia.[25] Extreme weather is likely to cause damage to the electricity grid—resulting in costly repairs and increasing outages.[25]

WA predominately relies on gas and coal for electricity generation. Despite the increase in the number of households across WA adopting rooftop solar over the last decade, the majority of its electricity is still generated using gas and coal (Figure 6).[28] While the amount of electricity generated from residential solar has been increasing since 2013, the total volume of solar electricity has been only around 3% of the amount produced using natural gas (Figure 6). Consequently, in WA, approximately 19 million tonnes of carbon dioxide are produced each year.[37] Electricity generation currently contributes around 34% of the national carbon dioxide emissions.[28,38] The ongoing reliance on fossil fuels for energy generation across WA and Australia and low volumes of renewable energy shows the system has a long way to go in the transition towards renewable energy dominance.

Changing demand for electricity. The average floor size of an Australian home reached its peak of 245.3m^2 in 2009, and has been slowly declining since then.[39] Over the same period, the introduction of increasingly efficient appliances combined with improvements in the energy efficient homes and uptake of DER have reduced the average household consumption of centrally generated electricity.[40] However, future population growth and rising uptake of energy-intensive technologies are likely to increase household demand for electricity in aggregate over the next decade.[39,40] In the future, lifestyle choices will impact the overall demand for electricity and the availability of renewable energy for a potential

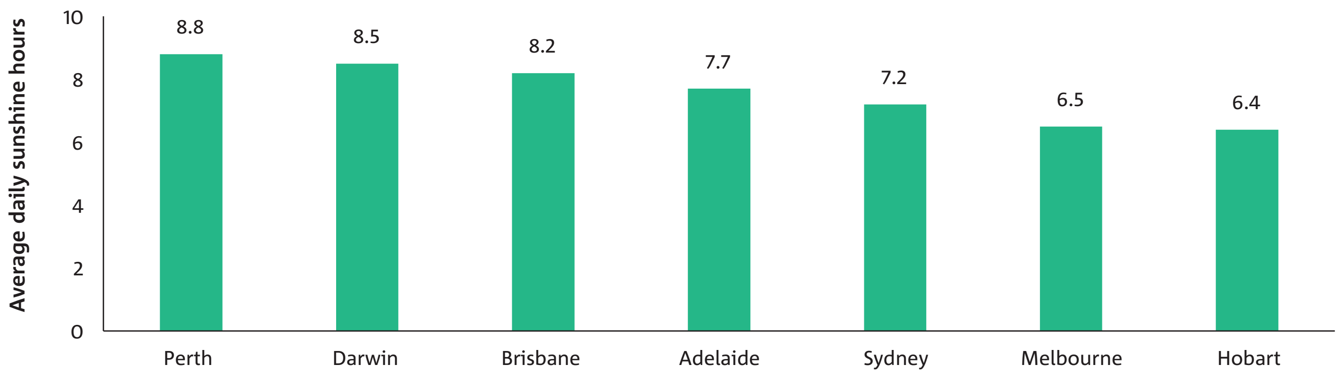


Figure 4. Average daily sunshine in across Australian capital cities[29,30,32]

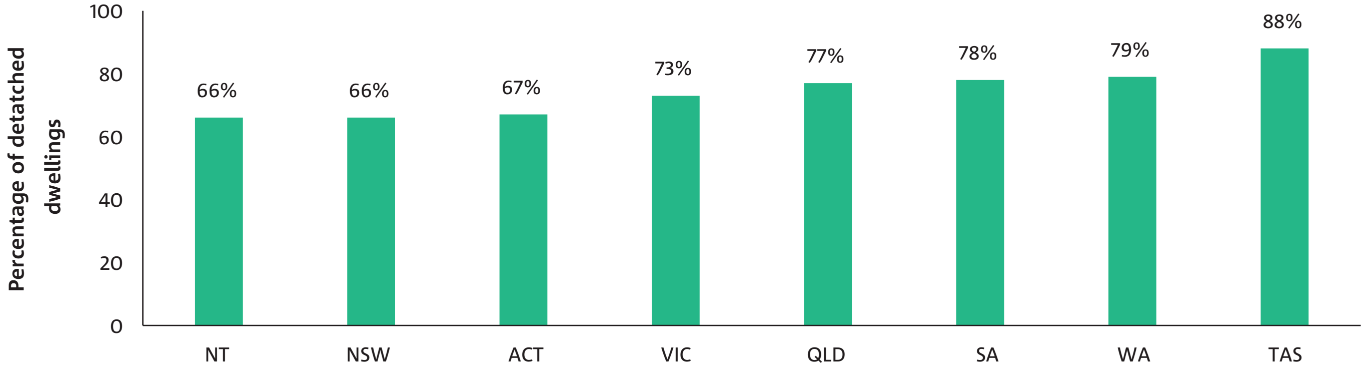


Figure 5. Percentage fully detached dwellings in each Australian state and territory[33]

P2P market. For households generating electricity through rooftop solar, the ability to produce excess electricity for P2P trading will likely depend on their ability to reduce and optimise their own energy consumption.

Uptake of DER across WA has the potential to stimulate employment. Estimates have revealed that it takes over three million solar panels and over 1,000 full time jobs a year to install one gigawatt of capacity.[41] Strategic investments in the development and uptake of green technology and microgrids across WA could potentially create as many as 70,000 jobs in the coming years.[24] Since 2010, the increasing uptake of rooftop solar across the state has created over 900 fulltime jobs each year (Figure 7).[42] Jobs in the areas of design, engineering, procurement, construction, operation and maintenance have all been created with the increasing uptake of solar. Developing and integrating renewable energy resources is likely to create new employment opportunities for those living in WA.

The environmental cost of solar and battery systems. The increasing adoption of DER is likely to contribute to the growing environmental impact of manufacturing and disposing of solar and battery systems. Although DER has the potential to provide energy consumers with a reliable source of clean energy that is 'fuel free', the production of DER is energy intensive.[43] Rooftop solar systems are made from a number of toxic metals and chemicals that could potentially leach into the environment if not disposed of appropriately.[44,45]

Similarly, increasing units of lithium-ion batteries going to landfill are likely to contribute to growing health and environmental challenges. A 2018 report by CSIRO revealed that only 2% of the 3,300 tonnes of waste from lithium-ion batteries generated in Australia in 2016 was actually recycled. In addition, waste from lithium-ion batteries is expected to grow to as much as 100,000 tonnes by 2036.[46] Only a limited number of facilities across Australia are equipped to recycle solar PV panels and lithium-ion batteries. Rooftop solar systems that were installed in the early 2000s will soon be reaching their end of life. Therefore, establishing systematic measures to efficiently reuse and recycle rooftop solar and battery systems will be crucial over the next decade.[47]

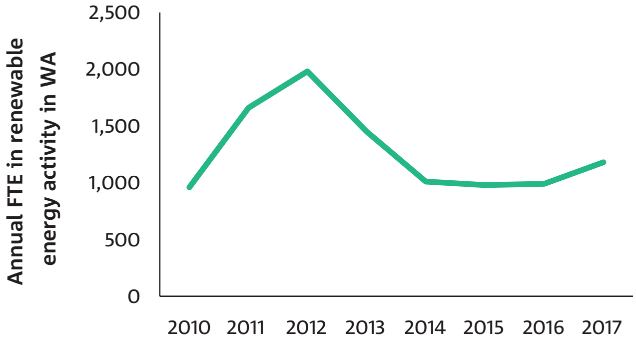


Figure 7. Annual direct full-time employment (FTE) in renewable energy activity in Western Australia[42]

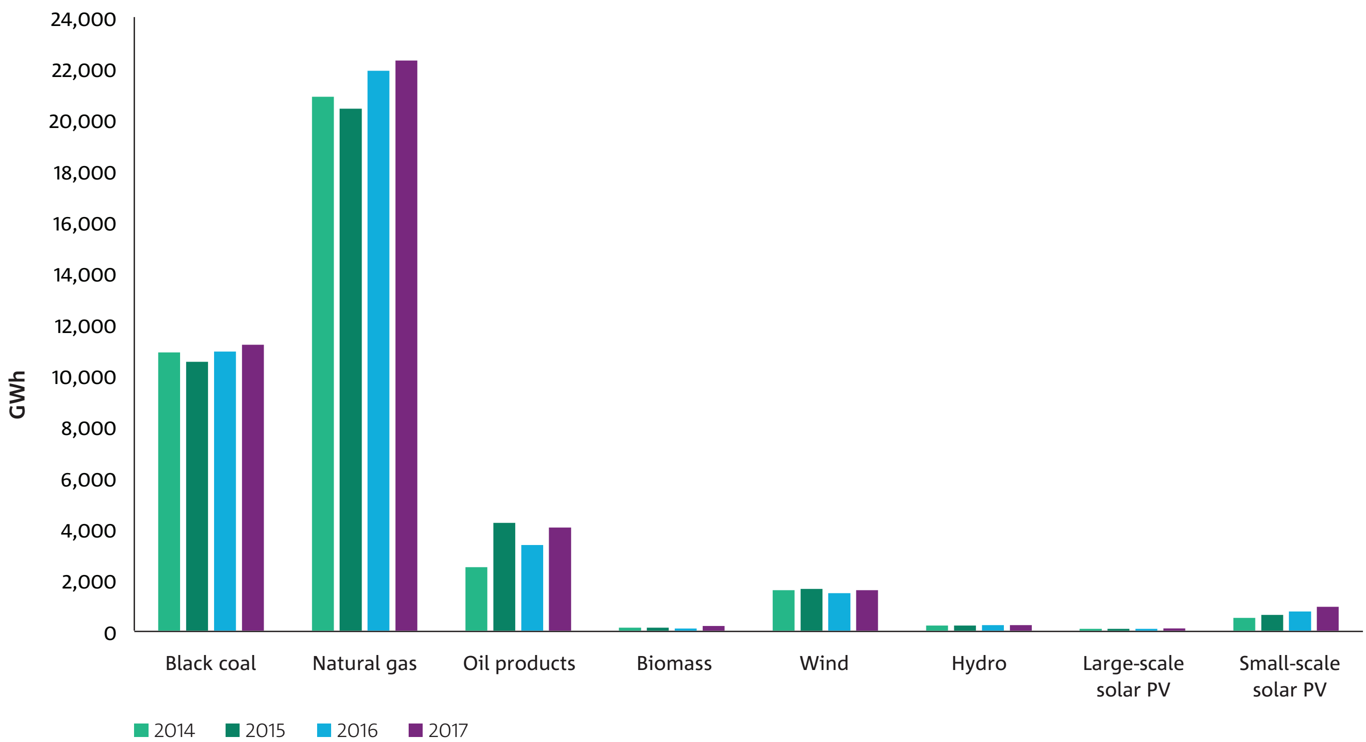


Figure 6. Electricity generation in Western Australia by fuel type 2014 to 2017, Australian Energy Statistics[28]

EMPOWERED CONSUMERS

The profile of energy consumers is evolving. The rise of tech-savvy generations, an aging population, globalisation and urbanisation are seeing shifting consumer values and preferences.[48-50]

Consumer trust in central institutions and energy companies has been declining in recent years, while support for renewable energy and climate action has been strengthening.[51-53] Communities are increasingly seeking to take control of how they generate and consume electricity.[54] They're motivated to take climate action into their own hands and seek new ways to improve the environment for future generations. With expanding work and family demands, a growing number of consumers are actively using P2P platforms to assist them with their day-to-day tasks and responsibilities.[55] Moving into the future, these trends have the potential to drive further development of DER and establish new platforms for trading renewable energy. However, increasing empowerment comes with increasing responsibility, which may overwhelm some consumers.

Changing profile of an 'average energy consumer'. Social changes coupled with accelerating technology development is shifting the profile of future energy consumers. Thus, the 'average energy consumer' in 2030 will differ from today's as they are impacted by emerging features including:

- **The rise of tech-savvy generations**. Digital natives (those born between 1980 and 2000) are the largest consumer group in Australia today.[48] Always connected, they are increasingly reliant on social media and tend to purchase more digital content than previous generations.[56,57] Over the next decade, tech-savvy generations are likely to seek new technology and business solutions for managing their energy consumption and generation, including P2P energy trading.
- **An aging population widening the digital divide.** The proportion of people aged 65 years and over has been steadily increasing in Australia over the past century, from 1 in 25 people in 1911 to 1 in every 6 people in 2016.[50] A growing aging population could potentially deepen the digital divide in the Australian population.[58] In addition, as new technology solutions for managing energy consumption and generation may not be accessible in older households, energy affordability may become a growing concern for them in the future.
- **New business models changing the way people work.** Increasing reliance on the internet for work is likely to see an increasing proportion of WA households and businesses adopting new employment and business models, including freelancing and co-working.[59] An increasingly mobile and dispersed workforce could require new approaches to demand management and infrastructure development from energy system operators in the future.
- **Personal time being valued over money.** Over 40% of Australians are feeling rushed and pressed for time. Compared to other OECD countries, Australia is ranked 33rd out of 38 on the amount of time we devote to leisure and personal care.[60,61] Therefore, time is being viewed as an increasingly precious commodity. Businesses are adapting to these shifts in attitude by providing user-friendly platforms for people to outsource jobs and tasks.[62]

Awareness of the energy system and consumption patterns varying among consumers. While many Australians hold environmentally conscious opinions and adopt DER, many still appear disengaged from the energy system. Studies of energy usage practices show high variability among energy consumers. In some cases, houses rated with high energy efficiency can perform worse than those rated less efficient.[63] These findings suggest that even within the optimal energy efficient environment, consumer understanding of how to effectively lower their power usage and their motivation to do so appear low.[63] A recent national survey of energy consumers revealed that only about three in five households were confident in making decisions about energy products and services, and about half were confident that there was easy-to-understand information about energy products and services.[64] Without adequate, accessible and practical information relating to smart use of energy, it may be difficult for some households with solar PV to ensure surplus energy is produced and available when needed.

Deteriorating trust in the power industry. Trust in traditional institutions has declined since the Global Financial Crisis, fuelled by many factors such as globalisation, technological change, the rise of the P2P economy and income inequality.[65,66] A 2018 global survey revealed that Australia was one of 20 countries classified as 'distrusters'.[67] The power industry is the least trusted by Australians—behind banking, mining and media.[51,52] According to the 2018 Edelman Trust Barometer, Australians' trust in the energy sector slipped around 11% from the year before.[52] For those living in regional Australia, the issue stems from the monopoly on energy supply in those areas.[68] Similarly, a recent Australian Energy Market Commission survey showed that customer satisfaction among small business owners was at the lowest level since the survey began in 2014. Almost half of those surveyed indicated they are dissatisfied with their electricity provider.[69] Another national consumer survey found that Australians are particularly concerned about value for money, and are not confident that the energy market is working in their interests.[64] Deteriorating trust in power companies and the mainstream energy market is likely to continue driving adoption of small-scale energy generation and storage, as well as potentially driving interest in alternatives to traditional intermediaries such as P2P energy trading.

Increasing consumer demand for personalised services. Consumer expectation for personalised services is growing.[70] According to a survey across 21 countries (including Australia), more than half of the respondents indicated that they are willing to share their personal data with their energy providers in exchange for more personalised services addressing their unique energy needs. In addition, the majority of the respondents revealed their desire to purchase personalised utility services or products if these services were made available.[71] An increase in the availability of data could potentially enable new data-driven energy business models to emerge, including services that facilitate sharing of excess electricity between peers. In addition, with data, energy suppliers will be able to inform their customers about their consumption patterns, and provide them with potential recommendations for saving energy. Progressing into the future, it's likely that existing energy companies will increasingly transform into data-driven businesses.

Increasing power of choice among energy consumers. Establishing new business models that both shape and cater to customer expectations for greater choice and control have the potential to rapidly disrupt existing industries, including those across the energy sector.[72] For example, a growing number of energy consumers are choosing to generate their own electricity via rooftop solar. In addition, new companies that allow customers to buy prepaid 'power packs' of renewable energy have the potential to change the way we generate and distribute energy.[73,74] It's likely that the existing model of unidirectional generation and consumption will increasingly transition to a disrupted energy landscape with numerous energy products and services available, and a blurring line between energy consumer and producer.

Stronger support for climate change action. A 2018 survey of 1,756 Australian adults found that more Australians believe anthropogenic climate change is occurring (Figure 8), with 73% expressing serious concern over its impact.[53] The same survey showed that over two-thirds of Australians support the phasing out of fossil fuels and substituting them with clean energy.[53,75] These findings show strong public support for all levels of government to focus strongly on energy issues, and develop effective and efficient pathways for transitioning to renewables. Public support for renewables across Australia is likely to influence decision-making in government and industry in the future. Growing support for climate action is likely to contribute to the adoption of small-scale renewables and battery systems, especially if consumers are not seeing enough action from government or industry.

Bottom-up community action on the rise. More communities are exploring ways to support a cleaner and more affordable energy system. Community action ranges from practical decarbonising strategies and projects advocated by Transition Towns, through to political campaigning promoted by global networks like 350.org. Since inception in 2006, Transition Towns, a movement of communities coming together to engage in sustainability projects, has grown to almost 1,000 registered community initiatives in over 50 countries, with potentially many more that are unregistered.[76] According to advocacy group Community Power Agency, over 100 community energy projects are active across Australia.[77] Over two-thirds of these are in regional areas, including Denmark and Geraldton in WA.[77] Such community action is likely to drive different social values around developing and sharing local energy assets and resources.

Booming P2P sharing movement. The P2P economy is estimated to grow to around AU$446 billion by 2025 (from AU$15.5 billion in 2014).[55] Digital platforms have the capacity to decentralise economic activity, connect peers directly for communication, and trade and share underutilised resources. The P2P or 'sharing' economy is bringing economic activity a step closer toward decentralisation—with greater convenience, lower barriers to entry, and higher mobility and efficiency. In May 2017, Uber completed its five billionth ride.[78] From the first Australian Uber ride in 2012, Australians have used the service in 614 cities across 80 countries.[78,79] In addition, P2P sharing has extended to business-to-business processes, including energy, logistics, storage, delivery and workspaces.[80-82] Popular marketplaces such as Freelancer, Upwork, Kaggle, Etsy and Madeit allow users to both outsource tasks as well as connect with sellers for a wide range of products and services. A survey of global electricity, oil and gas companies, technology providers and start-ups revealed that around 45% are trialling P2P projects aimed towards grid optimisation.[83] There are various drivers accelerating the rise of the sharing economy, and growth in online markets and digital platforms in particular. In addition, the desire to more efficiently use resources and collaborate with others is also accelerating the sharing economy.[84] Over the next decade, an accelerating P2P sharing economy has the potential to establish new ways for residential generators to exchange electricity.

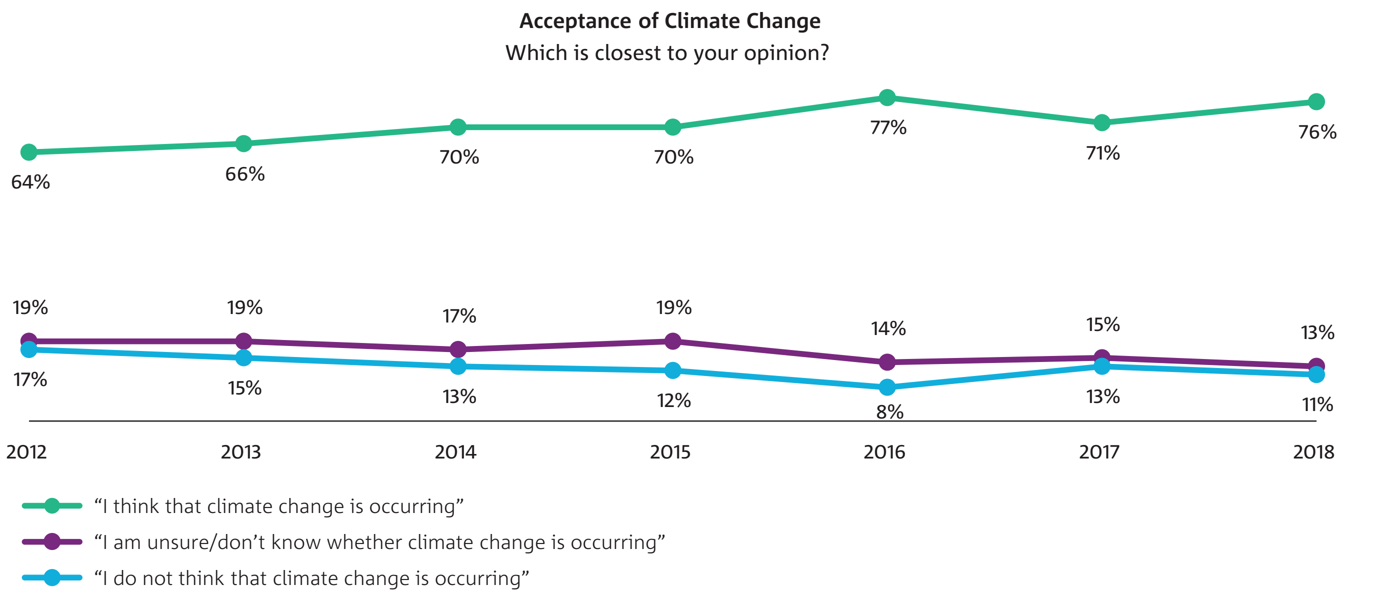


Figure 8. Acceptance of Climate Change, Climate of the Nation 2018[53]

SHIFTING ECONOMICS

The cost of solar PV has been declining rapidly over the last decade—fuelling a distributed energy revolution.[85,86] This trend is likely to continue as grid electricity prices remain high or continue to rise. While government incentives to install rooftop solar, in the form of subsidised FiTs, enable owners of rooftop solar to earn a good return on their excess solar electricity, P2P energy trading could provide end users an alternative to FiTs in the future. The increasing cost of electricity is becoming a sensitive political issue, with concerns relating to its impact on the Australian economy and our ability to compete globally.[87,88] Political uncertainty over energy and climate change policy may hamper the transition to a clean energy future.

Declining cost of renewable energy. Increasing efficiency and affordability of rooftop solar has enabled widespread adoption of DER that was not economically feasible a decade ago.[85] The generation cost of electricity using solar across its lifespan dropped a whopping 73% between 2010 and 2017, and has become comparable to the cost of fossil-fuel generated electricity (Figure 9).[89] At the same time, new developments are being made to address issues relating to battery efficiency and safety as well as regulatory barriers.[90] At present, the cost of lithium-ion batteries has hit a plateau due to commodity cost increases and supply chain constraints. Nevertheless, recent years have seen battery costs decline substantially, with prices falling by 79% from 2010, and a further 54% expected by 2030.[91-95] Because renewable energy sources are intermittent and rely on weather conditions, battery storage is likely to become an increasingly important tool for aiding the uptake and integration of renewable energy in the future.[90,96] In addition, the decreasing cost of renewables is likely to stimulate household adoption of rooftop solar and battery systems. Rooftop solar systems, combined with batteries, have the potential to present new opportunities for energy consumers to become generators and supply electricity to the P2P trading market in the future.[97]

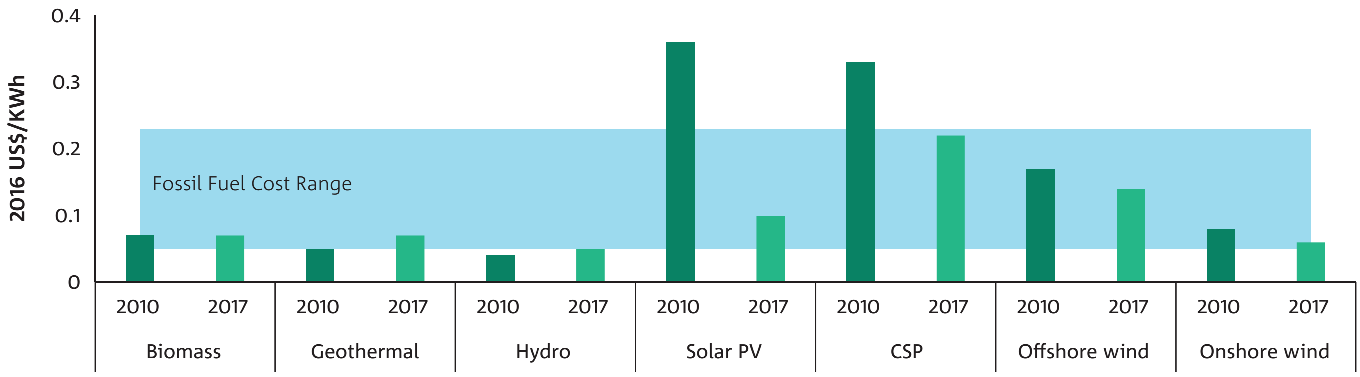


Figure 9. Global levelised cost of electricity from utility-scale renewable power generation technologies, 2010 to 2017 (CSP: concentrated solar power)[89]

Note: Levelised Cost of Energy refers to the unit-cost of electricity over the lifetime of a generation asset

Increasing costs for maintaining grid infrastructure. The cost of electricity only forms a small portion of the average residential electricity bill. Almost half of the amount charged for residential electricity across WA goes towards maintaining and upgrading its electricity network.[98] Across Australia, estimates indicate that these costs are likely to increase in the future.[99] Increasing network costs are likely to be required to replace aging infrastructure. In addition, resources may also be needed to support network upgrades for managing increasing future peak demand and standards of reliability.[100] Although trading electricity between peers may provide more control over electricity prices, it will have no impact on the bulk of the costs associated with providing electricity to properties.

Increasing electricity costs straining Australian households. The cost of electricity has been growing across all states of Australia over the past couple of decades.[101] The retail cost of electricity in WA is set by its state government.[102] Prior to around 2012, electricity prices across Perth were growing in line with or below the consumer price index (Figure 10). However, the yearly cost of electricity across Perth surpassed the overall increase in consumer index from around 2012.[103] In addition, estimates indicate that electricity costs across WA are likely to increase by a further 9% by 2020—driven by increasing network costs, and coal and gas prices.[98] Over the next decade, the rising cost of electricity is likely to present future financial challenges for lower income households who are struggling to keep up with the increasing cost of living.[104]

The changing nature of FiT incentives. Feed-in tariffs (FiTs) are variable depending on the geographical location of a given rooftop solar system and date it was installed. The Feed-in Tariff Scheme was made available to eligible Western Australian households who installed solar between 2010 and 2011.[106] Households that signed up for the Feed-in Tariff Scheme during the first year received an energy buy back rate of AU$0.40/kWh, while those who signed up in 2011 received AU$0.20/kWh for their excess solar electricity.[106] The generous buyback rates offered to those who signed up for the scheme are valid for a ten-year period and due to expire in August 2021.[106] Extending from the Feed-in Tariff Scheme, households installing rooftop solar are now eligible for the new Renewable Energy Buyback Scheme that has no expiry date. Although less attractive than the initial buy back rate of AU$0.40/kWh, the Renewable Energy Buyback Scheme offers SWIS customers a generous rate of AU$0.07135/kWh for their excess solar electricity.[21,107] In the more remote WA regions outside the SWIS that are serviced by Horizon Power, the buyback rates can vary from AU$0.0714/kWh to AU$0.5055/kWh.[108] Over the next decade, uncertainties around FiT incentives may motivate residential generators to seek out new platforms for selling their excess solar electricity.

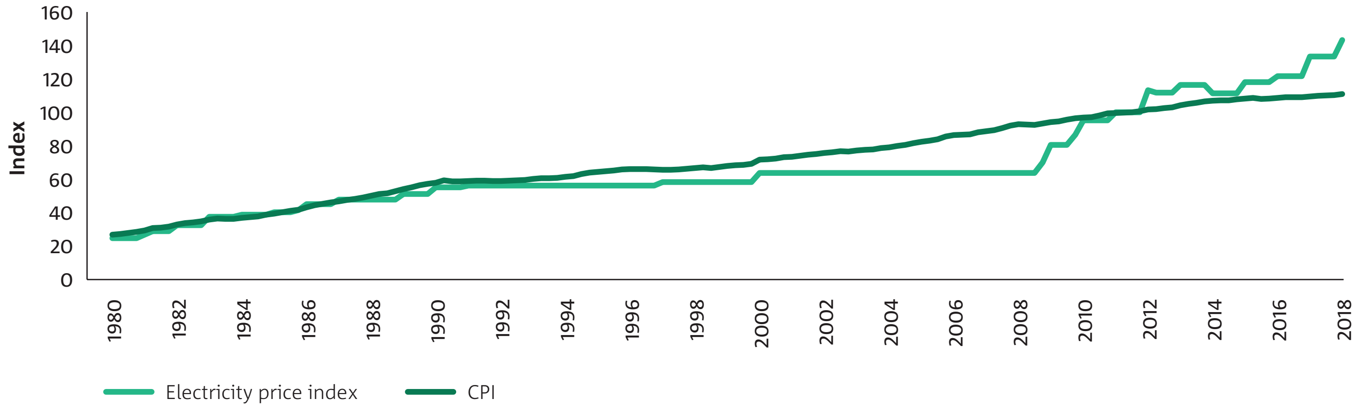


Figure 10. Perth's consumer price index vs. Perth's electricity index, 1999–2018[105]

Note: consumer price index measures changes in the price of consumer goods and services. The electricity index measures changes in electricity prices.

Decreasing government subsidies. Western Australia is the largest state in Australia by land area with more than 2.5 million square kilometres.[109] State-owned Horizon Power services around 50,000 energy customers over approximately 2.3 million square kilometres of regional WA.[110,111] Regardless of the true cost of providing electricity to the sparsely populated communities across WA, government regulations ensure that residents pay no more than AU$0.28 for a kilowatt hour of electricity. The extra costs for providing electricity to those living in remote regions of WA are covered through the Tariff Equalisation Contribution supported by network charges in the SWIS, as well as state government subsidies worth around AU$195 million for 2019.[110,112] The SWIS services around 900,000 households and 90,000 businesses in a smaller geographic region that includes the Perth metropolitan area.[113] Although the state government subsidy known as the Tariff Adjustment Payment has been offsetting the high cost of electricity across the SWIS, the value of this subsidy decreased from around AU$510 million in 2014 to around AU$140 million in 2018, and will drop to zero by the end of 2019 (Figure 11). With cuts to state government subsidies, it's likely that electricity operators will need to find new ways to work more efficiently, and introduce more cost-reflective electricity prices in the future. As the majority of the operating costs are fixed and cannot be readily reduced, energy businesses could streamline services in the future by integrating new digital tools including demand-management technologies to the existing network.

An uncertain political environment. Over the past decade, commentary on the development and implementation of energy policies in Australia has indicated significant uncertainty. Climate change and energy policy have become a subject of political debate with policy swings reflecting changes of governments and Prime Ministers within parliamentary terms.[115,116] As part of the National Energy Market, the National Energy Guarantee was developed by the coalition government to address emission targets. However, it was then abandoned, a decision attributed to the possibility that a Labor government may increase its flexible targets in the event they win government at the next federal election.[117,118] The past volatile political environment surrounding energy policy suggests that there is a high risk of future energy policies also becoming subject to political disagreements. This volatility can be seen in the now scrapped carbon tax policy (introduced in 2012 and then repealed in July 2014), which was based on the 2009 Carbon Pollution Reduction Scheme and the 2011 Clean Energy Future policy proposals.[119] In addition, there have also been political disputes over renewable energy targets, which in 2014 led claims of a temporary drop in investment in renewables.[120] The McGowan Government's announcement to develop a DER roadmap for integrating DER into the existing energy system has been perceived as a positive step towards establishing a more coordinated system for the future.[121]

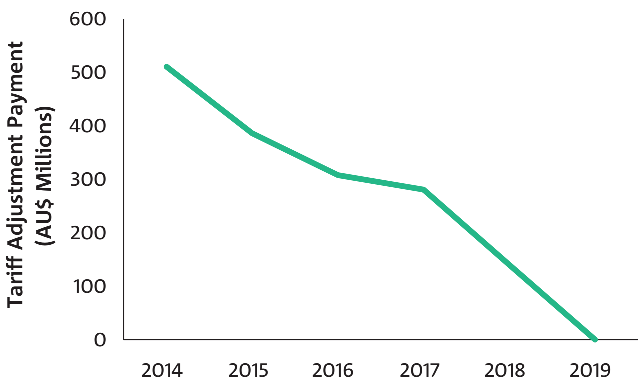


Figure 11. Yearly reduction in Tariff Adjustment Payments from the Western Australian Government to Synergy[114]

High electricity prices impacting global competitiveness. The World Economic Forum's latest Global Risks Report revealed that the cost of electricity is the number one concern for Australian businesses.[122] Since 2008, the growth in the price of electricity across Australia was steeper than that of the national consumer price index (Figure 12).[105] The increasing cost of electricity has contributed to the closure of a number of small businesses across Australia.[123] Moving into the future, the increasing cost of electricity is likely to pose further challenges to Australian businesses and their ability to compete globally, particularly those among energy intensive industries such as manufacturing.[124] In an effort to bring down electricity prices in Australia, Sanjeev Gupta from SIMEC ZEN Energy is building a 280 megawatt solar farm in South Australia with the capacity to generate around 600 gigawatt hours of electricity per year—enough to power nearly 100,000 households across South Australia.[125] As we move towards 2030, increasing challenges for Australian businesses to compete internationally may prompt governments to intensify their investment and support for large- and small-scale renewables.

Growing social inequity and mortgage stress. Over the past decade, household income has become more unequal in Australia, as it has in most other OECD countries.[126] There has been disproportionate income growth between poor and wealthy households in Australia, with the lowest quintile seeing just over 25% growth between 2004 and 2014, compared to over 40% for the highest quintile.[127] Recent estimates of energy poverty in Australia, where household expenditure on energy is more than 10% of income, suggest that 1% of Australians fall within this category. In addition, three million (or about 1 in 8) Australians live below the poverty line (50% of median income).[128] Therefore, future vulnerability to increasing energy prices could be substantial. A 2018 large-scale survey by Roy Morgan revealed that over 20% of Australian households are experiencing mortgage stress, with Sydney and WA residents most affected.[129] In addition, Western Australians are making more calls per capita to the National Debt Helpline than residents in any other state.[130] As battery storage options become more efficient and affordable, affluent households may be able to cost-effectively leave the grid—leaving fewer market customers to support the energy infrastructure. Solutions that provide incentives for households with rooftop solar to remain on the grid, such as P2P energy trading, could help reduce the impacts of grid defection on households that cannot afford the upfront costs of solar.

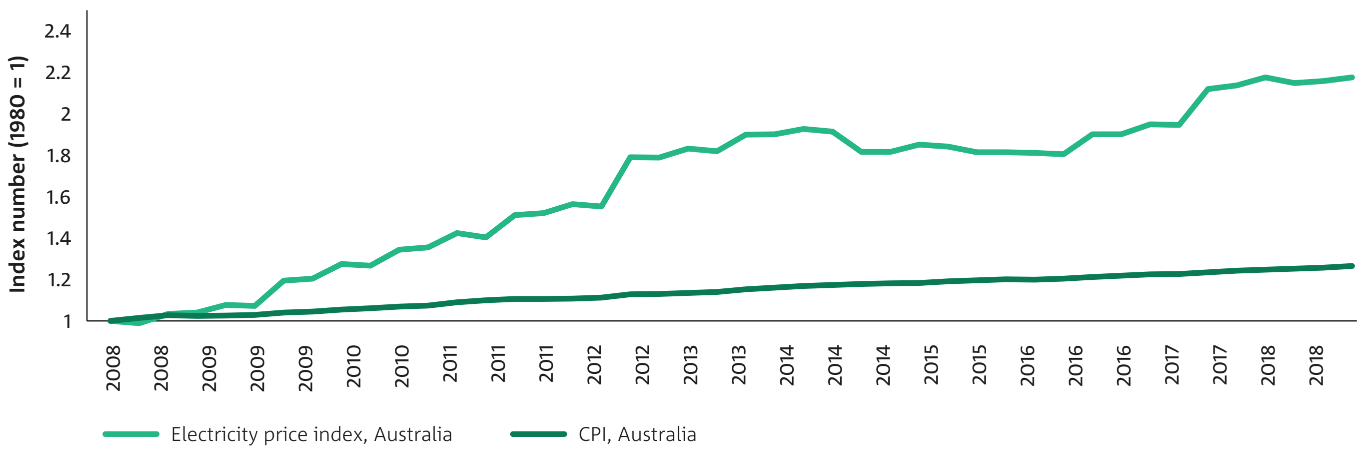


Figure 12. Consumer price index of electricity prices for Perth and Australia compared with overall CPI for Australia since 2008[105]


SMART
HOME

DIGITAL TECHNOLOGY AND PLATFORMS

New digital technologies are transforming industries across WA. Readily available and powerful mobile devices are enabling consumers to access platform marketplaces accompanied by seamless transactions. Behind the scenes are IoT, blockchain, AI and a symphony of other digital technologies. The future of energy will be dynamic, as more supply and demand data become available, and powerful new software is developed to manage that data.[131-135] More data means a larger amount of DER could potentially be integrated into the existing grid and improve the overall performance of the energy system. Over the next decade, smart-grid technologies could become increasingly essential in supporting DER for energy trading among consumers and ensuring grid reliability.

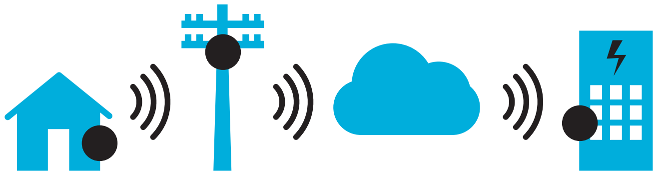
A growing need for establishing micro-grids across WA. Around the world, an increasing number of people are moving from rural to urban areas.[136] As urbanisation accelerates over the next decades, it's likely that more than two and a half billion people will be added to the population living in urban areas—representing 68% of the global population.[136] In line with this global trend, WA is experiencing increasing urbanisation with the metropolitan footprint of Perth expanding to more than twice the size of Tokyo.[137,138] With increasing urbanisation, new technology solutions will be needed to help augment the growth in demand on existing network infrastructure, as well as ensure the provision of affordable, reliable and sustainable energy services to those who remain living in regional WA. Micro-grids can be a cost-effective solution for delivering energy to those living at the 'fringe of grid', as well as those living in sparsely populated regional towns and remote communities across WA.[139,140]

WHAT IS A MICRO-GRID?

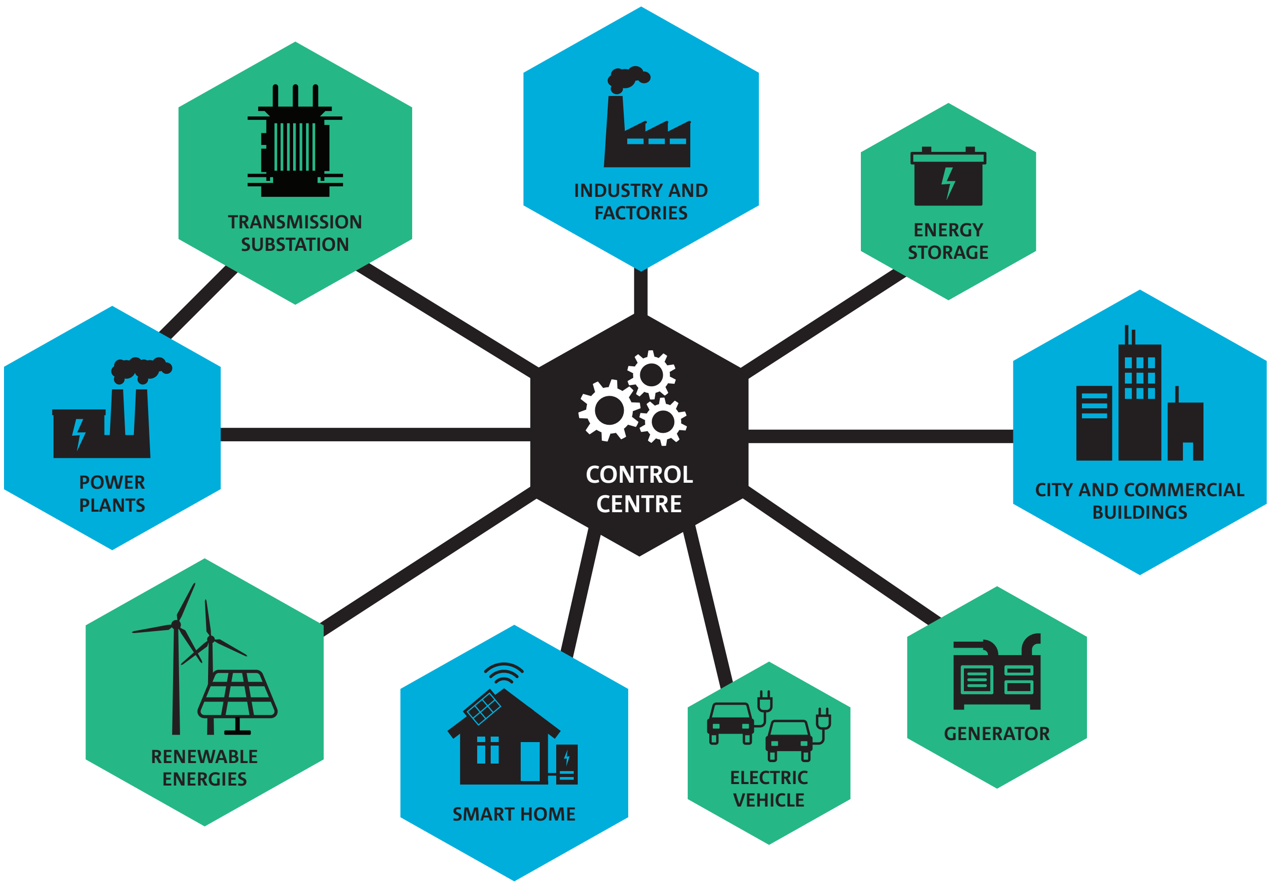
Micro-grids are small-scale autonomous electricity distribution systems.[2] Micro-grids can work independently from the grid, or be connected to the main grid. Supported predominantly by renewable wind and solar energy resources, micro-grids can contribute substantially towards achieving global emissions reduction goals while addressing consumer concerns about the environment. In addition, micro-grids can protect the end user against ongoing vulnerabilities in the traditional grid.

Smart-grids can help manage peak demand. Smart-grid technologies have the capacity to provide fine-grained and real-time visibility of energy consumption.[132-135] Smart-grid trials are being run across Victoria, NSW and South Australia, incentivising households and businesses to cut their power consumption during periods of peak demand.[141] Collectively, these trials are worth AU$36 million and are expected to deliver 200 megawatts of electricity by 2020, with 143 megawatts available in the first year.[141] Origin Energy is partnering with Tempus Energy and using AI to manage energy demand and usage across commercial and industrial customers in South Australia. This project uses a cloud-based software platform that connects energy consumers to renewable assets, and remotely adjusts consumption during peak demand periods.[142] Advancement in smart-grid technologies could improve grid performance and support higher penetration of renewable energy, including small-scale systems.[143] Over the next decade, smart-grid technologies are likely to become an essential ingredient in making DER more readily available for trading among energy consumers, while also ensuring grid reliability.

HOW DOES AMI WORK?



Advanced metering infrastructure (AMI) refers to an integrated system of smart meters connected to communications networks that enables a two-way dialog between utilities and their customers.[1] Well integrated AMI enables grid operators to remotely measure consumer electricity use, connect and disconnect energy service, detect tampering, isolate outages and monitor voltage.[3] Working with smart home technologies, AMI can assist utilities to better communicate with their customers and offer them new personalised services tailored to their unique needs and wants. However, challenges relating to mass deployment of smart meters could substantially damage early public perception of AMI. Adequate evaluation of upfront costs to energy consumers, active consumer engagement and effective governance will be crucial to ensure successful integration of AMI.[5]



Digitisation and disruption. Over the past 30 years, costs associated with computing power, data storage and internet bandwidth have dropped dramatically—exceeding the rate of previous technological advances such as electricity and telephony (Figure 13).[144,145] This trend is creating new opportunities for innovation and digital businesses. Moving into the future, advancement in digital technologies, including AI, IoT and blockchain, is likely to establish new applications in the energy system, and disrupt existing operations and practices. Together with advanced metering infrastructure (AMI), these technologies could potentially enable the management of complex P2P trading systems. However, the current ability of energy companies to receive and use the granular data that can be generated by AMI is limited. Over the next decade, the true potential of new technologies will only be realised by integrating accurate and secure data management systems, powerful but affordable computing, fast and reliable internet connection, broad consumer engagement and effective management of cybersecurity risks.

Increasing internet connectivity opens up opportunities for establishing new energy services. Between 1993 and 2016, the global share of internet users grew from 0.3% to around 50%.[146] In the financial year ending in 2017, around 88% of households in WA were connected to the internet—higher than the national average (Figure 14).[147] Increasing internet usage and connectivity is enabling further digitisation of energy-related operations across the sector. For example, emerging digital solutions, including P2P sharing platforms rely heavily on the internet to operate. However, digital connectivity across Australia is falling behind global standards. In 2017, the average internet connection speed in Australia was ranked 50th in the world (down from 39th in 2012), and is falling behind a number of other Asia-Pacific countries including South Korea, Hong Kong, Singapore, Japan, Taiwan, Thailand and New Zealand (Figure 15).[148,149] Over the next

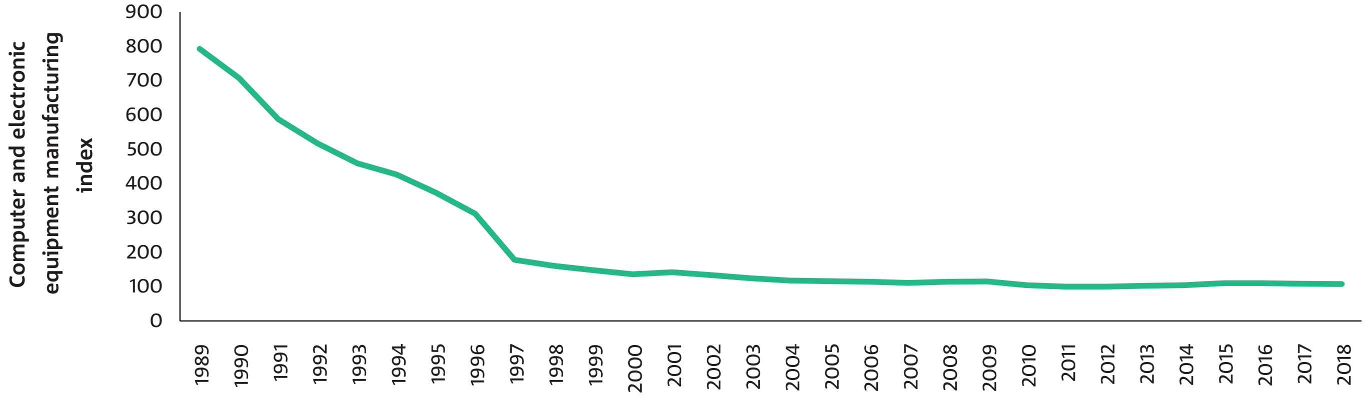


Figure 13. The computer and electronic equipment manufacturing index[144,145]

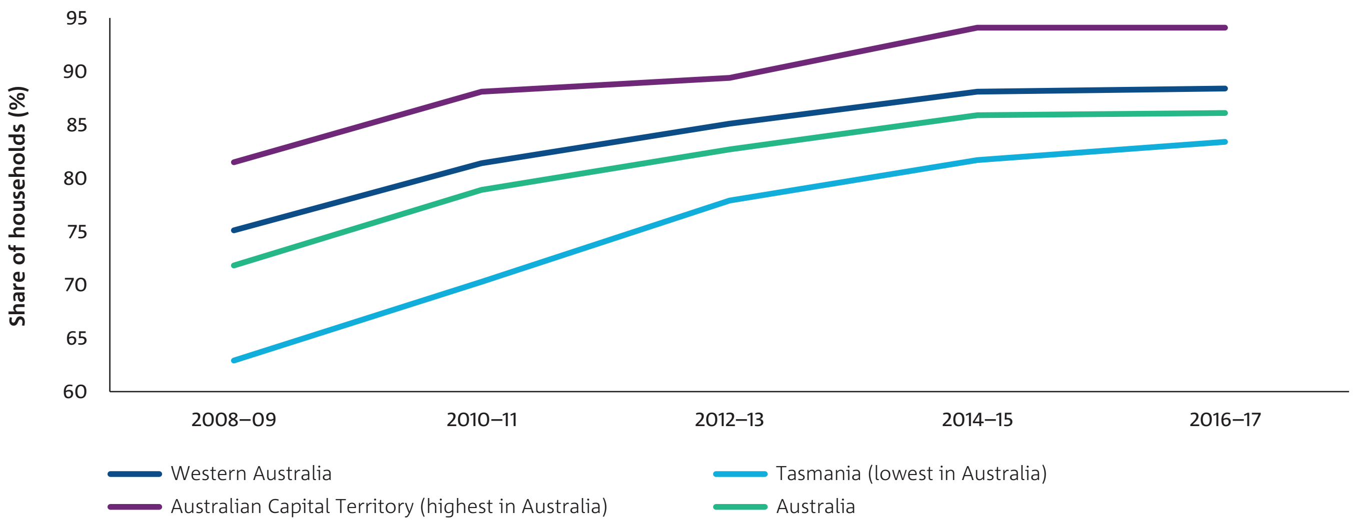


Figure 14. Share of households with internet access at home[147]

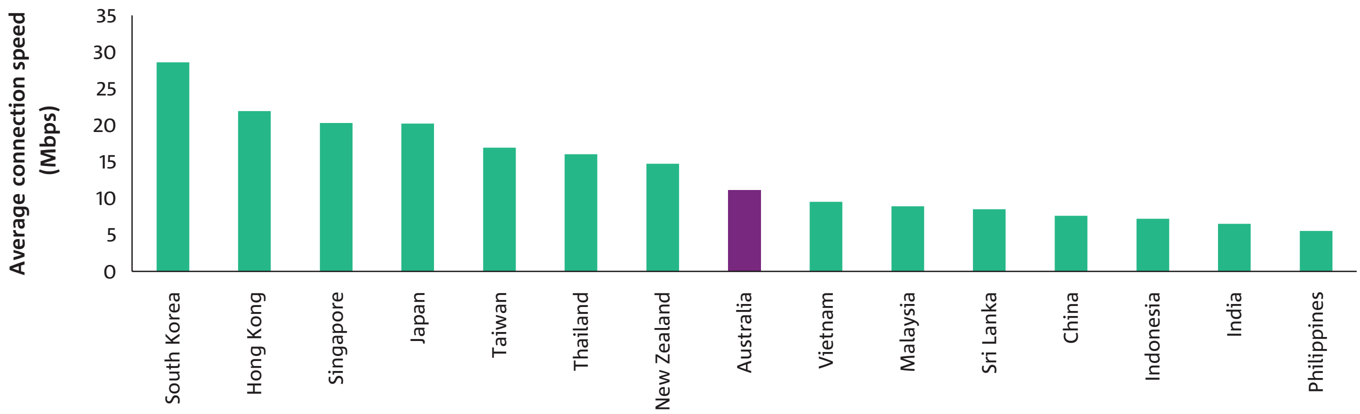


Figure 15. Average internet connection speed across Asia–Pacific countries in 2017[149]

decade, available, reliable and affordable internet across Australia will be essential to establish new operations in the energy sector, including the roll out and integration of AMI to the existing energy system. In addition, infrastructure bottlenecks, cybersecurity and privacy of online systems are likely to pose increasing risks and challenges to the rapidly digitising energy system.[149]

A growing volume of data. Data volumes can vary widely from a smart building generating around 250 gigabytes per day, to only around 400 megabytes over a whole year from a single household meter.[131] When integrated into the existing energy grid and networks, big data can be valuable for understanding patterns of energy demand, optimising resources, and enhancing asset use and reliability. Over the next decade, an increasing volume of data and demand for electricity is likely to be associated with advancement in renewable technologies, such as smart home devices, rooftop solar, electric vehicles and smart meters.

Blockchain technology is advancing. Although blockchain technology is still in its early stages of development, it's addressing challenges relating to scalability, energy efficiency and memory. Blockchain solutions are dealing with scalability issues of throughput (e.g. Bitcoin's low processing capacity of up to seven transactions per second) and required computational power. For example, SegWit, an update to the Bitcoin Core software, increased transaction throughput by around 40%.[150] In addition, throughput of new blockchain systems is also rapidly increasing. The Australian Red Belly Blockchain can now handle 660,000 transactions per second on 300 machines, compared to 2,000 transactions per second globally on the VISA network (Figure 16).[151,152] P2P energy trading platforms, including Power Ledger, LO3 Energy and EWF, use Ethereum to process their online transactions. As new layer scaling solutions are developed the implemented, the capacity of Ethereum is expected to grow to processing one million transactions every second.[153,154] Over the next decade, blockchain technology has the potential to support DER, through accurately reconciling P2P trading of electricity as a system where energy prosumers can sell their excess solar energy to consumers via smart contracts.

Increasing vulnerabilities. Accelerating digitisation and connectivity across the energy sector have the potential to introduce new cyber-security risks in the future. Cybersecurity is already a priority for energy companies. A survey of executives from the energy and utilities sector revealed that business interruption from cyber-attack is ranked as one of the top organisational risks.[161] In 2015, hackers gained access to confidential energy generation and distribution data of the NSW Department of Resources and Energy.[162] In particular, large centralised infrastructure assets are vulnerable to 'domino effect' damages.[162]

Blockchain technology is decentralised and thereby offers greater protection against hacking and fraud. However, advances in blockchain technology are likely to attract more users in the future, which in turn may increase different types of cybersecurity breaches where attacks on users' wallets become increasingly common.[163] If adopted, solutions in P2P energy trading could potentially pose new cybersecurity challenges to the energy system.

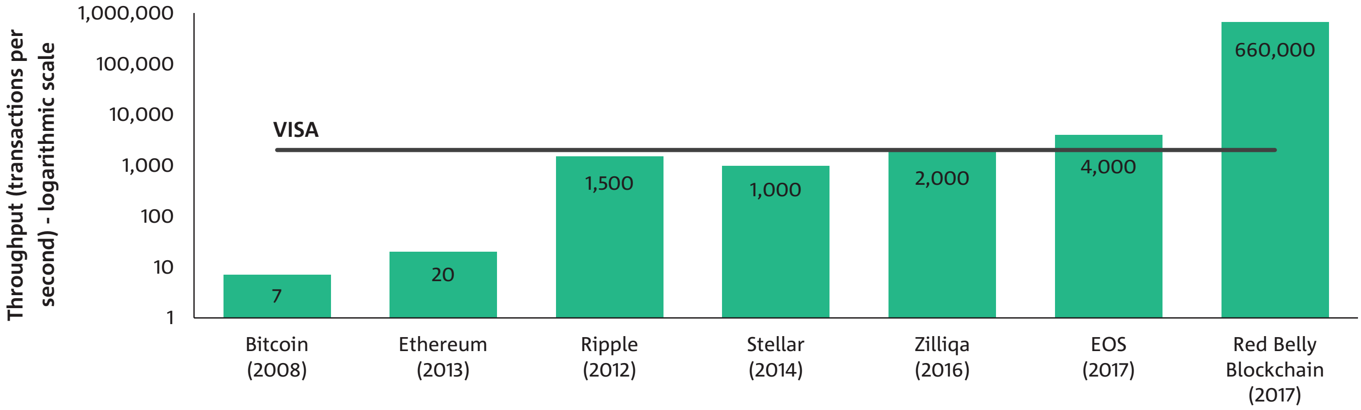


Figure 16. Transaction volumes per second for major blockchain platforms[155-160]

THE SCENARIOS

Key trends from the previous section help to identify the forces impacting on DER availability and utilisation, with related implications for P2P energy trading as one method for creating financial value from DER. However, the trends data is historic and can only signpost possible impacts in the near to medium term. Looking beyond this time frame to the year 2030 brings uncertainty as to how these shaping factors might develop. Therefore, to analyse the longer term requires the consideration of multiple alternative futures for DER and P2P trading. The aim is to prompt strategic thinking and conversations about implications, particularly for the end users of the system.

This section describes four plausible scenarios for the future of P2P energy trading in 2030. The scenario model sets P2P trading in the context of other approaches to managing and monetising DER. Scenarios are evidence-based narratives about the future at a set point in time, and represent an estimation of how the identified trends are likely to unfold over this time frame. Because the future is uncertain and unpredictable, we need to consider multiple plausible scenarios. The value of this approach is not in making accurate predictions. Scenarios do not have to be ‘correct’ to be useful, but should shine a light on blind spots and challenge conventional thinking.

The scenario planning process involves developing axes that represent separate continuums of broad uncertainties derived from current and emerging trends, and that have the highest impact on P2P energy trading. This analysis identified two critical areas of uncertainty:

1. Application of prosumer technologies
2. Viability of trading DER

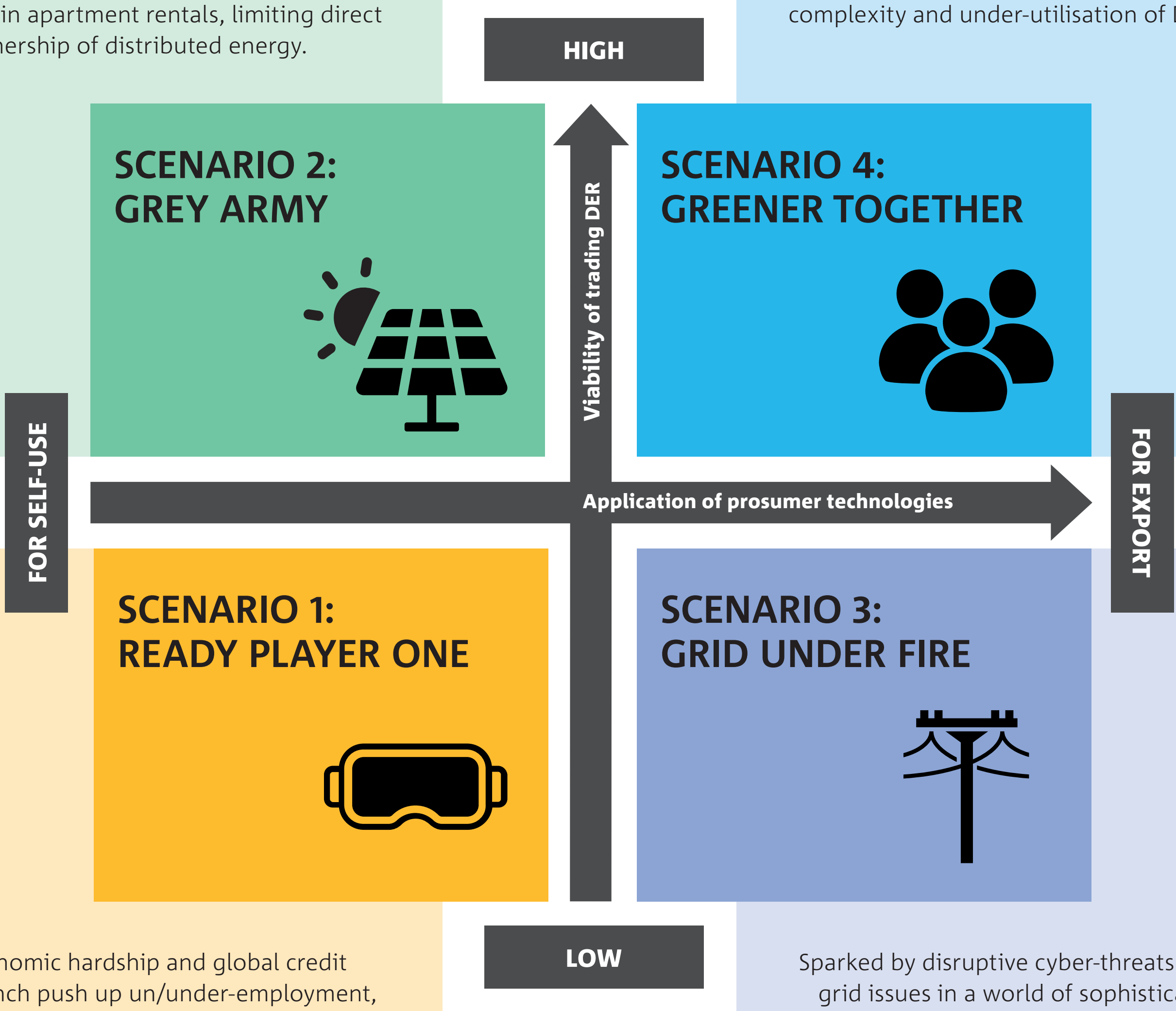
The first uncertainty relates to the extent to which prosumers are willing and able to unlock and trade DER—will they manage their behaviour to optimise export when needed, or will they channel most of their energy resources for self-use? The focus here is on prosumer attitudes and the technologies they possess to create surplus energy for trade to meet market demand.

The second uncertainty is focussed on market and regulatory factors that might support or undermine whether or not prosumers can generate financial value through trading their DER. The second axis is about the extent to which prosumers can find markets for their DER, and whether or not enabling regulations and grid infrastructure are present to facilitate those transactions.

Crossing these two axes creates a four-quadrant conceptual scenario model. Scenarios are derived from the extreme endpoints of each axis. Each scenario tells a story of how these uncertainties might interact and shape P2P energy trading (Figure 17). Because we are exploring how these uncertainties interact, we need to consider what changes to the broader societal context might push the world into each scenario quadrant. The narratives also consider the impact on the wider electricity system, including key groups such as consumers, prosumers, energy and property industries and government. This way, scenarios can better reflect insights from the horizon scan, and incorporate much of the complexity and uncertainty inherent in energy system changes that are likely to impact the prospect of P2P energy trading over the next 10 years.

Digital economy boom pushes up house prices near major cities. Workplaces and work-arrangements remain fairly traditional, which means peak demand remains a challenge. In this future, a few asset-rich prosumers find a niche market for P2P trading during peak-demand periods. However, aggregators are offering stiff competition. Most people live in apartment rentals, limiting direct ownership of distributed energy.

More apartments and rentals address housing affordability issues, and smart mixed-use developments cluster a diverse mix of prosumers and consumers. Prosumers opt for P2P trading to retain control over their energy devices. Grid operators levy high fixed costs to prosumers participating in P2P platforms amidst concerns about system complexity and under-utilisation of DER.



Economic hardship and global credit crunch push up un/under-employment, which limits investment and innovation in distributed energy technologies. People spend most of their time at home, working and immersed in virtual lives. This is a world of energy haves and have-nots, where the affluent few adopt distributed energy technologies to hedge against high electricity prices, while the rest manage by living small.

Sparked by disruptive cyber-threats and grid issues in a world of sophisticated DER and appliances. IoT products have been rushed to market without sufficient testing of vulnerabilities. Most prosumers decide they don’t want to be concerned with cyber-risks, and opt to sell their surplus to retailers for a modest standard feed-in tariff. However, the grid is struggling to cope with high amounts of poorly orchestrated DER.

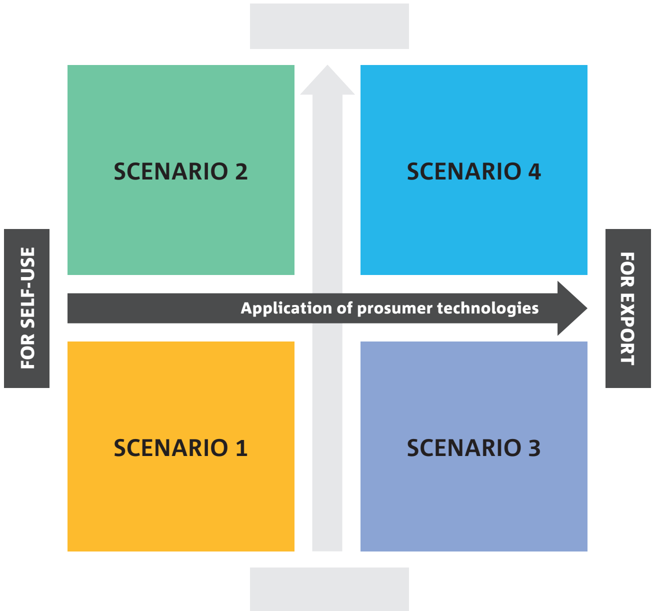
Figure 17. Four scenarios for the future of DER and P2P energy trading

HORIZONTAL AXIS
APPLICATION OF PROSUMER TECHNOLOGIES

The horizontal axis highlights the uncertainty around the effectiveness of prosumer technologies for increasing the availability of DER, and what prosumers will do with the additional resources. Will the majority of prosumers focus on meeting their own needs, or will they optimise their DER for export and trade?

Availability of DER will be a critical factor, driven not only by prosumer behaviour and preferences, but also the cost and efficiency of technologies that improve energy management, consumption, generation and storage. Increasing penetration of solar PVs has come with increasing efficiency and falling system costs. The next 10 years could see batteries follow a similar price-performance trajectory, and with it, a growth in the uptake of electric vehicles. In addition, load control of energy-intensive appliances such as air-conditioners and pool pumps has also improved in recent years.

There are also new technologies under development, including more efficient next generation solar PV, passive air-conditioners/HVAC systems, cheaper and more energy dense batteries, and smart building energy management systems. If made available to the mass market, such technologies could enable prosumers to share more of their DER when the market needs it, thereby creating more economic benefits for themselves, consumers and the wider system. On the other hand, these technologies and devices may not make it to the mass market between now and 2030. As a result, prosumers may choose not to share their DER and focus on self-use.



Application of prosumer technologies for self-use

Modern society brings increasing demand for energy. Households have more electricity-consuming devices than ever before with an 'online 24/7' life and personal ownership of electric cars. At this end of the axis, would-be prosumers of 2030 are finding it challenging to meet their own energy needs. Improvements in price-performance ratios for solar PV and batteries have plateaued over the past 10 years. Thermal performance of homes has not improved enough to reduce electricity demand for space heating and cooling, and new innovations in heating and cooling systems are not yet available to the mass market. At the same time, more climate change related heatwaves have increased the need for more cooling appliances and associated demand for electricity. Therefore, if prosumers only possess rooftop solar, then they schedule usage of their large consuming appliances (e.g. air-conditioner, pool pumps and hot water heaters) for daytime use. If they have solar-battery systems, then they use stored energy primarily for their own evening and early morning use.

Evidence supporting application of prosumer technologies for self-use

This axis end point can be viewed as an extension on today's reality. Electricity-consuming devices have proliferated over the past 10 years with the rollout of smart devices, such as phones, tablets and speakers, and many more devices could follow. Electric vehicles could significantly increase household electricity demand if consumers prefer to own them and charge at home. This could be the case if ownership of autonomous electric vehicles is only marginally more expensive than mobility-as-a-service.[164] Diffusion of air-conditioners is already high at around 0.94 units per household in Australia, but households might need to install more units to cope with the growing number of heatwaves.[40] Climate change related heat events continue to drive high use of air-conditioners across much of Australia.[165] The number of hot days over 35-degrees Celsius is projected to increase across state and territory capitals, which should drive further increases in electricity demand for cooling.[166,167]

More devices means more demand for electricity. Exacerbating the problem is Australia's relatively low scores on building energy efficiency in international comparisons.[168] If performance of household-scale solar and battery systems cannot keep pace with demand, prosumers are likely to prioritise meeting their own needs. The current generation of solar PV has a theoretical limit of about 30% efficiency, with market-leading solar panels achieving 22-23% efficiency.[169] While next generation solar systems have demonstrated upwards of 50% efficiency in research laboratories, this technology may not be available by 2030.[170] After all, it's taken current solar technology decades to reach the industry average of 18% efficiency.[171] Likewise, there are limitations on increasing the energy density of energy storage technologies like lithium-ion batteries.[172] Again, while next generation storage is under development, these may not transition to the mass market within the next decade. In this circumstance, storage capacity may only be adequate to cover self-use in most cases.

Application of prosumer technologies for export

At this end of the axis, prosumers have oversized their solar and battery systems to ensure they are flush with surplus energy. They are also able to free up DER to provide other services to the electricity system. This future sees cutting-edge technology rapidly transition from research lab and small-scale trials to the mass market. Widely available and affordable small-scale electricity generation and storage, as well as energy-efficient appliances and management systems offer prosumers an unprecedented opportunity for energy abundance. Adoption of 'zero energy' buildings (new and retrofitted ones) has reached market take-off, and most prosumers have opted for mobility-on-demand to cut their household costs on electricity (for home charging) and transportation.

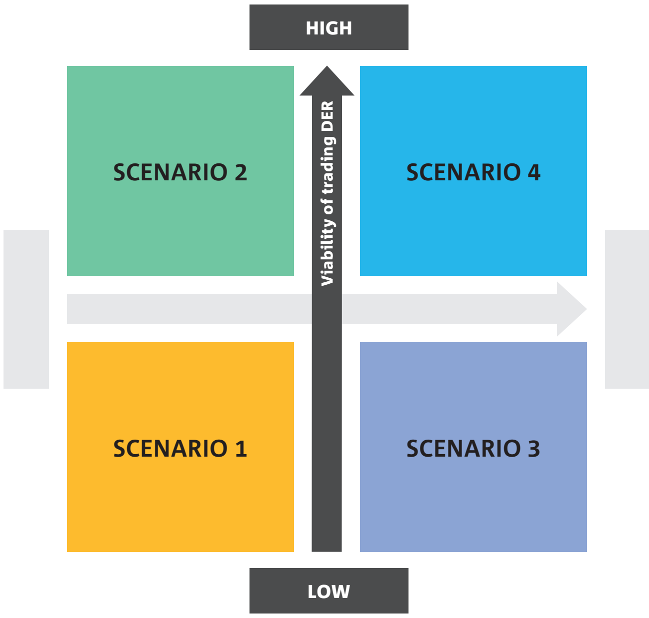
Evidence supporting application of prosumer technologies for export

What makes this end point plausible is the high growth in energy-related R&D investment and tech commercialisation, particularly with emerging energy-tech giants like Tesla. According to the International Energy Agency, R&D investment in clean energy increased 13% in 2017 after years of stagnation, and corporate investment in new energy tech reached their highest level of just over US$6 billion in 2017, up from under US$4 billion the year before.[173]

Electricity demand from housing and cars is expected to plummet with new technology and standards. Industry experts and large auto companies are predicting that most, if not all, cars will be fully autonomous by 2030.[174,175] We can observe renewed interest in high performance housing driven by rising electricity costs and changes to building standards. New houses today are mandated at 6-stars energy rating, while 9- and 10-star houses are currently being demonstrated.[176,177] While high performance housing products are not being widely adopted, this could change with improved industry practices and marketing. It's also plausible that existing business models, such as solar-battery leasing and power purchase agreements could be packaged with high performance housing, thereby negating the impact on upfront costs.

VERTICAL AXIS
VIABILITY OF TRADING DER

The viability of trading DER will be impacted by a number of factors, including regulation, grid and transaction costs, market demand, and grid integration and management. These factors will weigh into the decision of prosumers about whether trading surplus energy is worthwhile. Because grid operators are not mandated to enable trading of DER, it's possible that they may not provide the necessary fixed infrastructure upgrades to accommodate access to new markets for these resources. On the other hand, more grid operators are working on ways to use DER to support the grid and improve utilisation of existing infrastructure. Innovation in micro- and smart-grid technologies could further improve the utilisation of DER. However, increasing affordability of solar PV and batteries may cause high diffusion rates for these systems, and consequently push too much electricity to the grid, causing problems of reverse flow at transformers and negative pricing for this energy.



Low viability of trading DER

This future sees a glut of surplus energy for much of the daytime, troubles with grid integration and little change to regulations. The regulatory context for DER has not shifted substantially since 2019, leaving prosumers with low reliability grid infrastructure, which frequently 'switches off' export of their surplus electricity to prevent damage to transformers, consumer equipment and local outages. Their DER are also not able to create value through other service to the electricity system. Some would-be prosumers have low trust in incumbent energy companies, and are disconnecting from the grid altogether. The energy market continues to decline due to people load- and grid-defecting, which has substantially increased the fixed-costs consumers pay on 2019 levels. By 2030, these factors have dampened the enthusiasm for DER trading among prosumers and consumers alike.

Evidence supporting low viability of trading DER

This end of the axis is plausible given the mass adoption of solar PV in Australia, grid issues with connecting these systems and low trust in energy companies. One in four households now has rooftop solar, and the average system size has increased from about <2 kilowatts in 2010 to over 6 kilowatts in 2018.[178] Electricity from these systems is cheaper than grid-electricity for most households and businesses fuelling growth of installed capacity to over 11 gigawatts across the country, and pointing to a future where the demand for prosumer energy might be relatively weak, particularly during periods of peak supply.[178] Furthermore, existing electricity grids were not designed to handle two-way flow of electricity, so issues of 'solar spill' or exporting of too much electricity when usage is low could become a problem, which can negatively impact grid stability and cause solar system inverters to disconnect from the grid.[179]

Some grid operators in WA, QLD and SA are taking preventative action by declining applications for new grid-connected solar systems in areas with high solar PV penetration.[180] Upgrading the grid to manage these issues could become costly in the future as the network costs of energy already account for between 33% and 57% of an average consumer's energy bill, depending on jurisdiction.[99] Risks of grid disruptions and high costs, along with low trust in energy companies,[181] could prompt some households and businesses to disconnect from the grid entirely, increasing the grid costs shared by remaining grid-connected consumers and increasing transaction costs of trading DER. CSIRO's Future Grid report explored the plausibility of large-scale grid disconnections due to falling battery costs and increasing electricity prices.[182]

High viability of trading DER

In this future, markets for DER are thriving. Clear regulatory settings and new innovations in grid management technologies have enabled utilities to efficiently, safely and reliably integrate DER to existing infrastructure. Prosumers can easily find a market for their excess electricity. In addition, both prosumers and consumers find trading DER seamless and user friendly, with business models that provide value for consumers and sufficient rewards for prosumers. At this end of the axis, grids operate efficiently with an optimal balance between exported energy from prosumers and consumer demand, which drives a virtuous cycle of increasing participation, grid utilisation and reducing transaction costs.

Evidence supporting high viability of trading DER

This high market viability future is plausible if battery costs decline at a similar rate to solar PV, and regulations are established to support integration and utilisation of DER. Bloomberg New Energy Finance projects global battery prices to fall from US$162 in 2017 to US$74 in 2030.[95] Current plans to improve market access, regulations and standards for DER could also increase the likelihood of a viable DER trading environment. For example, Energy Networks Australia and the Australian Energy Market Operator are partnering on the Open Energy Networks project, which is investigating ways to better integrate DER into the grid.[183]

From a technical standpoint, many enabling grid innovations have already been developed in the field, albeit on a small-scale. Micro-grids with distributed energy technologies are being trialled in Australia[24], so the engineering know-how is there—it just needs to be deployed at scale and with appropriate regulatory signals and markets.

The concept of utilising DER is gaining momentum across government and industry as many recognise its contribution to affordable energy supply.[18] New aggregators and platforms are already emerging to support trading of DER. Sonnen and Tesla have developed business models that involve controlling and aggregating DER.[184,185] In Australia, Newcastle-based energy tech start-up SwitchDin is commercialising a control system to effectively aggregate DER,[186] while Melbourne-based company GreenSync established the world's first marketplace for DER (deX) in October 2018.[187]

SCENARIO 1: **Ready Player One**

KEY TRIGGER: Financial crisis and credit crunch

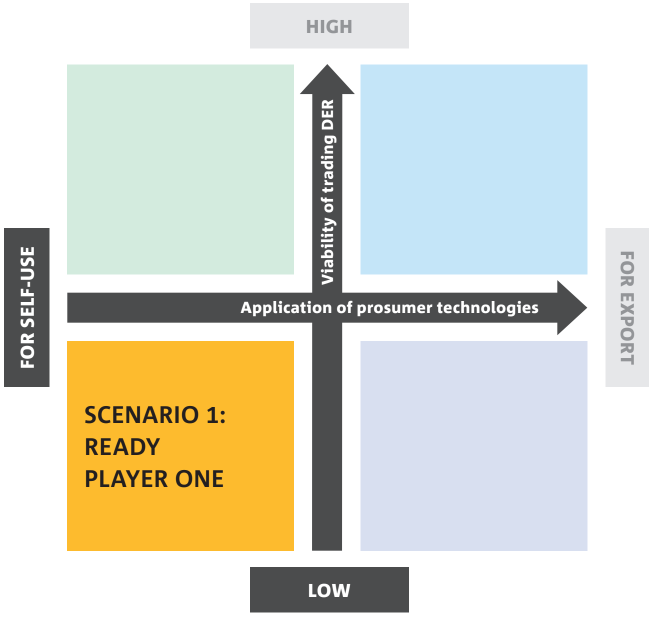
WATCH POINTS: Mortgage stress and available credit domestically and internationally as lead indicators of private investment in DER.

STATE OF P2P ENERGY TRADING: P2P trading may not be viable in this scenario given the lack of enabling infrastructure and regulation, and also prosumer preference to use the energy they generate/store for self-use. Only a modest FiT is available for people who export to the grid.

DILEMMA FOR P2P ENERGY TRADING: What incentives could P2P trading platforms offer prosumers to promote export and trade?

ATTITUDE OF PROSUMERS: *'I need the energy for myself to keep me online 24/7'*

CONSUMER SENTIMENT: *'My electricity bills are stressing me out!'*



Ready Player One sees much of the world in economic trouble following a property market meltdown. People cocoon themselves at home and use virtual reality technology to immerse themselves in virtual lives as an escapist and more affordable lifestyle. Credit crunch, high un/under-employment and social norms around self-focussed 'insularism' has impacted the way people live. People have withdrawn to virtual lives and echo-chambers. Large suburban houses are divided into smaller units, while tiny houses can be found in many backyards and parking lots.

Those with jobs are incentivised to work from home as companies seek to keep operating costs down. People are energy hungry, but offset the high cost of energy by living small. A few affluent households are adopting available distributed energy technologies for their own use.

Regulations haven't changed in Australia to promote utilisation of DER, and consequently grid integration and management technology has lagged the rest of the world. Regulators and governments are focussing more on cutting costs from the system, including downsizing the workforce, selling off expensive and/or aging network elements (e.g. at edge of grid) and mothballing inefficient generation assets. Governments and the energy industry have also invested heavily in energy hardship and behaviour-change programs. The feeling among government and industry is that the present crisis will pass in the next few years, and that stopgaps are necessary in the meantime. Load shedding is the norm and consumers have learnt to be frugal with their usage, though many make sacrifices (e.g. fasting from food) to stay online. While available solar PVs, batteries and micro-grid tech are rudimentary, they are sufficient to support off-grid applications with diesel/gas generators for backup.

With little market demand for distributed energy technologies, R&D investment has fallen. Some investment is being channelled into existing affordable low-tech energy solutions developed for poor and remote communities such as the 'off grid box' (www.offgrid.com).

Immersing in virtual reality technology

Consumers manage high electricity cost by embracing tiny house living and adopting enough solar and battery systems to meet their own needs

Government and energy industry work together to slash costs across the electricity system

KEY IMPLICATIONS OF THE READY PLAYER ONE SCENARIO

GROUP	IMPLICATIONS
Prosumers	• Must self-fund investment in generation and storage technologies. • Prefer not to share their DER for fear they won't have enough.
Consumers	• Struggle with high electricity prices. • Many are in energy hardship programs. • Learning frugal behaviours to save energy, similar to the behaviour change that occurred for water consumption during the millennium drought.
Government	• Fiscally challenged, but under pressure to provide relief to consumers. • Investing in energy hardship programs. • Face difficulties in 'selling' government assistance when social norms elevate individualism and self-sufficiency. • Financial resources are likely to be stretched, which could limit their capacity to address energy sector challenges. • This scenario could provide many low-cost strategies to decarbonise the economy, which could inform future energy and climate policy.
Energy industry	• Struggling with inefficient grid utilisation and high outages due to insufficient infrastructure development. • Managing grid issues through routine load shedding. • Recognise that emergency cost-cutting measures in the electricity industry is seen as a necessary measure, but express concern about grid and social instability if prolonged. • New low cost and affordable technologies might emerge by necessity, which could boost energy resilience in the future.
Urban planning and development industry	• Enabling multiple-occupancy development, and use of tiny houses to meet demand for affordable housing.

SCENARIO 2: **Grey Army**

KEY TRIGGER: Property boom and shift away from home ownership and low-density suburbanism towards renting and higher density urban living.

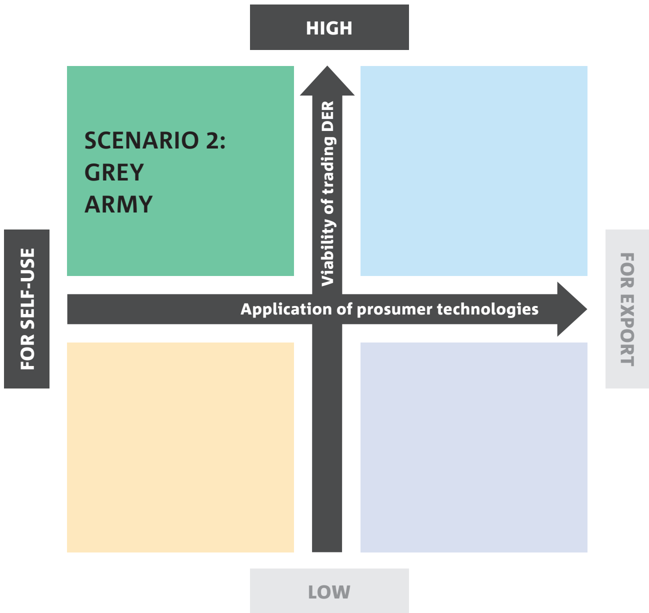
WATCH POINTS: Proportion of owner-occupiers vs. renters. Number of dwellings per hectare, or population per square kilometre. Proportion of rental properties with solar PV and battery systems. Population density of urban areas.

STATE OF P2P ENERGY TRADING: P2P trading has a niche market during peak times, especially for consumers in high-density urban centres. The challenge with P2P is the high fixed infrastructure costs, which have to be factored into transaction costs.

DILEMMA FOR P2P ENERGY TRADING: Could P2P energy trading be viable in niche markets?

ATTITUDE OF PROSUMERS: *'I'm retired, asset rich and ready to trade energy to supplement my income'*

CONSUMER SENTIMENT: *'My peak energy usage is high, but the cost is manageable thanks to the grey prosumer!'*

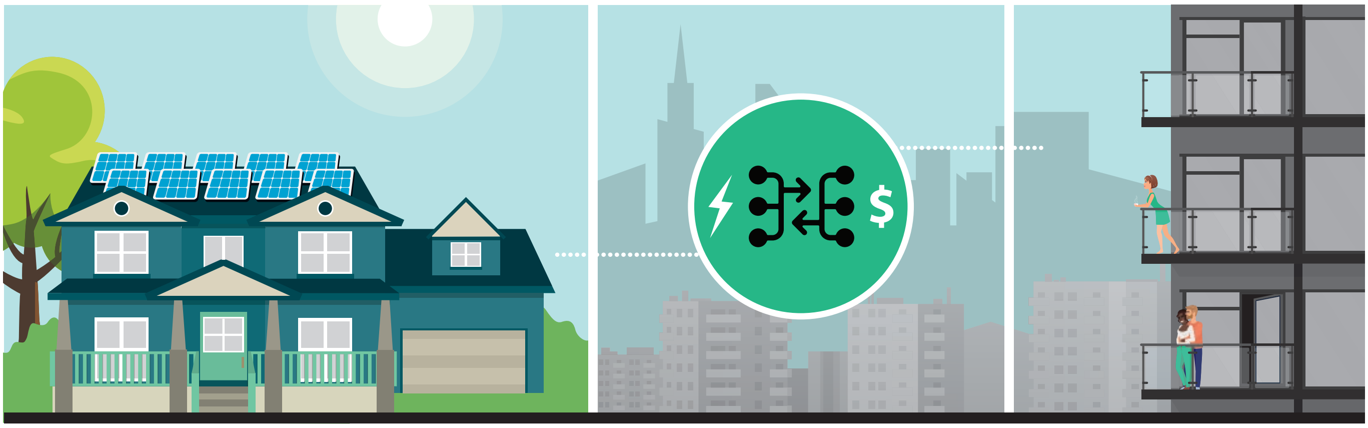


The Grey Army sees an economic and property boom as Australia successfully nurtures new industries in the global digital economy. However, workplaces and work-arrangements remain fairly traditional. Limited uptake of technologies for shifting demand profiles means peak demand remains a challenge. Time-of-use tariffing has become a popular tool for shaping consumer behaviour, but causes expensive headaches for larger households.

In this future, there is a niche market for P2P trading during peak demand periods. Prosumers are also able to trade their excess electricity to small businesses during the day. However, aggregators are offering stiff competition for both off-peak and peak-time markets. While distributed energy technologies have come down in price, they remain an expensive proposition and confined to owner-occupier households in detached housing. Government subsidies are still available for solar battery systems.

Strong economic growth and demand for housing is a boon for investors, while home ownership is elusive for most. With growth in single- and two-person households, more are choosing to live in apartments close to major cities. Most prosumers tend to generate and store energy for self-use, though many are participating in DER aggregation schemes to provide services to the electricity system and sell the small amounts of energy they are able to export. Retired empty nesters still living in large suburban houses have become the stereotypical P2P energy trader, attempting to provide surplus electricity for consumers in high-density residential and commercial markets. They strategically deploy battery capacity from their electric cars to trade during the peak demand period.

Changes to regulations and infrastructure upgrades have enabled high levels of DER to be deployed in the system, and for stored energy to be exported and transmitted from low- to high-density urban areas. These changes were enabled by strong government vision and strategic planning to maximise the use of low-density 'solar suburbs'. Investment in R&D is not a strong strategic priority but investment has occurred in grid management and home energy storage.



Retired empty nesters living in large suburban detached houses are the stereotypical P2P energy prosumers who have enough surplus electricity to trade

Prosumers are trading their excess electricity to consumers in high density residential and commercial markets

Growth in single and two person households means that most people are now living in apartments close to major cities

KEY IMPLICATIONS OF THE GREY ARMY SCENARIO

GROUP	IMPLICATIONS
Prosumers	• Finding markets for their DER through P2P and aggregator platforms. • Prosumers might get stung with high transaction costs that exceed income from their energy trading. • Grid defection could result if prosumers become disillusioned with DER platforms.
Consumers	• Still grappling with high retail electricity prices. • Able to access electricity below retail rates, particularly during peak times.
Government	• Strong financial position. • Able to provide incentives for solar-battery systems. • Social divide between owner-occupiers and renters could make new energy policies contentious if they don't directly address inequity.
Energy industry	• Outages is an issue for some low-density suburbs with high solar penetration. • Managing prosumer expectations could be a key challenge. • Balancing the grid might be physically difficult in suburbs with a very high proportion of exporting prosumers, unless there is significant investment in grid management and storage. • Could deploy community micro-grids to increase DER and trading, and then provide ancillary services to the grid. • Business model innovation could capture value from trading DER, which should reinforce the value proposition for those who remain grid-connected.
Urban planning and development industry	• More infill development in response to high demand for apartments near the CBD.

SCENARIO 3: **Grid Under Fire**

KEY TRIGGER: Cyber-attacks and privacy breaches on prosumer technologies disrupt the grid and markets for DER.

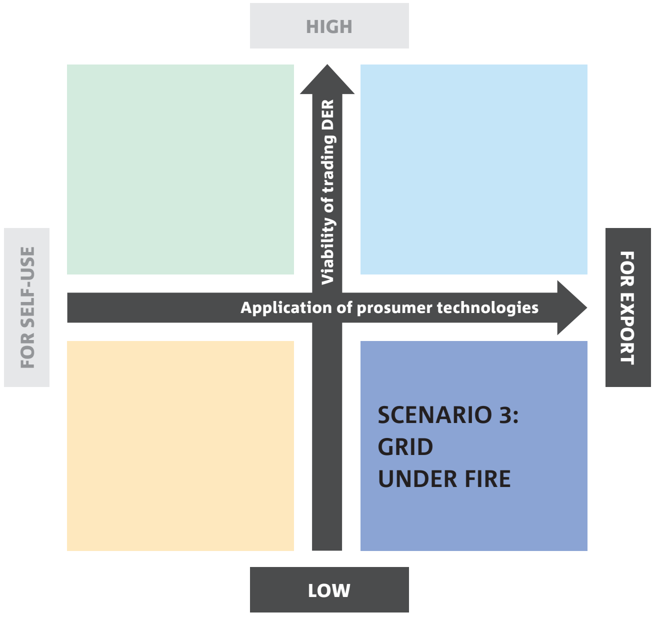
WATCH POINTS: Rate and cost of cyber-attack and privacy breaches on energy assets, including data stores.

STATE OF P2P ENERGY TRADING: P2P is considered risky as are other platforms for trading DER that involve IoT systems. Most prosumers prefer to simply export their surplus energy for standard retailer FiTs.

DILEMMA FOR P2P ENERGY TRADING: Will P2P platforms address cyber-security threats, or will individual prosumers and consumers be expected to manage these risks?

ATTITUDE OF PROSUMERS: *'I've got lots of DER but want a hassle-free approach to trading it'*

CONSUMER SENTIMENT: *'I don't understand why my bills are going up when clean energy is cheap and abundant!'*



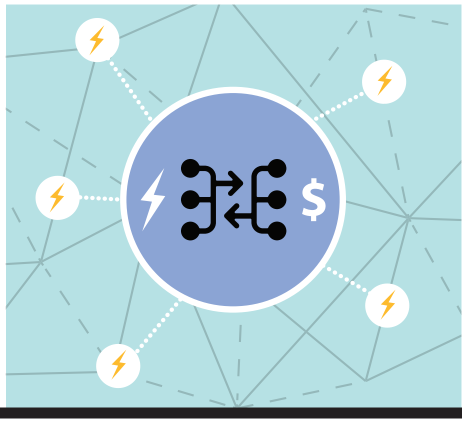
Grid Under Fire is a world plagued by disruptive cyber-threats and grid issues brought on by the widespread adoption of sophisticated DER and IoT-enabled appliances by end users. The problem stems from most tech manufacturers having rushed their IoT products to market without sufficiently testing vulnerabilities. Initially prosumers embraced the new technology but quickly became concerned by growing cyber warfare globally, and high-profile cases of privacy breaches and hacking of devices domestically.

Regulations and infrastructure have progressed in step with the large number of grid-connected distributed energy technologies. However, regulators have been caught by surprise at the rate of IoT development in the sector and overlooked cybersecurity standards for grid-connected IoT devices. Prosumers and consumers fear the safety and reliability of direct P2P interaction and aggregator platforms that operate via the 'energy internet'.

Prosumer technologies are advanced enough to enable abundant surplus energy, but it's too cheap to monetise. Most prosumers decide there isn't enough value relative to the risk of cyber-attack to adopt IoT devices and participate in P2P or VPP marketplaces. Instead, they choose to simply operate 'dumb tech' through standard retailer FiTs, where their exported energy can be assessed through 'dumb meters' that keep hackers at bay.

Unfortunately, grid utilisation is a problem and much of the grid is stretched to capacity with large quantities of DER and poor orchestration. Consequently, solar systems are switching out, outages are on the up, and the proportion of fixed infrastructure charges on electricity bills continues to increase. Many prosumers are fed up and want to disconnect from the grid entirely. Their energy needs are modest because they have adopted high-performance housing and ditched car ownership in favour of mobility-as-a-service. Governments grapple with how to fix the grid and protect prosumers and consumers. A plan to hit grid-defectors with a levy has been touted as a necessary fix to maintain the grid in a dwindling market.

IoT-enabled DER devices and appliances are rushed to market without sufficient cybersecurity measures resulting in disruptive cyber-attacks



Many prosumers have enough surplus electricity to trade but prefer exporting to a non-IoT-enabled grid to minimise risks of being hacked

However, high amounts of renewable energy feeding back into the grid, along with poor orchestration of additional energy, mean the grid is stretched to absolute capacity

KEY IMPLICATIONS OF THE GRID UNDER FIRE SCENARIO

GROUP	IMPLICATIONS
Prosumers	• Low retailer FiTs and high frequency of outages make exporting unattractive. • Many want to leave the grid entirely as costs and cyber-risks exceed the benefits of being connected.
Consumers	• Struggling with energy bills as fixed costs are rising over and above declining energy costs.
Government	• Under pressure to do something about the grid. • Reviewing the implementation of a levy on grid defectors. • Enforcement of product standards could be too complex and costly in a fast-paced global market for IoT devices.
Energy industry	• Overwhelmed by the rapid pace of tech change behind the meter • Putting out spot fires, while a wider coordinated response is being worked through. • Managing the threat of privacy breaches and system disruptions compounding existing cost challenges for the grid. Electricity price could be high due to high fixed costs. • Innovation explosion could bring solutions to cyber security issues.
Urban planning and development industry	• Coping with growth through low-density suburban development. • Some developers are ‘adding value’ by incorporating micro-grid developments to protect property buyers from wider grid disruptions.

SCENARIO 4: **Greener Together**

KEY TRIGGER: Housing affordability reaches a crisis point. Political mood towards climate change reaches critical thresholds. Persistently low trust in energy companies drives prosumer participation in P2P platforms as a means of maintaining control over their devices.

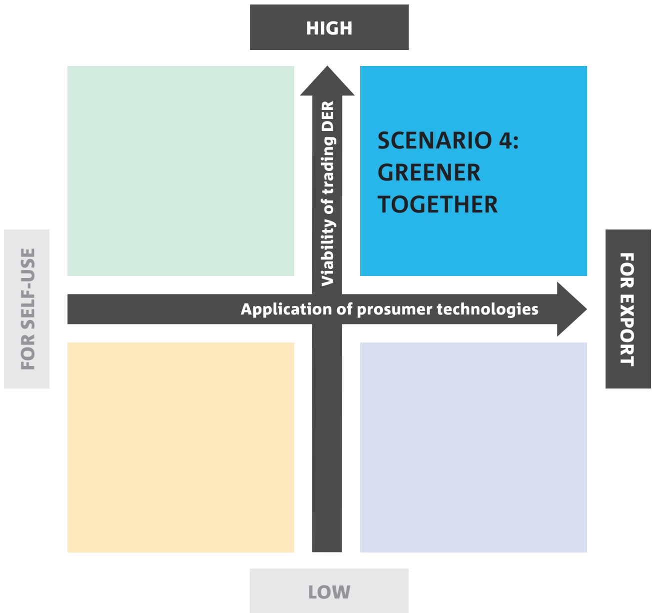
WATCH POINTS: Proportion of households living in apartments and renting. Changes to energy hardship and mortgage stress statistics. Trust in energy companies.

STATE OF P2P ENERGY TRADING: P2P is highly attractive in this scenario, given diverse housing types and uses within many localities, which bring a relatively even distribution of prosumers and consumers. P2P trading is also more attractive than aggregator-controlled DER for many prosumers who want to retain control over their devices. However, transaction costs are high as network system operators levy charges to P2P participants because of concerns that the trading system leads to poor DERs orchestration and grid utilisation.

DILEMMA FOR P2P ENERGY TRADING: How could P2P platforms mitigate against energy industry concerns about poor coordination of DER?

ATTITUDE OF PROSUMERS: *'P2P energy trading allows me to stay in control of my home and trade on my terms'*

CONSUMER SENTIMENT: *'It's so easy and affordable to source clean energy from my neighbours'*



Greener Together features rational urban and energy planning that drove greater adoption of distributed energy technologies, substantial improvements to the energy performance of buildings, and more compact town and cities. These changes were implemented to address the chronic cost of living pressures and public demands to accelerate the renewable energy transition.

The new urban policy settings increased the stock of apartment buildings and rentals, and promoted more mixed-use developments that gathered commercial uses together with diverse residential housing types, creating a balance between prosumer energy supply and consumer demand. This urban form has proliferated alongside increases in the number of single- and two-person households, and shifting preferences of younger generations towards renting apartments and using mobility-as-a-service to meet their travel needs. Higher energy performance standards for buildings were also implemented to ensure these buildings were cost-effective to operate. Developers responded to higher building energy standards by installing distributed energy technologies to buildings as standard. While this is a world of advanced renewables and storage systems, high-density areas remain net importers of energy, making P2P energy trading between low and high density areas attractive.

Energy policies responded to public calls to concurrently address climate change and electricity prices. Ambitious renewable energy targets increased investment, grid regulations and standards enabled better integration and management of DER, and cost-reflective pricing promoted more load shifting and trading of surplus energy. While retailers and aggregators are able to operate in this scenario, they've found low trust in energy companies a key barrier. Prosumers do not want to relinquish control over their devices to any energy company, and value a sense of independence over their home and how their surplus energy is managed. Most prosumer energy flows through easy-to-use and highly secure P2P platforms.

The trouble is, the energy industry perceives risks with this approach to managing DER, and responded by levying high fixed costs to platform participants. Instances of grid outages are blamed on P2P trading and the lack of effective DER-grid orchestration that results from too many agents in the system acting in their own interests. While abundant with DER, some prosumers are finding the fixed cost of P2P energy trading is exceeding the revenue they can generate. However, most in this camp persist because they see this cost as a necessary 'tax on wealth', and are happy to support the system.

Efficient and rational urban and energy planning driving great adoption of solar and battery systems

Substantial improvements to the energy performance of buildings

Towns and cities are more compact and have incorporated more smart mixed-use developments that have a good combination of commercial and diverse residential housing types

A fleet of autonomous electric vehicles is enabling new solutions including mobility- and storage-as-a-service

In addition, ongoing innovation in distributed energy technologies continues to bring a stream of new solutions such as autonomous electric vehicles that provide services for both mobility and storage. Strong investment in R&D is being led by new energy tech companies and property developers, who curate 'urban living lab' spaces for trialling and refining new distributed energy technologies, systems and business models. Some developers are proposing micro-grid solutions for new strata and torrens title developments with micro-grids where P2P energy trading can be enabled with lower transaction costs.

KEY IMPLICATIONS OF THE GREENER TOGETHER SCENARIO

GROUP	IMPLICATIONS
Prosumers	• Prefer to retain control over their devices, and how and when their energy is traded. • High transaction costs, and low profit margins.
Consumers	• Enjoy lower electricity prices and abundant renewable energy. • Bills could still be high due to higher fixed costs.
Government	• Focussed on getting the policy settings right for efficient use of existing infrastructure. • Is challenged with resolving who bears the cost of necessary upgrades to the network and loss of revenue to government-owned assets. • Defers the need for new large power stations, which are costly, take a long time to build and require lengthy debt financing. • Give more people a sense of ownership over energy assets and energy issues, which could increase support for more aggressive renewable energy policies.
Energy industry	• Dealing with physical grid system issues of poorly orchestrated DER. • Concerned about missed opportunities with utilising DER. • Highly interconnected future with substantial DER and many market participants could prove to be a complex management challenge, with unforeseen costs and unintended consequences.
Urban planning and development industry	• Better coordination between government planners and private developers is creating more compact and sustainable towns and cities. • Taking the lead in micro-grid developments that enable prosumers to trade without high grid-related costs.

OPPORTUNITIES AND CHALLENGES FOR P2P TRADING OF RENEWABLE ENERGY

OPPORTUNITIES

Enable prosumers to have

MORE CONTROL OVER THEIR EXCESS SOLAR ENERGY,

and receive a potentially higher return compared to future FiTs.

CONNECT

local prosumers and consumers in the community.

Potentially offer consumers

MORE AFFORDABLE ELECTRICITY

compared to retail tariffs, and transparency on the exact source of the purchased energy.

ENGAGE

more households on energy issues, and the transition to a cleaner energy mix.

Current flat tariff structures do not incentivise P2P trading, but

FUTURE MARKET REFORMS

and removal of current guaranteed renewable energy buy-back rates could make trading more viable.

CHALLENGES

NETWORK UPGRADES

could be needed to enable high volumes of export-capable DER.

CUSTOMER ENGAGEMENT

can be difficult due to the complexity of the cost structure, management and regulation of the electricity system. P2P energy trading may not align with public expectations from other more familiar P2P platforms (e.g. Uber and Airbnb).

UPGRADING GRID INFRASTRUCTURE

to enable more export-capable DER will likely increase transaction costs and adversely impact on viability of trading.

Increasing DER trading may lead to more complicated

DATA SECURITY AND PRIVACY ISSUES.

REGULATIONS

require P2P platforms to operate in cooperation with incumbent utilities.

P2P ENERGY TRADING

doesn't address network costs embedded in electricity bills. It only addresses the 'generation' portion of the bill, and therefore, is likely to only offer a very small cost advantage to the energy consumer.

Growing number of large-scale renewables coupled with an increasing number of small-scale solar will likely

DRIVE DOWN GENERATION COSTS IN THE FUTURE.

The price advantage in the generation cost of energy that P2P may offer could diminish in the future, particularly if cost-reflective pricing eventuates.

Difficulty accessing

REAL-TIME METER DATA

to collate accurate records of transactions.

CONCLUSION

Advancements in renewable technologies are changing the way households across WA are generating and consuming energy. The emergence of digital technologies and platforms, coupled with new business models for managing DER, could potentially empower energy consumers to increasingly become prosumers in the future. The increasing cost of electricity across WA, the declining cost of rooftop solar and battery systems, along with increasing consumer concerns about the environment, are elements of a perfect storm driving the rise of DER and interest in ways to create value among owners of DER assets.

While P2P energy trading could potentially present many benefits to both consumers and prosumers in the future, there are uncertainties around the availability of surplus renewable energy when market demand is high. With growing uptake of energy-consuming devices among WA households, the would-be prosumers of 2030 may find it challenging to meet their own energy needs during peak-demand periods. On the other hand, cutting-edge technologies could transition from the research lab to the mass market, and give rise to an increasing number of prosumers who can store and trade surplus energy when required.

The viability of trading DER overall could be negatively impacted by the financial cost of upgrading and maintaining the centralised grid, unsupportive regulations, and concerns over cyber-security and privacy. Furthermore, insufficient grid infrastructure may see frequent 'cut-out' of exported electricity to prevent local outages. Consequently, many would-be prosumers may disconnect from the central grid and become self-sufficient, leading to increasing fixed costs of the grid for those who remain connected. On the other hand, new innovations in grid management technologies could enable energy providers to efficiently, safely and reliably integrate DER to the existing infrastructure, and facilitate P2P trading, as well as other markets for monetising DER. In addition, both consumers and prosumers could enthusiastically embrace P2P energy trading as a trend towards diversification across the energy sector.

This report describes contrasting futures for DER in the energy system and speculates how P2P energy trading could operate in those futures. Technology advancements in solar PV, batteries, IoT, AI and autonomous vehicles are already taking place to help unlock value from DER for customers and the wider electricity system. As we move towards 2030, the question will be less about whether or not transformation will occur across the energy sector, but about the nature and extent of the transformation. The availability of affordable and reliable energy across the state of WA will be a key enabler to its future economic development—particularly in regional areas. Future changes to the energy system will demand a unified approach. Looking ahead, developing collaborations, fostering knowledge exchange, and establishing long-term strategic planning and cooperation across government, industries and communities will be crucial. The tools of strategic foresight can be used to foster constructive discussions among diverse stakeholders, and identify strategies and policies to effectively navigate future change to the WA energy system. This work is a positive first step towards informing decisions around future priorities and investments in distributed energy systems and technologies.

METHODOLOGY

The strategic foresight process

The strategic foresight process is a structured analysis of future trends, scenarios, opportunities and risks to inform present-day strategic decision-making. In broad terms, 'foresight' involves identifying and describing plausible futures, and 'strategy' involves identifying, choosing and implementing actions for achieving the desired outcomes. CSIRO has developed a generic strategic foresight process for identifying evidence-based and relevant trends impacting an industry, region, organisation or society over time (Figure 18). The strategic foresight process has been applied in this report to first identify the current and emerging trends impacting the electricity system, and then develop potential plausible future scenarios describing how energy trading may operate in 2030.

Interview and workshop outcomes

As part of the broad horizon scan, stakeholder interviews were conducted to gather and validate the trends outlined in this report. The 30-minute interviews were conducted using the convergent interviewing technique.[188,189]
In addition, a three-hour stakeholder workshop validated the plausibility of the four scenarios outlined in this report. The stakeholders who participated in the interviews and workshop were representatives from government and energy industries. The CSIRO Social Science Human Research Ethics Committee approved these research protocols.

1

UNDERSTAND CORE ISSUES & QUESTIONS

BACKGROUND STUDY & SCOPE DEFINITION

2

IDENTIFY PATTERNS OF CHANGE (TRENDS)

HORIZON SCAN & INVESTIGATIVE INTERVIEWS

ENVIRONMENTAL TRENDS | **SOCIAL TRENDS** | **GEOPOLITICAL TRENDS** | **ECONOMIC TRENDS** | **TECHNOLOGICAL TRENDS**

3

IDENTIFY SALIENT PATTERNS OF CHANGE

SCREEN, CLASSIFY, VALIDATE & PRIORITISE TRENDS + CATEGORISE TRENDS INTO FOUR MAIN THEMES

4

DEVELOP PLAUSIBLE SCENARIOS REFLECTING THE FUTURE OF P2P ENERGY TRADING

SCENARIO VALIDATION WORKSHOP

5

CRAFT & COMMUNICATE FINAL REPORT

INFORM STRATEGY, PLANNING AND FUTURE INVESTMENT DECISIONS

Figure 18: The generic strategic foresight process developed by CSIRO

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