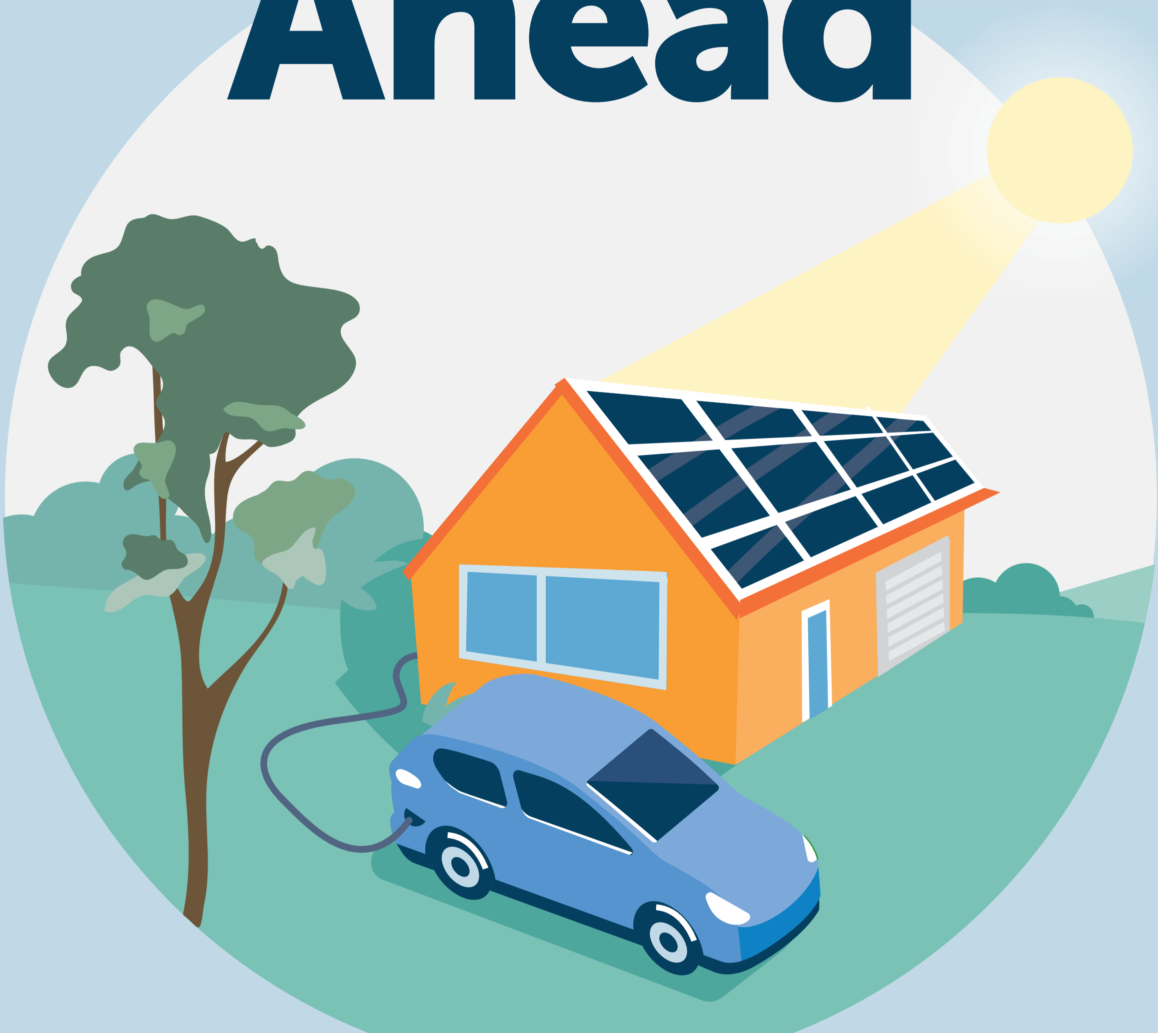
Charging Ahead



NEW ENERGY TECHNOLOGY AND THE FUTURE OF ENERGY COMPLAINTS IN VICTORIA

MARCH 2020

ENERGY AND WATER OMBUDSMAN
Victoria Listen Assist Resolve

Contents

EWOV acknowledges the Traditional Owners of country on which we operate throughout Victoria and recognises their continuing connection to land, waters and culture. We pay our respects to Elders past, present and emerging.

Abbreviations

ACL	Australian Consumer Law
ACCC	Australian Competition and Consumer Commission
AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
ANZEWON	Australia and New Zealand Energy and Water Ombudsman Network
ARENA	Australian Renewable Energy Agency
API	Application programming interface
CAV	Consumer Affairs Victoria
CDR	Consumer Data Right
CEC	Clean Energy Council
CEFC	Clean Energy Finance Council
CER	Clean Energy Regulator
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DELWP	Victorian Government Department of Environment, Land, Water and Planning
DER	Distributed energy resource(s)
ESC	Essential Services Commission
EV	Electric vehicle
EWOV	Energy and Water Ombudsman Victoria
FACS	Frequency Control Ancillary Services
HEMS	Home energy management system
kW	Kilowatt
kWh	Kilowatt-hour
NEM	National Electricity Market
P2P	Peer-to-peer
PV	Photovoltaic
SEC	Smart Energy Council
VCAT	Victorian Civil and Administrative Tribunal
VPP	Virtual power plant

Authors: Zac Gillam and Elly Ganakas.

The EWOV *Charging Ahead* report was supported by the Victorian Government in conjunction with the *VOICES* field-research project, to be conducted by the Australian National University (ANU) Battery Storage and Grid Integration Program (BSGIP) throughout 2020.

The ANU BSGIP *VOICES* report will be released in early 2021.

Executive summary

Background and introduction

Energy policy in Australia - and in fact Victoria - is notoriously contentious, but there is one point all stakeholders can unequivocally agree on. Things are changing, and changing quickly. The most obvious sign of this is the impressive growth of renewable electricity generation, be it through large-scale commercial solar or wind farms, or the rapid uptake of **residential solar panels** which are all beginning to have an impact on the state's generation mix. But these changes are just the beginning. Residential solar panels, in particular, herald the transition from a largely centralised power system to a highly decentralised system, making increasing use of **distributed energy resources (DER)**.

The future decentralised power grid will be comprised of millions of small solar generators, enabling those who were previously passive consumers to become energy "prosumers" – both producing and consuming energy. More and more people will both draw from, and feed back into, the electricity grid. This 'two way' energy flow is relatively new for our system. As the volume of DER-generated energy increases, it will present particular challenges for the Australian Energy Market Operator (AEMO) in their role as the 'orchestrator' of the grid - ensuring a steady flow of reliable power to all connected users, and managing a growing number of variable inputs to achieve that balance.

As people increasingly transition towards being prosumers, other new energy technologies will grow in importance. Residential energy storage, whether in the form of a **residential home battery** or an **electric vehicle (EV)**, will become increasingly critical to making efficient use of surplus solar power generated during daylight hours. And **home energy management systems (HEMS)**, whether through the use of an in-home display or a web-based application, will be needed to help manage the flow of residential energy in the best interests of the prosumer – and the collective benefit of the grid. The soon to be implemented Consumer Data Right (CDR) will help facilitate this process, by enabling prosumers to authorise third parties to access their energy data, and make advantageous decisions on their behalf.

Beyond the individual household use of DER, there is also the potential for households to connect with each other and configure their own resources in various ways. Households could choose to organise themselves into small scale autonomous grids knowns as **microgrids**, or a large number of disparate solar power systems may consent to being managed as one large input, known as a **Virtual Power Plant (VPP)**. In yet another variation, individual households may choose to simply trade directly with each other, in what is known as **peer-to-peer energy trading (P2P)**.

The following report investigates all of these technologies and more. We examine the degree to which they have already been adopted, how they are projected to grow in the coming decades, and how they are likely to interact.

Some of the technologies – such as solar panels – have already achieved a reasonable degree of market penetration and are rapidly becoming mainstream, while others (such as P2P trading) are very much in their infancy, with a number of technical and regulatory challenges to be overcome before they can be widely implemented. Despite these different stages of development, all of the technologies examined here are likely to grow, and as they grow together, they will create a far more complex energy system, engaging more parties in more complex ways than ever before.

While we make an attempt to project future growth of various technologies in this report, we are conscious that it is not possible to do so with absolute certainty. There are simply too many variables. The exact shape of the future energy system will depend on consumer behaviour, government incentives, and the extent to which intended parties (both individual and corporate) respond to those incentives. The future may be more decentralised than we could ever have imagined, or large-scale commercial renewable energy generation and storage may rise to the fore, and assert a more traditional, centralised structure on the grid than we expect.

Even if this were to occur, it is hard to imagine that a decade from now DER won't be playing a much bigger role in our energy system than it does now. This in turn means that more people than ever before will be reliant on DER to meet their energy needs, and will be interacting with the grid as prosumers.

Through all of this change, energy will remain just as essential to the health, safety and social participation of every individual as it always has been. While the system may become more decentralised, (and even fractured to the extent that many more, potentially much smaller, entities will be involved), the over-riding social contract for government to ensure a safe and reliable supply will remain.

Currently, EWOV is critical to an effective consumer protection framework in the energy market by providing a free, independent dispute resolution service. As the system transitions, there is a risk that our membership and operating model will no longer suit the changing energy system and this will negatively affect our ability to deliver. EWOV was designed around the current, centralised energy model – a system based on large energy companies (retailers and distributors) belonging to EWOV as members and serving large numbers of customers, who may come to EWOV in the event that they cannot resolve their dispute directly with their energy company. For EWOV (and other energy ombudsman schemes) to evolve and serve customers in a more decentralised system, our jurisdiction and membership structure will have to change. Those necessary changes are the subject of a recent Australia and New Zealand Energy and Water Ombudsman Network (ANZEWON) funded research paper, undertaken by the University of Sydney.

By contrast, this report has a more 'on the ground', pragmatic focus.

We ask - exactly what kinds of complaints are energy consumers and prosumers going to have, as we transition into a DER future? We note that not everything can be predicted at this stage. Inevitably, there will be surprises and unintended consequences as new energy technology is adopted more broadly throughout Victoria, and the interactions between different parties and technologies become increasingly complex.

That disclaimer aside, we have made an attempt to anticipate where things are likely to go wrong. This will help us understand the scope of potential new jurisdictions, prepare for the complaints they may generate and hopefully avoid a situation where people are left unable to access our services.

Residential solar panels provide a compelling early test case. Already, we receive approximately 500- 600 solar complaints a year which fall outside of our jurisdiction, generally representing around 30% of our total solar complaints.[1] Very often, this is because the complaint is related to installation issues. As solar installers are not currently required to be EWOV members, we usually cannot help to resolve the complaint – despite the fact that it is unequivocally related to the safe and reliable supply of energy to the complainant's home.

This jurisdictional pattern has the potential to be replicated in any number of ways across the various technologies investigated by this report. And as these technologies become more common, we may become inaccessible to a large proportion of Victorian energy users. As stated above - amendments to our jurisdiction will be needed to avoid this situation, and are the subject of a recent University of Sydney paper.

The intent of this report is to provide us with the early thinking needed to understand and smoothly 'onboard' new categories of complaint in the event that our jurisdiction is widened, so that we may continue to provide efficient, free and independent dispute resolution services to Victorians in relation to their energy supply.

Accordingly, we have sought to map the projected growth of these new energy technologies, and identify the heads of complaint they are likely to generate. Our findings are presented below.

Disclaimer: This report was compiled immediately prior to the onset of the global COVID-19 pandemic. Accordingly, the report does not consider the complex impact COVID-19 will have on the short to medium term growth of new energy technology in Victoria. Despite this limitation, the issues raised by the report remain relevant and provide a useful roadmap to the future of energy complaints in Victoria.

1 While these numbers vary slightly from year to year, they generally fall into the vicinity identified here. In the 2018-19 year, for example, we received 2,156 solar cases overall, of which 573 (27%) were outside of our jurisdiction. See: EWOV, Annual Report 2018-19: 46. https://www.ewov.com.au/files/ewov_2019_annual_report.pdf

Summary of findings

Through our research we found that when it came to projecting future industry growth, the degree of available data varied widely between different forms of technology. Very often where projections did exist, they too varied widely – making it extremely difficult to build a definitive picture of where things are likely to be by 2030, and 2050.

That said, we have attempted to provide at least 'likely' outcomes. We've also attempted to identify barriers for growth and presented those along with our findings. By identifying those barriers, and surmising when they are likely to lessen or fall away, we can be more confident of the kind of growth that various technologies may enjoy. Despite widely varying rates of growth over the next decade, it is not unreasonable to expect that by 2050 solar PV, residential batteries, electric vehicles and home energy management systems will have achieved either high or very high market penetration. Microgrids, virtual power plants and peer-to-peer trading are more difficult to project - but may also achieve high or very high penetration by that time.

We have presented our findings in table form below, followed by an additional table outlining current and projected barriers to growth.

Table 1.
New energy technology penetration and projected growth - Victoria

Technology	Current	Projected: 2020 - 2030	Projected: 2030 - 2050
SOLAR PV	**Moderate** Clean Energy Regulator (CER): 391,935 solar systems under 10 kW since April 2001 Collective generation capacity: 1,363.1 MW Accounts for 17.5% of Victorian dwellings[2]	**Moderate - High** CSIRO moderate growth projection: collective generation capacity of 3,000 MW by 2030[3]	**Very High** CSIRO moderate growth projection: collective generation capacity of 6,000+ MW by 2050[4]

2 "Mapping Australian photovoltaic installations," Australian PV Institute, accessed 15 October 2019. https://pv-map.apvi.org.au/historical#11/-37.8282/144.9646,.

3 Paul Graham, Dongxiao Wang, Julio Braslavsky, & Luke Reedman, *Projections for small-scale embedded technologies*, CSIRO report for AEMO, (2018): 35. https://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/NEM_ESOO/2018/Projections-for-Small-Scale-Embedded-Technologies-Report-by-CSIRO.pdf

4 Ibid.

RESIDENTIAL BATTERIES	**Minimal** CSIRO estimate approximately 200 MWh capacity by end of 2020[5] Smart Energy Council (SEC): Under a high penetration scenario, up to 450,000 storage systems could be installed nation-wide by the end of 2020[6] Note: The SEC estimate seems optimistic, but attempts to measure industry size are hampered by a lack of CER data	**Minimal - Moderate** CSIRO moderate growth projection: approx. 700 MWh by 2030[7]	**High – Very High** CSIRO moderate growth projection: approx. 4,250MWh by 2050[8] Note: Across the NEM, the Moderate CSIRO projection for collective residential battery storage by 2050 is approximately 13,700MWh[9]
ELECTRIC VEHICLES (EVs)	**Very Minimal** Climateworks Australia report that between 2011 and 2017, Victorians bought only 1,324 EVs – which nevertheless made Victoria Australia's leading state for EV purchases over that period[10]	**High** The Clean Energy Finance Corporation (CEFC) has forecast that EV's will account for 50% of all new car sales in Australia by 2030[11]	**Very High** The CEFC has forecast that EV's will account for 100% of all new car sales in Australia by 2040[12] Collectively, EV's are predicted to account for 95% of all vehicles on Australian roads by 2050[13]

5 Paul Graham, Dongxiao Wang, Julio Braslavsky, & Luke Reedman, *Projections for small-scale embedded technologies*, CSIRO report for AEMO, (2018): 41. https://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/NEM_ESOO/2018/Projections-for-Small-Scale-Embedded-Technologies-Report-by-CSIRO.pdf

6 Smart Energy Council, *Australian Energy Storage Market Analysis*, (2018): 1. https://www.smartenergy.org.au/sites/default/files/uploaded-content/field_f_content_file/australian_energy_storage_market_analysis_report_sep18_final.pdf

7 Paul Graham, Dongxiao Wang, Julio Braslavsky, & Luke Reedman, *Projections for small-scale embedded technologies*, CSIRO report for AEMO, (2018): 43. https://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/NEM_ESOO/2018/Projections-for-Small-Scale-Embedded-Technologies-Report-by-CSIRO.pdf

8 Ibid.

9 Ibid.

10 Climateworks Australia, *The State of Electric Vehicles in Australia*, (2018): 7. https://www.climateworksaustralia.org/sites/default/files/documents/publications/climateworks_australia_state_of_electric_vehicles2_june_2018.pdf

11 CEFC, *Clean Energy Snapshot: Australian Electric Vehicle Market Study*, (2018): 7. https://www.cefc.com.au/media/401922/cefc-snapshot-electric-vehicles-jun2018.pdf

12 Ibid.

13 KPMG, *Electric Vehicles: Is the energy sector ready?* (2018): 2. https://assets.kpmg/content/dam/kpmg/au/pdf/2018/electric-vehicles-is-the-energy-sector-ready.pdf

HOME ENERGY MANAGEMENT SYSTEMS (HEMS)	**Very Minimal** HEMS' are still at early adopter stage, as the lack of data on market penetration speaks to the novelty of the technology	**Moderate** As the price of electricity increases, more households are likely to install a HEMS to manage their energy use and maximise benefits As aggregators and 'disruptor' technology enters the market, customers may also utilise a HEMS to monitor exchanges	**Very High** Almost all homes will have a HEMS as P2P trading, VPPs and demand response are potentially widely adopted
MICROGRIDS	**Very Minimal** Microgrids are still in their early days, with the Victorian Government running a *Microgrid Demonstration Initiative* including six projects across the state[14] Distributor-led and university-based microgrid projects have also emerged, notably the Monash Net Zero Initiative[15] (see: Policy Spotlight pg. 42)	**Moderate** It will be standard for distribution-led microgrids to serve remote communities at the fringe of the grid Third-party led microgrids will gain prominence, while almost all universities will operate as microgrids to demonstrate their research and commitment to sustainability	**Moderate - High** Third-parties will own a significant share of the market, establishing microgrids in communities already connected to the grid, that strive to be sustainable

14 "Microgrids," Department of Environment, Land, Water and Planning (DELWP), accessed October 2019. www.energy.vic.gov.au/microgrids

15 "Net Zero Initiative," Monash University, accessed October 2019. https://www.monash.edu/net-zero-initiative

VIRTUAL POWER PLANTS (VPPs)	**Very Minimal** Isolated trials, most notably Bruny Island CONSORT trial 2016-2018[16] (see: Policy Spotlight pg. 57) AEMO, in conjunction with ARENA, have announced the Virtual Power Plant Integration Trial, enrolments commenced 31 July 2019[17]	**Minimal - Moderate** Is dependent on regulatory reform, uptake of residential batteries and/or electric vehicles and technical innovation	**Potentially High - Very High** Is dependent on regulatory reform, uptake of residential batteries and/or electric vehicles and technical innovation
PEER TO PEER TRADING (P2P)	**Very Minimal** RENeW Nexus P2P Plan – a 2018 trial in Western Australia involving 40 households in Fremantle. Curtin University due to report on the results[18]	**Minimal – Moderate** Is dependent on regulatory reform, uptake of residential batteries and/or electric vehicles and technical innovation	**Potentially High - Very High** Is dependent on regulatory reform, uptake of residential batteries and/or electric vehicles and technical innovation

16 “CONSORT Bruny Island Battery Trial,” Bruny Battery Trial, accessed November 2019. http://brunybatterytrial.org/

17 “AEMO Virtual Power Plant Demonstrations,” Australian Renewable Energy Agency (ARENA), accessed December 2019. https://arena.gov.au/projects/aemo-virtual-power-plant-demonstrations/

18 “RENeW Nexus (P2P) Plan,” Synergy, accessed December 2019. https://www.synergy.net.au/Our-energy/Future-energy/RENeW-Nexus-Trial

Table 2.

New energy technology barriers to growth - Victoria

Technology	Current	Projected: 2020 - 2030	Projected: 2030 - 2050
Solar PV	› Cost › Changing government policies/initiatives › Housing status* › Urban density and dwelling type (e.g. apartments) › Lack of information about the potential of solar and the installation process › Absence of a feed-in tariff for embedded network customers **Customers who are private renters or public housing tenants.*	› Cost (less than current, but still a barrier) › Changing government policies/initiatives › Housing status › Urban density and dwelling type (e.g. apartments) › Residential export restrictions	› Changing government policies/initiatives › Housing status › Urban density and dwelling type (e.g. apartments) › Residential export restrictions
Residential Batteries	› Cost › Safety concerns › Australian Standard AS/NZS 5139:2019 › Generous solar feed-in tariffs › Housing status	› Cost (less than current, but still a barrier) › Growth of electric vehicles as a storage alternative › Housing status	› Growth of electric vehicles (EV) as a storage alternative › Housing status
Electric Vehicles (EVs)	› Cost › Lack of charging infrastructure › Concerns over limited battery life › Perceived as 'futuristic' i.e. lack of buyer comfort	› Possible lack of charging infrastructure	› None. Likely to be no alternative
Home energy management systems (HEMS)	› Cost › Scepticism surrounding the benefits of a HEMS › Fear of data security risks › High level of user knowledge and engagement required (for non-automated HEMS')	› Cost › Scepticism surrounding the benefits of a HEMS › Fear of data security risks. › High level of user knowledge and engagement required (for non-automated HEMS')	› Scepticism surrounding the benefits of a HEMS › Fear of data security risks

Microgrids	› Cost › Housing status › Lack of investment incentives – third-party investors aren't able to capture a share of the public value of a microgrid › Community distrust in energy companies › 'Prosumer' knowledge and engagement required › Existing barriers to solar PV and battery storage uptake	› Cost › Housing status › Lack of investment incentives – third-party investors aren't able to capture a share of the public value of a microgrid › Community distrust in energy companies	› Housing status › Lack of investment incentives – third-party investors aren't able to capture a share of the public value of a microgrid › Community distrust in energy companies
Virtual Power Plants (VPPs)	› Lack of prosumer resources/infrastructure › Regulatory barriers › Lack of consumer knowledge/education › Requires high engagement from prosumer › Lack of prosumer faith/trust in collective engagement	› Lack of prosumer resources/infrastructure › Regulatory barriers › Lack of consumer knowledge/education › Requires high engagement from prosumer › Lack of prosumer faith/trust in collective engagement	› All barriers may potentially be resolved, could be highly automated process
Peer to Peer trading (P2P)	› Lack of prosumer resources/infrastructure › Significant regulatory barriers › Lack of consumer knowledge education › Requires high engagement from prosumer	› Lack of prosumer resources/infrastructure › Significant regulatory barriers › Lack of consumer knowledge/education › Requires high engagement from prosumer	› All barriers may potentially be resolved, could be highly automated process

Having projected the potential growth of these technologies, and therefore how the energy system may look in the decades ahead, we then turned our minds to the potential kinds of complaints they may generate – or in some cases, already are.

Further, we considered which do or would currently fall into our current jurisdiction - and which will, or will not. These are represented in the table below, with those not falling into jurisdiction highlighted in orange. Those which do, (or would if we received them today), are highlighted blue.

Table 3.

New energy technology heads of complaint

Technology	Existing and/or anticipated head of complaint
Solar PV	• Misleading marketing and high-pressure sales • Problematic leasing agreements and unfair contract terms • Delays in the solar pre-approval process • Failed grid connections/poor installation • Delays in configuring a customer's meter for solar • Technical product faults and quality issues • Billing errors, including incorrect feed-in tariffs • Solar installation and supply business closures • Local government planning that increases urban density and overshadows existing homes
Residential Batteries	• Misleading marketing and high-pressure sales • Failed solar and/or grid connections/poor installation • Technical product faults and quality issues • Billing errors, including incorrect feed-in tariffs • Functional issues from interface with HEMS, VPPs, P2P platforms or microgrids
Electric Vehicles	• Misleading marketing and high-pressure sales • Technical product faults and quality issues • Billing errors, including incorrect feed-in tariffs • Functional issues from interface with HEMS, VPPs, P2P platforms or microgrids
HEMS	• Customer privacy concerns about data security risks • Inaccuracies in data (especially for those integrated with VPPs and P2P trading) • Product faults and communication errors that result in missed savings • Compensation claims for missed savings • Unsuccessful integration with home appliances
Microgrids	• A lack of customer consent in the transition to a distributor-run microgrid • Unclear roles and responsibilities in the management of the microgrid • Billing and tariff disputes • Reliability issues related to the generation source • Supply issues from faults in the microgrid infrastructure • Functional issues from in-home interfaces and/or the HEMS • Unfair contracts and leasing agreements (for customers that have to finance the installation of microgrid components) • Poor implementation of demand response mechanisms
Virtual Power Plants (VPPs)	• Functional issues from interface with HEMS • Software faults potentially causing financial loss • Complaints around unexpectedly poor returns
Peer to Peer trading (P2P)	• Functional issues from interface with HEMS • Software faults potentially causing financial loss • Complaints around unexpectedly poor returns

- Blue = In EWOV's current jurisdiction
- Orange = Out of EWOV's current jurisdiction

Chapter One: Residential Solar PV

FAST FACTS

- Residential Solar PV is expected to provide 3,000MW of generation capacity in Victoria by 2030, and over 6,000MW by 2050. In 2016 it provided less than 1,000MW.
- Anticipated heads of complaint include access to benefits (feed-in tariffs) and technology faults.
- EWOV currently covers energy retailers and distributors – not solar installers. Approximately 30% of the solar complaints we currently receive fall outside of our jurisdiction, most of those are installation related complaints.

Introduction

Residential customers are increasingly turning to solar photovoltaic (PV) [19] energy in an effort to reduce electricity bills, to safeguard themselves from future electricity price increases, and to minimise their environmental impact.[20] Some solar customers are also motivated by a desire to be self-sufficient from the grid - although this driver is somewhat illusory, as their homes necessarily remain connected to the grid for supply when their panels aren't generating power.[21]

Solar PV is categorised by generation capacity. Small-scale systems generate less than 100kW of power, and large-scale systems are those that generate more than 100kW. Within the small-scale category, residential solar systems tend to fall within a modest 0-10kW of generation capacity.[22] However, generation capacity is not a guarantee of the amount of power a customer can expect to get from their system – this is contingent on how much sunlight is available, the position of the panel, its condition, and even how clean it is.[23]

It is worth noting that generation capacity (kW) also differs from kilowatt *hours* (kWh) – the amount of energy used over a given time. For example, a typical PV system on a Victorian home may have a generation capacity of 4kW, which depending on conditions would produce around 14.5kWh of energy per day.

This chapter focuses on solar PV systems that generate electricity for use in the home, as distinct from solar thermal energy used to create hot water. Solar hot-water systems use heat-absorbent solar collectors or tubes mounted on the roof of a house, connected to a water storage unit. As the sun heats the tubes, water within them is circulated through the system, providing hot water to the house.[24]

Solar hot water systems are less prevalent than solar PV. As of December 2018, approximately 2 million residential solar PV systems had been installed throughout Australia, compared to 1.16 million solar hot water heaters.[25,26]

19 Throughout this chapter, solar photovoltaic (PV) will be used interchangeably with the term 'solar' alone.
20 Adam McHugh, "Are solar panels a middle-class purchase? This survey says yes," *The Conversation,* (2018). https://theconversation.com/are-solar-panels-a-middle-class-purchase-this-survey-says-yes-97614
21 Ibid.
22 Australian PV Institute, *National survey report of PV power applications in Australia 2018,* (2019): 5. http://apvi.org.au/wp-content/uploads/2019/08/NSR-Guidelines-2019_AUSTRALIA_AU.pdf
23 "What is the difference between power and energy?" Solar Quotes, accessed 31 October 2019. https://www.solarquotes.com.au/good-solar-guide/power-energy-difference/
24 "Solar water heaters," Energy Rating, accessed 31 October 2019. http://www.energyrating.gov.au/products/water-heaters/solar-water-heaters
25 "Solar energy," Clean Energy Council, accessed October 2019. https://www.cleanenergycouncil.org.au/resources/technologies/solar-energy
26 "Solar water heating," Clean Energy Council, accessed October 2019. https://www.cleanenergycouncil.org.au/resources/technologies/solar-water-heating

Nonetheless, installations continue to steadily increase, with Victoria leading other Australian states in both the number of solar PV and solar hot water heater installations per month.[27,28] Despite this, Victoria still has a long way to go. Overall, Queensland and New South Wales have the highest installed PV generation capacity, while Queensland and South Australia have the highest market penetration of rooftop solar.[29]

Given Australia is "one of the sunniest countries in the world"[30], solar energy has the potential to be a primary source of electricity generation. For households, this is particularly relevant in terms of distributed energy resources located 'behind the meter'. In light of high electricity prices, and as the cost of solar PV decreases and battery storage technology improves, residential solar PV sales are expected to grow strongly.[31]

Growth in residential solar is likely to occur alongside significant large-scale technology investment in solar, which will dwarf the supply that households will contribute. Although large-scale solar could provide affordable renewable power and ensure grid stability, households may continue to invest in their own residential PV – driven by factors such as market distrust. If market distrust deepens, consumers are likely to keep investing even if it's not in the grid's interest.

How these challenges will be managed is yet to be determined. Market operators may impose restrictions on solar generated behind the meter, which will undoubtably lead to consumer complaints. As such, with the expected proliferation of residential solar, adequate consumer protections are needed to fill anticipated gaps and those already emerging through EWOV's dispute resolution process.

Market penetration in Victoria

Victoria's position as the leading state in monthly solar PV installations is largely due to the government-funded *Solar Homes* package, which provides a rebate of up to $2,225 for solar PV installations to eligible homeowners and renters.[32]

In Victoria, the market penetration rate of residential solar PV has increased from 11% in the 2014-15 financial year up to 14.2% for the 2017-18 financial year.[33] As the rate of solar installations continues to steadily increase, so too has the generating capacity. As of June 2019, the average system size in Australia has risen to 8kW.[34]

Data from the Clean Energy Regulator indicates that 391,935 solar systems under 10kW have been installed in Victoria since April 2001.[35],[36] This equates to a total generation capacity of 1,363.1MW, and accounts for 17.5% of Victorian dwellings.[37]

This is a significant proportion of the Victorian population, and if solar PV installations continue to increase at this rate, a significant proportion of Victoria's electricity can be expected to come from residential solar. Amidst this trend of positive growth, consumers will face many challenges in accessing and installing solar PV.

27 "Solar water heating," Clean Energy Council, accessed October 2019. https://www.cleanenergycouncil.org.au/resources/technologies/solar-water-heating
28 Australian Energy Council, *Solar report: Quarter 2 2019,* (2019): 4. https://www.energycouncil.com.au/media/16671/australian-energy-council-solar-report_-june-2019_final.pdf
29 "Mapping Australian photovoltaic installations," Australian PV Institute, accessed 31 October 2019. https://pv-map.apvi.org.au/historical#11/-37.8282/144.9646
30 "Solar energy," Clean Energy Council, accessed 2019. https://www.cleanenergycouncil.org.au/resources/technologies/solar-energy
31 Rohan Best, Paul J Burke and Shuhei Nishitateno, "Evaluating the effectiveness of Australia's small-scale renewable energy scheme for rooftop solar," *CCEP Working Paper 1903,* (Crawford School of Public Policy, The Australian National University 2019): 2. https://ccep.crawford.anu.edu.au/sites/default/files/publication/ccep_crawford_anu_edu_au/2019-08/wp_1903.pdf
32 "Solar panel rebate," Solar Victoria, accessed October 2019. https://www.solar.vic.gov.au/solar-panel-rebate
33 Australian Energy Council, *Solar report: Quarter 2 2019,* (2019): 9. https://www.energycouncil.com.au/media/16671/australian-energy-council-solar-report_-june-2019_final.pdf
34 Ibid, 3.
35 Accurate as of June 2019.
36 "Postcode data for small-scale installations: June 2019," Clean Energy Regulator, accessed October 2019. http://www.cleanenergyregulator.gov.au/RET/Forms-and-resources/Postcode-data-for-small-scale-installations
37 "Mapping Australian photovoltaic installations," Ausatralian PV Institute, accessed 15 October 2019. https://pv-map.apvi.org.au/historical#11/-37.8282/144.9646

Identified barriers to uptake

Despite the steady growth in residential solar, numerous barriers to uptake exist.

Costs

Up-front installation costs remain the primary barrier, preventing many would-be solar users from transitioning to renewable energy. Average installation costs vary from $3,130 for a 1.5kW system, to $10,540 for a 10kW system.[38]

While the cost of installation has declined over time, this is still a significant and unaffordable sum for many Victorians. Ironically, while solar can play a key role in reducing energy bills, it is usually only those who are affluent enough to afford the up-front installation costs that benefit from this reduction.

The *Solar Homes* package is designed to address this barrier, but anticipating and meeting demand for the program was arguably more complex than expected. Phase 1 of the program initially allocated 24,000 rebates for the 2018-19 financial year, but surged to 32,000 applications before the program was temporarily put on hold while development was taking place to launch the new program as part of the Government's election commitment.[39] To address this issue, Phase 2 was upgraded to include 63,416 rebates for 2019-20 financial year, yet extremely strong demand continued to pose a challenge. For example, when the rebate was re-opened for August 2019, the monthly allocation ran out in under two hours.[40]

Following this, the shortfall of rebates was addressed through a significant increase in rebates and other measures to ensure a consistent supply of rebates were available throughout the year, meaning that consumer demand is now being met.

While the package is indeed stimulating growth, during the period of industry instability between May and August 2019 when rebates were in short supply, some customers who intended to install solar may have held off until more rebates became available. This adversely impacted the solar industry in the short term with uncertainty putting a number of small business solar installers at risk.[41] When solar installation businesses close – as will be discussed later in the chapter – customers are in turn affected. A key challenge for programs of this nature is to ensure they are designed to support a sustainable and prolonged expansion of the industry.

While power purchase agreements and solar leases exist to minimise up-front costs and encourage investment in solar, these arrangements can be problematic when poorly structured.[42] Alternatively, many solar companies work with finance providers that fund the up-front installation costs, yet these providers are often unregulated and leave customers vulnerable to substantial credit repayments which can be beyond their means.[43]

Housing status

Housing status is another major barrier to uptake, as renters are unable to install solar. Solar PV is not a rational investment for landlords who would receive little to no benefit from the reduction in electricity bills.[44] Urban

38 "Average solar panel costs by city & system size," Solar Choice, accessed October 2019. https://www.solarchoice.net.au/blog/solar-power-system-prices

39 Liz Hobday, "Victorian solar rebates never had hope of meeting demand, figures show," *ABC News,* (2019). https://www.abc.net.au/news/2019-05-28/victorian-solar-rebates-never-had-hope-of-meeting-demand/11156712

40 "Victorian solar industry in crisis as August solar homes rebates run out within hours," Clean Energy Council, accessed October 2019. https://www.cleanenergycouncil.org.au/news/victorian-solar-industry-in-crisis-as-august-solar-homes-rebates-run-out-within-hours

41 Ibid.

42 Consumer Action Law Centre, *Sunny side up: Strengthening the consumer protection regime for solar panels in Victoria,* (2019): 62. https://consumeraction.org.au/wp-content/uploads/2019/04/1904_Sunny-Side-Up-Report_FINAL_WEB.pdf

43 Ibid, 35.

44 Rohan Best, Paul J Burke and Shuhei Nishitateno, "Understanding the determinants of rooftop solar installation: Evidence from household surveys in Australia," *CCEP working paper 1902* (Crawford School of Public Policy, The Australian National University 2019): 8. https://ccep.crawford.anu.edu.au/sites/default/files/publication/ccep_crawford_anu_edu_au/2019-04/1902_0.pdf

density can also act as a barrier to uptake, as those who live in apartment buildings are less likely to have solar panels due to limited roof space and the joint-ownership of that roof space between the building dwellers.[45] These concerns may be overcome as aggregators enter the market and provide new opportunities for shared solar PV assets. Some customers in dense urban areas may also be concerned about overshadowing from neighbouring buildings.

Customers living in embedded networks face a unique challenge when it comes to exporting solar PV as embedded networks are not required to provide a feed-in tariff.[46] The absence of a feed-in tariff can act as a disincentive for would-be solar consumers. The viability of solar for customers in embedded networks is therefore subject to the effectiveness of the PV system, for example, and whether it is designed primarily to maximise self-consumption.[47]

On the other hand, the absence of a feed-in tariff in embedded networks may present market opportunities for 'disruptors' seeking to trial peer-to-peer trading and virtual power plants. Solar customers in embedded networks could sell the energy they generate to other participants in a peer-to-peer trial, or if participating in a virtual power plant, receive a feed-in tariff from the plant operator. Of course, it should be noted that these technologies are still in the very early trial stages as discussed in *Chapter 5 – The Future of DER Storage: VPPs and P2P Trading* (p. 51). So, while they may eventually become an option for embedded network customers, they are not realistic in the short to medium term.

Anticipated future improvements

Customers may anticipate future improvements in solar PV (and associated technologies), and resist installing solar until they feel confident that an improvement has occurred.[48] For example, the expectation that battery storage will become more affordable may prevent customers from installing solar PV until this happens, as it will enable the customer to maximise the benefits of their system by utilising almost all of the energy generated during the day. For customers who receive little, or no feed-in tariff (such as embedded network customers) this consideration could play a key inhibiting role. See *Chapter 2 – Residential Batteries* (p. 24) for an overview of the current and projected battery landscape.

Lack of information

Notably, a study that interviewed City of Melbourne residents found that a lack of information about rooftop solar can act as a barrier to installation.[49] Coupled with the tendency of consumers to distrust information provided by their retailers and third-party solar installers, this speaks to the importance of fostering trust and providing impartial sources of information, (by government and non-government organisations, for example).

45 Rohan Best, Paul J Burke and Shuhei Nishitateno, "Understanding the determinants of rooftop solar installation: Evidence from household surveys in Australia," *CCEP working paper 1902* (Crawford School of Public Policy, The Australian National University 2019): 9. https://ccep.crawford.anu.edu.au/sites/default/files/publication/ccep_crawford_anu_edu_au/2019-04/1902_0.pdf

46 Section 40F(1) of the *Electricity Industry Act 2000* specifies that a qualifying customer means a person who "purchases electricity from that relevant licensee or small retail licensee". As embedded networks are exempt from holding a licence to sell electricity, their customers do not qualify for a feed-in tariff.

47 Mike Roberts, Anna Bruce and Ian MacGill, "Collective prosumerism: Accessing the potential of embedded networks to increase the deployment of distributed generation on Australian apartment buildings," *IEEE International Energy Conference,* (2018): 2. http://unsworks.unsw.edu.au/fapi/datastream/unsworks:50745/bin8da51ea6-91d5-4498-810d-17a1d82542ca?view=true

48 Colmar Brunton, *Community attitudes and barriers to rooftop solar: Final report*, prepared for City of Melbourne, (2015): 39. https://www.melbourne.vic.gov.au/sitecollectiondocuments/attitudes-rooftop-solar-final-report.pdf

49 Ibid, 37.

Projected penetration by 2030-2050

While there has been a steady increase in residential solar PV uptake up to 2019 (largely driven by high electricity retail prices and government subsidies) a period of slower growth is expected to follow from 2020 to 2030-31 in 'moderate' modelling proposed by the CSIRO.[50] This would likely occur if retail electricity prices drop as more large-scale renewable systems are deployed, and subsidies (such as the small-scale technology system subsidy), are no longer available.

Following this, from 2030 onwards solar uptake is anticipated to increase again as the solar payback period – the time it takes for a PV system to 'pay itself off' – falls due to "assumed rising retail prices".[51] If these patterns occur, the total generating capacity of rooftop solar in Victoria will likely reach 3,000MW by 2030, and exceed 6,000MW by 2050.[52] Similarly, the capital costs for rooftop solar should drop from around $1500 per kW in 2018 to $800 per kW by 2030, and $600 per kW by 2050.[53]

The proliferation of solar is also expected to increase as battery storage technology becomes more widely available and cost effective, (whether in the form of residential batteries or electric vehicles), as batteries enable customers to utilise more of the electricity generated by their system. Additionally, a rise in household income and growth in the customer base should have a positive impact on solar uptake – although these factors can be undermined by falling trends in home ownership.[54]

Researchers from the Institute for Sustainable Futures have mapped the potential for residential solar PV, and found that Victoria has the second highest potential in Australia. In Victoria, the key areas for solar generation are the urban local government areas surrounding Melbourne, due to higher building density and larger homes that equate to more roof space for solar, without the drawbacks of increased density in inner-city areas. Greater Bendigo and Ballarat have the most potential in regional Victoria, followed by Greater Shepparton and Mildura.[55]

If the challenges surrounding solar PV uptake are overcome, Victoria will play a significant role in behind-the-meter electricity generation by 2050.

However, it is worth noting that despite the optimism about residential solar PV, the emergence of large-scale solar farms may disincentivise residential solar uptake. Currently, Victoria has five solar farms in operation, with another four under construction.[56]

Table 4.

Solar farms under construction in victoria

Operating	Under construction
Gannawarra Solar Farm (50MW)	Winton Solar Farm (98.8MW)
Wemen Solar Farm (88MW)	Yatpool Solar Park (112MW)
Bannerton Solar Park (88MW)	Carwarp Solar Farm (121.6MW)
Karadoc Solar Farm (90MW)	Kiamal Solar Farm – Stage 1 (1200MW)
Numurkah Solar Farm (100MW)	

50 Paul Graham, Dongxiao Wang, Julio Braslavsky, & Luke Reedman, *Projections for small-scale embedded technologies*, CSIRO report for AEMO, (2018). https://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/NEM_ESOO/2018/Projections-for-Small-Scale-Embedded-Technologies-Report-by-CSIRO.pdf

51 Ibid, 35.

52 Ibid, 36.

53 Ibid, 23.

54 Ibid, 35.

55 Mike Roberts et al., *How much rooftop solar can be installed in Australia?*, report for the CEFC and the Property Council of Australia, (2019): 19. http://apvi.org.au/wp-content/uploads/2019/06/isf-rooftop-solar-potential-report-final_.pdf

56 "A guide to Solar farms Australia," Canstar Blue, accessed October 2019. https://www.canstarblue.com.au/solar-power/solar-farms-australia/

As the cost of large-scale solar generation decreases[57], and as states seek to meet their large-scale renewable energy targets[58], it is likely that investment at this scale will occupy a significant share of the energy market going forward. If market operators prioritise large scale solar, state-wide limits may be placed on the amount of residential solar that can be installed or exported in order to ensure grid stability. This will adversely impact customers who want to install residential solar, but also those with existing systems who could see their feed-in tariffs significantly reduced.

How residential solar PV will interact with the energy grid

Infrastructure challenges could hinder the anticipated proliferation of solar PV. The existing electricity grid is designed to accommodate large-scale, centralized generation and one-way transmission. Residential solar PV contradicts this process by 'feeding' electricity back into the grid when generation exceeds consumption. While the current penetration of residential solar is insufficient to significantly overload the grid, as more customers adopt the technology increased pressure will be placed on local networks further challenging distribution business models.

If too much electricity is fed back into the grid at one time, this increases the risk of a voltage limit breach in the local network. Spikes in voltage can damage the power lines and a customer's infrastructure, and may also result in temporary blackouts as the voltage limit is restored.[59] Feed-in electricity may also result in failures of substation transformers because of thermal overload. EWOV expects these consequences to be a source of numerous customer complaints.

In light of this effect, grid operators may seek to prevent solar exports as more people install solar PV at home. The Clean Energy Council have noted an example from Hawaii, where the grid operator has "imposed a zero-export policy on all new residential and commercial rooftop solar", and suggested that due to networks with high solar penetration operators could implement a similar constraint.[60] If such measures were ever enforced in Victoria, this would likely have immediate consumer back lash, followed by an adverse effect on the uptake of solar PV. Customers would no longer be incentivised by the availability of feed-in tariffs for exported energy.

To minimise this risk, technology standards have been implemented by AEMO as of 1 December 2019. While almost all solar inverters currently installed are able to "sense grid conditions" and automatically constrain a customer's exports when required (known as a 'volt-watt and volt-var' response),[61] these power quality response settings must now be enabled by default in all inverters.[62]

Solar PV can also be installed as a stand-alone system for 'off grid' homes. In particular, residential solar is likely to form a significant component of microgrids (discussed in Chapter 3, p.34) as they increase in prevalence.

Despite all of these measures, and despite all of its positive potential – the fact remains that solar energy is dependent on available sunlight. Solar alone provides an intermittent and unreliable supply of electricity. Residential solar PV will almost always need to be coupled with additional sources of energy and battery storage systems, in particular, to ensure reliability of supply. Eventually, Virtual Power Plants (see Chapter 5, p.51) will also help strengthen the distribution of solar-generated electricity.

The complexity created by integration of solar technology to the grid inevitably leads to mistakes, errors and technical failures – resulting in customer complaints.

57 "Large-scale solar," ARENA, accessed October 2019. https://arena.gov.au/renewable-energy/what-is-large-scale-solar/

58 "The Renewable Energy Target (RET) scheme," Australian Government Department of Environment and Energy, accessed October 2019. https://www.environment.gov.au/climate-change/government/renewable-energy-target-scheme

59 Monishka Narayan, "Could the solar boom bust the grid," *Energy Insider,* Energy Networks Australia, (2019). https://www.energynetworks.com.au/news/energy-insider/could-the-solar-boom-bust-the-grid/

60 Clean Energy Council, *The distributed energy resources revolution: A roadmap for Australia's enormous rooftop solar and battery potential,* (2019): 8. https://www.cleanenergycouncil.org.au/resources/resources-hub/the-distributed-energy-resources-revolution-a-roadmap-for-australias-enormous-rooftop-solar-and-battery-potential

61 Ibid, 9.

62 AEMO, *DER register overview & Victorian DNSP implementation – Victorian installers seminars* [presentation], 12 & 13 November (2019). https://www.aemo.com.au/-/media/Files/Electricity/NEM/DER/2019/DER-Register-Implementation/Introducing-DER-Register-to-VIC-Solar-Installers_12-November-Werribee.pdf

How residential solar PV can (and does) go wrong

Solar PV is uniquely positioned among the renewable energy technologies discussed in this report, as it has been widely used by consumers for some time. EWOV's experience with solar complaints provides valuable insight into areas where customer protections for new energy technology may be necessary, to minimise consumer detriment.

A number of solar related complaints received by EWOV to date, have resulted from miscommunication between various parties involved from solar installation to billing. In the 2018-19 financial year, EWOV received 242 cases about the general feed-in tariff, and 368 cases about a delay in upgrading a customer's existing connection to solar. In most of these cases, the appropriate paperwork had either not been submitted to the retailer and/or distributor, or was incorrectly filled out.

Further, the Consumer Action Law Centre (Consumer Action) has identified the following issues experienced by existing solar customers: "*failure to install or connect to the grid properly, unregulated finance arrangements, misleading and high-pressure unsolicited sales, product faults and poor performance, a lack of affordable dispute resolution, business closures, and solar power purchase agreements (PPAs)*".[63]

These problems directly contribute to solar complaints, that may or may not fall within EWOV's jurisdiction.

EWOV's jurisdiction

In the last financial year, 30% of the solar complaints received have been out of EWOV's jurisdiction.

EWOV is unable to resolve a complaint if the party implicated is not a member of our scheme. For example, if a solar installer is responsible for an error, then the complaint is outside EWOV's jurisdiction and we are unable to assist the customer. Conversely, if the implicated party is a member of EWOV, (for example the distributor or licensed retailer), then we can assist the customer. Complexity arises when it is unclear which party is at fault.

We receive complaints regarding product faults, such as a solar inverter not working properly, and are also aware that poor quality solar panels fail to produce their advertised output and can rapidly degrade over time.[64]

In the 2018-19 financial year, we received 13 complaints that were deemed out of jurisdiction because the issue related to a product fault, and another 440 complaints relating to a solar installer or solar installation. While product faults are not always out of jurisdiction, the 453 complaints are outside EWOV's jurisdiction as they relate to a product installed by a non-scheme participant, rather than the sale and supply of energy that a retailer or distributor is accountable for under their licence, and as an EWOV member. However, complaints may first present to EWOV as an issue relating to a customer's bill, and may progress through our complaint handling process until the true cause of the complaint is identified. When it is identified as being a product issue that is outside an EWOV member's control, the complaint is referred onto the Victorian Civil and Administrative Tribunal (VCAT) or Consumer Affairs Victoria (CAV) for review under the *Australian Consumer Law*.[65]

Embedded networks

Our case portfolio also illustrates the challenges faced by customers in embedded networks who are seeking installation of solar panels. Poor communication on behalf of the embedded network and/or billing agent can result in customers not knowing they require distributor pre-approval before installing a solar system.

Additionally, customers who have already installed solar and are used to receiving a feed-in tariff risk losing their feed-in tariff if their apartment block or group of units decide to become an embedded network. As previously mentioned, in the case of solar, embedded network owners do not have to provide a feed-in tariff.

63 Consumer Action Law Centre, *Sunny side up: Strengthening the consumer protection regime for solar panels in Victoria,* (2019). https://consumeraction.org.au/wp-content/uploads/2019/04/1904_Sunny-Side-Up-Report_FINAL_WEB.pdf

64 Liz Hobday and Sybilla Gross, "Australia's obsession with cheap solar is derailing the market, insiders say," *ABC News,* 27 May 2019. https://www.abc.net.au/news/2019-05-27/australias-obsession-with-cheap-solar-derailing-market-insiders/11139856

65 Consumer Action Law Centre, *Sunny side up: Strengthening the consumer protection regime for solar panels in Victoria,* (2019): 17. https://consumeraction.org.au/wp-content/uploads/2019/04/1904_Sunny-Side-Up-Report_FINAL_WEB.pdf

Solar business closure

Solar installation and supply businesses that suddenly close down also generate complaints, and are expected to continue doing so well into the future. In the current financial year to the date of writing, (5/12/19), EWOV had received four solar cases about a business closure that were deemed out of jurisdiction because the business wasn't required to be a member of EWOV.

Compared to the 2018-19 financial year, (in which we only received one case of this nature), this is an increase that echoes recent activity at the policy level. In April 2019 alone, at least three solar companies closed when the Solar Homes Rebate Program was temporarily frozen.[66] This is problematic as it leaves customers unable to resolve their complaint, given the absence of a responsible party. It also highlights the increased complexity in managing an energy landscape where multiple parties and policy decisions impact the customer experience.

Developments / local government planning

New multi-level apartment buildings in urban areas could overshadow existing homes with solar panels, rendering them less effective – and reports of this are already emerging. For example, homeowners have been left powerless after VCAT ruled that overshadowing is an acceptable outcome for a proposal for a 10-story development next-to their home.[67] The building will significantly limit the amount of sunlight available during the day, which in turn will limit the household's ability to reduce their electricity bills.

Irresponsible lending and misleading marketing

Because of the significant up-front installation costs of solar, some customers may take out a bank loan or enter an unregulated finance arrangement to cover the costs. For these customers, the perceived effectiveness of a solar panel compared to the *actual* benefits they will receive could not be more important. However, these benefits can be overstated by marketing and solar installation companies who may promise free electricity and unrealistically short payback periods.[68] Considering that many customers are often confused about the expected output of a solar system (such as the difference between the kW of a system and the kWh of power it will generate), and may also have limited knowledge about export limitations, misleading marketing can be deeply problematic.

In the United Kingdom, at least 2,000 customers have lodged complaints with the Financial Services Ombudsman, regarding loans taken to install solar panels under misleading advice from marketing and solar installation businesses.[69] These customers now face significant debts because the solar they installed did not provide the returns they were promised. Such issues highlight how financial and energy matters converge, and how influential – and damaging – misleading marketing and irresponsible lending in the solar industry can be.

The above examples about how residential solar PV can go wrong serve to illustrate the importance of effective dispute resolution for customers of new energy technology. Even though solar is already commonplace in the energy market, our case handling has shown that customers remain vulnerable to numerous risks. Ultimately, this reinforces the need to think ahead and implement customer safeguards *before* new energy technologies emerge.

66 Cheryl Hall and Bridget Rollason, "Victorian solar companies reeling after popular rebate scheme halted temporarily," *ABC News,* 25 April 2019. https://www.abc.net.au/news/2019-04-25/vic-solar-installer-staff-laid-off-after-temporary-halt-rebate/11045054

67 Jim Malo, "Proposed Brunswick apartment tower could overshadow elderly neighbour's solar panels, making them less effective," *Domain,* 17 November 2019. https://www.domain.com.au/news/proposed-brunswick-apartment-tower-could-overshadow-elderly-neighbours-solar-panels-making-them-less-effective-909131/

68 "Misleading claims about solar," DELWP: Renewable Energy, (2017). https://www.energy.vic.gov.au/renewable-energy/victorian-feed-in-tariff/whats-involved-in-going-solar/misleading-claims-about-solar

69 Ed Hanson, "Solar panels: Thousands of customers complain," *BBC News Online,* 9 September 2019. https://www.bbc.com/news/uk-england-49566130

CASE STUDY

Solar complaint is out of jurisdiction
"Alex" [2019/906 and 2019/909]

Alex noticed that his solar panels were not working around January 2018. He raised this issue with his distribution company, who advised that his inverter was faulty and had not been working properly for two years.

He also raised the issue with his retailer in March 2018. Following this, the retailer repaired the solar system and issued Alex with bills totalling $2,140. Alex did not pay this because he believed the panels should be under warranty. Indeed, his distribution company advised him that because his panels were never properly activated, they should still be under warranty. His retailer, on the other hand, asserted that because Alex did not raise the matter with them for two years, and because his panels worked *intermittently* throughout this time, the warranty had expired.

Alex received letters and phone calls from a debt collection agency seeking payment for the bill. In February 2019, Alex lodged a complaint with EWOV wanting to have the debt waived because of the lost solar credits resulting from his faulty inverter.

At first, our legal advisor noted that it was not clear if Alex's case was in EWOV's jurisdiction. While solar installation is not an activity covered by the retailer's licence to sell electricity (which makes claims about equipment failure and faulty inverters out of EWOV's jurisdiction), Alex's claim for a loss of solar credits may be covered by their licence as it related to a customer's bill.

During the Investigation the retailer maintained their position that Alex should have raised the matter with them when he first noticed that solar credits were not applied. Alex also confirmed to us that he was aware that he was not receiving solar credits in 2016 and 2017 because this was reflected in his bills. This made the element of his claim for lost solar credits out of EWOV's jurisdiction because Alex had been aware of the issue for over 12 months. Furthermore, we concluded that because the lost solar credits directly related to faulty equipment, it was out of jurisdiction.

As such, it was a whole three months after Alex's case was initially registered that we were able to deem it out of jurisdiction and refer Alex on to Consumer Affairs Victoria.

Table 5.

Summary table – residential solar PV

SOLAR PV	Current Market Penetration	Projected: 2020 – 2030	Projected: 2030 - 2050
	Moderate Clean Energy Regulator: 391,935 solar systems under 10 kW since April 2001 Collective generation capacity: 1363.1 MW Accounts for 17.5% of Victorian dwellings[70]	**Moderate - High** CSIRO moderate growth projection: collective generation capacity of 3000 MW by 2030[71]	**Very High** CSIRO moderate growth projection: collective generation capacity of 6000+ MW by 2050[72]
	Barriers to Growth		
	› Cost › Changing government policies/initiatives › Housing status (i.e. renters) › Urban density and dwelling type (e.g. apartments) › Lack of information about the potential of solar and the installation process › Absence of a feed-in tariff for embedded network customers	› Cost (less than current, but still a barrier) › Changing government policies/initiatives › Housing status › Urban density and dwelling type (e.g. apartments) › Residential export restrictions	› Changing government policies/initiatives › Housing status › Urban density and dwelling type (e.g. apartments) › Residential export restrictions
	Existing/anticipated heads of complaint*		
	• Misleading marketing and high-pressure sales • Problematic leasing agreements and unfair contract terms • Delays in the solar pre-approval process • Failed grid connections/poor installation • Delays in configuring a customer's meter for solar • Technical product faults and quality issues • Billing errors, including incorrect feed-in tariffs • Solar installation and supply business closures • Local government planning that increases urban density and overshadows existing homes		

- Blue = In EWOV's current jurisdiction
- Orange = Out of EWOV's current jurisdiction

70 "Mapping Australian photovoltaic installations," Australian PV Institute, accessed 15 October 2019. https://pv-map.apvi.org.au/historical#11/-37.8282/144.9646

71 Paul Graham, Dongxiao Wang, Julio Braslavsky, & Luke Reedman, *Projections for small-scale embedded technologies*, CSIRO report for AEMO, (2018): 35. https://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/NEM_ESOO/2018/Projections-for-Small-Scale-Embedded-Technologies-Report-by-CSIRO.pdf

72 Ibid.

Chapter Two: Residential Batteries

FAST FACTS

- Residential batteries do not have high market penetration in Victoria, but this is expected to change as battery prices (and therefore, the battery payback periods), reduce.
- While definitive figures are surprisingly difficult to find, there is a consensus that battery installations increased nationally from 7,500 in 2016 to 20,000 in 2017, marking clear upward growth.
- Depending on the uptake and use of electric vehicles (EV) and/or the degree to which energy storage needs are met by large commercial, grid-scale batteries, residential batteries *may* eventually serve a critical need for energy storage in the grid, making them essential to effective grid management.
- The growth of residential batteries will create the potential for a range of energy related consumer disputes which EWOV would not be able to handle under current arrangements.

Introduction

As a technology, home battery storage systems, (or residential batteries as we will call them for the purposes of this report), go hand in hand with solar photovoltaic (PV) panels. Residential batteries provide a way to store surplus energy produced by residential PV panels so it can be preserved for later use. The majority of residential batteries do this through a lithium-ion electro-chemical process[73], and range in storage capacity from 1kWh to 16kWh.[74] They are often sold in packages together with a PV system, although their relative expense (and therefore, longer payback period) has meant that they have not yet experienced the spectacular growth seen with rooftop solar.

This situation is expected to change as batteries become increasingly affordable. Not only will more PV systems be sold in conjunction with residential batteries, but more existing PV systems are likely to be retro-fitted with battery storage as battery prices fall and the consumer benefits of battery ownership become clear. This is especially true if available revenues from solar feed-in tariffs drop significantly. Such a drop would make it less profitable for customers to export excess solar power, and would incentivise them to store power and offset their usage charges instead.

Residential batteries are appealing to those customers who are increasingly conscious of climate change, as a means to maximise the use of renewably generated energy.[75] They also provide some independence and peace of mind for households concerned about grid reliability. This may potentially be important in the short term, (or at least be perceived to be important), as the energy system transitions away from traditional generation,[76] and may also be fuelled by peak demand events such as blackouts. Like solar panels, residential batteries can be perceived as a way to 'take control' of one's energy needs and reduce reliance on the grid.

Of course, this mentality is most clearly demonstrated by those installing their batteries off-grid, and some estimates are that up to 75% of battery storage systems installed between 2010 and 2015 were in fact not connected to the grid.[77] This reflects the 'early adopter' stage of residential batteries, where those investing have

73 Smart Energy Council, *Australian Energy Storage Market Analysis*, (2018): 5. https://www.smartenergy.org.au/sites/default/files/uploaded-content/field_f_content_file/australian_energy_storage_market_analysis_report_sep18_final.pdf

74 "Solar battery storage comparison table," Solar Quotes, accessed October 2019. https://www.solarquotes.com.au/battery-storage/comparison-table/

75 Larissa Nicholls, Paula Arcari, Andrew Golver, Rex Martin, & Yolande Strengers, *Engaging households towards the Future Grid: Experiences, expectations and emerging trends*, (RMIT University, 2019): 29. https://cur.org.au/cms/wp-content/uploads/2019/03/future-grid-homes-household-report-final-1-1.pdf

76 Ibid.

77 Smart Energy Council, *Australian Energy Storage Market Analysis*, (2018): 21. https://www.smartenergy.org.au/sites/default/files/uploaded-content/field_f_content_file/australian_energy_storage_market_analysis_report_sep18_final.pdf

been prepared to pay a premium price to meet customised energy needs and willingly 'opt out' of the mainstream energy system . While batteries may currently serve that niche, most expectations are that they will soon go 'mainstream', and the proportion of on-grid systems will increase as a result.

A November 2015 report by Renew, (an organisation that has specialised in research and advice on renewable energy technology since 1980), found that:

> *"Grid connected batteries are likely to become economically attractive for many households around 2020."*[78]

Renew's *Household Battery Analysis* investigated the economic value of adding residential batteries to a solar panel system, modelling results for ten different locations around Australia, and using consumption data typical to working couples and young families. Renew found that at the time of the study, most consumers would not be able to achieve a ten-year payback period – with ten years being the typical life-span of a well-designed battery system. Accordingly, residential batteries were not economical at the time of the report, and may only just be becoming economical now.

If Renew's predictions hold, the period we are now entering will be a critical stage for the energy system's transition to a DER based prosumer led system. Batteries are crucial because without the ability to store energy, it is difficult for people to engage in VPPs, P2P trading, microgrids or other new forms of energy management that may emerge over the next few decades.

That being said, the true extent to which the residential battery market will grow remains difficult to predict, as much may depend on the growth of EVs (see Chapter 4, p. 45), and/or the growth of large, commercial grid-scale batteries

Given that the uptake of EVs is predicted to rise dramatically, it is possible to foresee a time when households choose not to invest in residential batteries because their function can be served by an EV instead. For grid management purposes, EVs are essentially mobile batteries - there may well be no need for a household to own both. On the other hand, with the rise of autonomous vehicles, some have predicted that car ownership relative to population growth will decline – in the near future owning one's own car may be more of a choice than a necessity.[79]If that does occur (and the National Roads and Motorists' Association (NRMA) have projected that autonomous vehicles may be common as soon as 2025)[80], then EVs may not dampen the growth of residential batteries as much as may otherwise be expected.

Large grid-scale batteries (such as the Tesla battery in South Australia), are another significant factor as they have the potential to fill the grid's need for energy storage, obviating the need for small domestic systems. Known as the Hornsdale Power Reserve, the South Australian Tesla battery is charged by a nearby windfarm and is the largest lithium-ion battery in the word - with a capacity of 100 megawatts (and plans to increase that to 150 megawatts).[81] Since commencing operations on 1 December 2017, the Hornsdale Power Reserve has successfully responded at times when the grid is most under strain. The battery is estimated to have saved consumers approximately $50 million during its first year of operation.[82] Large, grid-scale batteries such as the Hornsdale Power Reserve clearly have a significant role to play and it is possible that if enough grid-scale storage is built then this may reduce demand for residential batteries, or at least negate their use as a tool for grid management.

That caveat aside, whether it is in the form of EVs or residential batteries, (or more likely, a mix of both), prosumer owned energy storage is expected by many to play a major role in Victoria's energy system in the near future. As

78 Renew, *Household Battery Analysis*, (2015): 4. https://renew.org.au/wp-content/uploads/2018/11/ATA-Household-Battery-Study.pdf

79 NRMA, *The future of car ownership*, (2017): 2. https://www.mynrma.com.au/-/media/documents/reports/the-future-of-car-ownership.pdf?la=en&hash=9AF4B0574E4FFD3F1A371551D89D182F

80 Ibid.

81 Nick Toscano, "Huge Tesla battery in South Australia primed for big upgrade," *Sydney Morning Herald*, 19 November 2019. https://www.smh.com.au/business/companies/huge-tesla-battery-in-south-australia-primed-for-big-upgrade-20191119-p53byo.html

82 Ibid.

we shift towards renewable power generation, the collective need for energy storage to stabilise the grid during periods of high demand or low generation will grow more acute. The Australian Energy Market Commission (AEMC) has acknowledged this need, and has commenced consultation on how market rules must change to allow for a two-sided energy market – where consumers are rewarded for buying and selling in real time.

As the AEMC chairman, John Pierce, has stated – "*...digitialisation has progressed to the point where it is time to consider a completely new approach.*"[83]

> *"Looking to the future – both the demand and supply sides of the energy market would be actively engaged in electricity scheduling and dispatch processes – while delivering all the services people expect like hot water, air-con and dishwashing."*[84]

Current market penetration in Victoria

Determining the current number of residential batteries installed in Australia is a surprisingly inexact science.

For their purposes, industry association the Smart Energy Council (SEC) make the assumption that any off-grid PV system is likely to include battery storage.[85] On-grid systems are more difficult to identify, as it is entirely voluntary to declare to the Clean Energy Regulator (CER) whether a battery has been installed along with a PV system, and the CER does not have a system for declaring and recording batteries retro-fitted to existing PVs. Fortunately, this situation will soon be rectified with the March 2020 launch[86] of AEMO's DER Register. The DER Register will give AEMO visibility of DER devices, to help them manage the grid and ensure that DER devices are able to deliver what the prosumer expects. [87]

That aside, and given the current lack of registration requirements, the SEC believes that the CER only identifies a third to a half of all battery installations.[88] These estimates are disputed by some, who argue the market is either much smaller or much larger than SEC claims – but the figures arrived at by the SEC do largely accord with SunWiz, (an organisation that identifies itself as Australia's chief solar market analyst)[89], and the CSIRO.[90] The Climate Council also broadly agree with these estimates.[91]

83 Katherine Murphy, "Australia told to prepare for a 'completely new' two-sided energy market," *The Guardian*, 14 November 2019. https://www.theguardian.com/australia-news/2019/nov/14/australia-told-to-prepare-for-completely-new-two-sided-energy-market

84 Ibid.

85 Smart Energy Council, *Australian Energy Storage Market Analysis*, (2018): 38. https://www.smartenergy.org.au/sites/default/files/uploaded-content/field_f_content_file/australian_energy_storage_market_analysis_report_sep18_final.pdf

86 "DER register implementation," AEMO, accessed November 2019. https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/DER-program/DER-Register-Implementation

87 Ibid.

88 Ibid.

89 SunWiz, accessed November 2019. http://www.sunwiz.com.au/

90 Paul Graham, Dongxiao Wang, Julio Braslavsky, & Luke Reedman, *Projections for small-scale embedded technologies*, CSIRO report for AEMO, (2018): 41. https://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/NEM_ESOO/2018/Projections-for-Small-Scale-Embedded-Technologies-Report-by-CSIRO.pdf

91 Climate Council, *Fully Charged: Renewables and Storage Powering Australia*, (2018): II. https://www.climatecouncil.org.au/resources/battery-storage-2018/

A June 2018 report by the CSIRO, commissioned by AEMO, reported that nation-wide growth in integrated PV and battery systems accelerated from 7,500 in 2016 to 20,000 in 2017.[92]

To put this growth in context – the Smart Energy Council Report, *Australian Energy Storage – Market Analysis – September 2018*, found that:

> *"An estimated 32,500 on-grid and off-grid energy storage systems were installed in Australia up to the end of 2016.*
>
> *Around 20,000 energy storage systems were installed in 2017."*[93]

Amongst Australian states, Victoria sits behind New South Wales and Queensland in terms of the overall proportion of on-grid residential batteries installed (19%), as well as off-grid (16%).[94]

The recent rise in storage installation was likely driven by strong growth in rooftop solar sales over the same 2016 to 2017 period, and while positive the figures still suggest that the proportion of PVs installed with storage remains relatively low.

In their report, the SEC estimate that under a high growth scenario around 450,000 energy storage systems could be installed by 2020, nation-wide. It is unclear if that rate of uptake has been met - but it does seem optimistic.[95]

A more concrete local measure is the Andrews' Government Solar Homes program which since late 2018 has attempted to boost to residential batteries in Victoria by providing a rebate for retro-fitting.[96]

Under that program, 1,000 rebates of up to $4,838 are available throughout the 2019/20 financial year for eligible applicants to fit batteries to their existing PV system. As at 23 October 2019, 67 out of a possible 200 rebates remained available up until 31 October 2019 - which is to say that only 133 had been allocated, and it was unlikely the full quota would be taken up.[97]

It is important to note that the program is carefully managed, with narrow eligibility requirements. To qualify for a rebate, an applicant must be living in an eligible suburb with at least 10 percent of homes in the suburb having solar panels, and the grid in that area must be deemed able to cope with the additional power a battery would provide. Initially, twenty-four eligible postcodes had been identified. In addition, applicants must already have solar panels with a power rating of at least 5kW (without any existing form of battery storage), and meet a means test based on combined income and property value.[98]

In November 2019 and March 2020 the list of eligible postcodes was expanded twice and now includes 247 postcodes, encompassing roughly 50 per cent of potential eligible households. This controlled expansion has steadily increased demand, with the 1,000 battery rebate allocations now expected to be fully exhausted by the end of the 2019/20 financial year.

92 Paul Graham, Dongxiao Wang, Julio Braslavsky, & Luke Reedman, *Projections for small-scale embedded technologies*, CSIRO report for AEMO, (2018): 41. https://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/NEM_ESOO/2018/Projections-for-Small-Scale-Embedded-Technologies-Report-by-CSIRO.pdf

93 Ibid, 1.

94 Smart Energy Council, *Australian Energy Storage Market Analysis*, (2018): 1. https://www.smartenergy.org.au/sites/default/files/uploaded-content/field_f_content_file/australian_energy_storage_market_analysis_report_sep18_final.pdf

95 Ibid.

96 "Solar battery rebate," Solar Victoria, accessed November 2019. https://www.solar.vic.gov.au/solar-battery-rebate

97 Ibid.

98 Ibid.

Identified barriers to uptake

The primary barrier to uptake of residential batteries is cost, with the upfront price being too high for most consumers to justify making the purchase despite batteries having dramatically reduced in price over the past twenty years.[99]

Payback period

As it is, in an unsubsidised market payback periods for PV and battery packages are still estimated at between ten to sixteen years[100] (with some sources estimating even higher, at over twenty years).[101] This is clearly problematic given the life expectancy of residential batteries is usually between five and fifteen years. This presents a financial barrier to many households, and until this situation improves, residential batteries are unlikely to progress from the early adopter stage to a more mainstream market. As already mentioned, Renew's 2015 *Household Battery Analysis* report identified 2020 as the point at which the economics of residential batteries may begin to shift – but whether this plays out as predicted remains to be seen.

Safety

Safety concerns are another barrier to uptake. If not installed properly, (or if they're poor quality), lithium-ion batteries can constitute a fire hazard through overheating and combustion. Indeed, there have been isolated instances of house-fires in Australia caused by the batteries, resulting in warnings by fire departments.[102]

That being said, high quality, professionally installed residential batteries are very safe. Despite this, the relatively novel status of residential batteries means that consumers are likely to err on the side of caution. Any hint of product safety concerns can have a disproportionate impact on uptake, and may already be doing so.

To address product safety concerns, a new Australian Standard - *AS/NZS 5139:2019, Electrical installations – Safety of battery systems for use with power conversion equipment* – was released on 11 October 2019[103], following a protracted and divisive five-year development period. Indeed, the development process included the 2017 scrapping of a draft standard which would have all but banned the installation of lithium-ion batteries in Australian homes and garages.

As it is, the new standard has been described by Renew as *"…a massive brake on the entire industry"*, [104] and it is likely to make battery installation more expensive.

Under the standard, mandatory fire-proofing measures must be taken on installation – including compressed concrete sheeting on any walls connected to habitable rooms. The standard also creates proximity limits of battery installation to doors, windows, ceilings, stairs or un-associated electric appliances.

99 "Four charts that show the future of battery storage," ARENA, 21 August 2017. https://arena.gov.au/blog/future-of-battery-storage/.

100 Paul Graham, Dongxiao Wang, Julio Braslavsky, & Luke Reedman, *Projections for small-scale embedded technologies*, CSIRO report for AEMO, (2018): 41. https://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/NEM_ESOO/2018/Projections-for-Small-Scale-Embedded-Technologies-Report-by-CSIRO.pdf

101 "The evolving investment case for home battery storage: Incentives & virtual power plant programs," SwitchDin, 25 July 2019. https://www.switchdin.com/blog/2019/battery-storage-incentives-virtual-power-plants

102 Toby Crockford, "Solar home battery warnings after Brisbane housefire," *Brisbane Times*, 27 December 2018. https://www.brisbanetimes.com.au/national/queensland/solar-home-battery-warning-after-brisbane-house-fire-20181227-p50od1.html

103 "Positive new standard for battery storage sector," Standards Australia, accessed November 2019. https://www.standards.org.au/news/positive-new-standard-for-battery-storage-sector

104 Sophie Vorrath, "Is this the end of household battery storage in Australia?" *Renew Economy*, 11 October 2019. https://reneweconomy.com.au/is-this-the-end-of-household-battery-storage-in-australia-79766/

Despite the extensive efforts of Standards Australia to find an acceptable compromise between product safety concerns and industry growth, the new standard has been met with consternation by many. Well-established European and American battery manufacturers who have installed hundreds of thousands of residential batteries across the northern hemisphere - without incident - now face strict installation requirements for the same products in Australia. The fact that Standards Australia have acknowledged the products pose a negligible fire-risk no doubt adds to the frustration.

Feed-in tariffs

Finally, relatively generous, regulated solar feed-in tariffs in Victoria mean that customers with solar panels have been strongly incentivised to export excess solar energy back into the grid - rather than store it.

This is particularly so for those fortunate enough to be receiving the Victorian premium feed-in tariff rate (PFIT) which pays at least 60 cents per kWh, and will continue until 2024.[105] For those customers, what they can earn through solar feed-in tariffs outweighs what they would save by having battery storage, especially when the expensive upfront purchase price and reasonably short product life-span of batteries are taken into account.

Given these existing barriers, it is perhaps not surprising that uptake to this stage has been low.

Projected penetration 2030 – 2050.

While lithium-ion batteries remain expensive, they have dropped dramatically in cost over recent decades – so much so that ARENA has described them as *"a brilliant illustration of the mechanics of commercialisation."*[106] Through mass production and innovation, the price has dropped while energy storage capacity has increased – from $3000USD/kWh in 1995, to $400USD/kWh in 2015.

This trend is expected to continue, and Tesla has predicted that costs will reduce to $100USD/kWh by the end of 2020.[107]

All of this means that the major barrier to uptake – cost – will become less of an issue over time, (just as Renew and others have predicted), and uptake should increase significantly.

The CSIRO predicts that as we move into the 2030s the payback period for integrated battery and solar systems will draw close to five years, which should certainly promote uptake beyond the early adopter market and into the wider domestic energy market.[108]

Uptake will also improve if customers become more comfortable with batteries as a safe product, and if solar feed-in tariffs decline as expected, limiting the potential of solar export earnings. Offsetting those losses, customers will likely have the potential to earn feed-in tariffs through their battery – again promoting uptake. Certainly, the public expectation is that batteries will become commonplace – the Climate Council found in their 2017 poll, (commissioned through ReachTEL), 74% of respondents expect residential batteries to be commonplace in the next decade.[109]

105 "Premium feed-in tariff," DELWP, accessed November 2019. https://www.energy.vic.gov.au/renewable-energy/victorian-feed-in-tariff/premium-feed-in-tariff

106 "Four charts that show the future of battery storage," ARENA, 21 August 2017. https://arena.gov.au/blog/future-of-battery-storage/

107 Ibid.

108 Paul Graham, Dongxiao Wang, Julio Braslavsky, & Luke Reedman, *Projections for small-scale embedded technologies*, CSIRO report for AEMO, (2018): 41. https://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/NEM_ESOO/2018/Projections-for-Small-Scale-Embedded-Technologies-Report-by-CSIRO.pdf

109 Climate Council, *Fully Charged: Renewables and Storage Powering Australia*, (2018): II. https://www.climatecouncil.org.au/resources/battery-storage-2018/

That being said, the exact degree to which uptake will improve remains unclear. Given a range of variables (including how effectively the benefits of battery ownership are communicated, and the growth of EVs), the CSIRO spreads their projections across three potential uptake scenarios – Slow, Medium and Fast.[110]

Under the Slow scenario, the battery share of residential solar sits between 6% and 27%, depending on the state or territory. Under the Moderate scenario the figures shift to 21% and 57%, and under Fast, to 25% and 64%.[111]

Under all scenarios, Victoria is predicted to install the second highest amount of residential batteries after New South Wales. Under the Moderate scenario, this would see collective storage capacity in Victoria grow from 700 MWh in 2030, to 4,250MWh by 2050. [112]

Across the NEM, the Moderate CSIRO projection for collective residential battery storage by 2050 is approximately 13,700MWh. [113]

Clearly, this presents significant implications – and opportunities - for future grid management.

How residential batteries will interact with the energy grid

The importance of energy storage to the future grid, including storage in the form of residential batteries, cannot be overstated. This is true not only in Victoria, and even Australia – but worldwide.

By 2050, it is expected that wind and solar will together provide almost 50% of the world's energy. This generation mix will not be viable unless it is bolstered by large amounts of energy storage.[114] Simply put, residential batteries and other forms of storage will help ensure that future energy supplies can meet peak demand as well as remaining reliable during the night-time hours, and when the wind isn't blowing (or is blowing too hard).

Batteries will achieve this by feeding stored energy back into the grid when needed. Therefore, the energy flow from residential batteries into the grid may soon be critical to effectively harnessing renewable energy - far extending the use of a residential battery beyond a simple back-up for home use.

Of course, (and as previously noted), the extent to which this occurs may depend on the uptake and use of EV's, and/or the degree to which storage needs are met by large grid-scale batteries. Another issue that should not be underestimated is the degree to which owners may or may not be willing to use their residential batteries for the benefit of the broader grid. A significant proportion of consumers may prefer to utilise their battery strictly for their own back-up use, as their need for independence and peace of mind may outweigh the perceived benefits of sharing their resource. Indeed, the Bruny Island CONSORT trial did reveal that even in a very small sample of participants, this view was present. This is an important reminder not to assume that householders will be willing to participate in DER, just because it is technically possible (or economically "rational") to do so. For more on the CONSORT trial, see our Bruny Island "Policy Spotlight" on page 57.

Those customers who are willing to share their battery with the grid will be incentivised to do so. Beyond feed-in tariffs offered by traditional retailers, this potential is likely to be harnessed through Virtual Power Plants (VPPs), or peer-to-peer trading, which are discussed in more detail in Chapter 5 (p. 51).

110 Paul Graham, Dongxiao Wang, Julio Braslavsky, & Luke Reedman, *Projections for small-scale embedded technologies*, CSIRO report for AEMO, (2018): 42. https://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/NEM_ESOO/2018/Projections-for-Small-Scale-Embedded-Technologies-Report-by-CSIRO.pdf

111 Ibid, 43.

112 Ibid.

113 Ibid.

114 David Stringer, "A deluge of batteries is about to rewire the power grid," *Bloomberg,* 5 August 2019. https://www.bloomberg.com/news/features/2019-08-03/a-deluge-of-batteries-is-about-to-rewire-the-power-grid

How residential batteries could go wrong

Marketing and sales

Given the imminent potential of a steep growth in sales, there is a risk of poor market behaviour by opportunists seeking to 'cash in' on residential batteries in the Victorian market. This conduct could include misleading or deceptive sales, unconscionable conduct, unfair contract terms or other contractual issues such as breaches of warranties or consumer guarantees.

All of these issues are dealt with by the Australian Consumer Law (ACL), which is administered by the Australian Competition Consumer Commission (ACCC) and state based fair trading agencies (in Victoria, Consumer Affairs Victoria). The ACL also covers issues that may arise in relation to product faults, or poor workmanship.

Tariffs and billing

Beyond these categories of complaint, there is also the potential for residential batteries to generate billing complaints. The need for residential batteries to feed back into the grid will inevitably stimulate the introduction of residential battery specific feed-in tariffs, which will need to exceed the value of solar feed-in tariffs to ensure customers store excess energy stored during the day – rather than simply export it straight from their panels into the grid.

The implementation of these tariffs will of course generate some complaints - due either to billing errors arising through incorrect application, software faults or disputes over lower than expected feed-in revenue (which may or may not turn out to be vexatious).

Resolving such complaints will require specialist energy industry knowledge, and will involve liaising with the service provider issuing the bill.

EWOV jurisdiction

If the provider making the billing or tariff error is a licensed electricity retailer or an exempt market participant, they already fall into EWOV's jurisdiction. But if they belong to a new category of energy business called 'aggregators' - then they do not. There is the potential, for example, for an aggregator business to experience a software glitch which means a large number of customers fail to maximise the value of their residential battery - and do not receive the export income that they should. Under current arrangements, EWOV would not be able to assist those customers with their complaint.

In addition to jurisdictional challenges based on the party incentivising a customer to export power from their battery, there will also be jurisdictional challenges concerning complaints which at first seem billing related, but on further investigation are found to be a product fault.

An obvious example would be a faulty residential battery, perhaps incorrectly installed, which does not feed-back properly into the grid. While this complaint may initially present as a billing error, upon investigation EWOV may uncover that it is in fact a product or installation fault. In the meantime, the retailer will have borne the cost of EWOV's investigation to that point – and the customer will be left to pursue the complaint elsewhere under the ACL.

This is not satisfactory for either party, and raises the question of whether EWOV's jurisdiction should be broadened to handle a wider range of complaints – potentially involving a wider range of parties. In this case, for example, the installer may be the truly responsible party.

It is apparent that as the energy system transforms a new range of 'energy related' complaints will emerge in Victoria. Currently, no specialised external dispute resolution body is authorised to handle those complaints.

What is an 'aggregator'?

Aggregators are a relatively new type of business in the electricity market. As the electricity system decentralises and prosumers become more common, aggregators are likely to grow in size and importance.

Simply put, an aggregator is a business that is able to co-ordinate a (potentially large) number of disparate grid-connected batteries and gather their collective power so that it may be traded for its highest value, and greatest benefit. In doing so, they are able to reward the owners of the batteries while also having the effect that the stored power is used to meet periods of peak demand - stabilising the grid.

Aggregators are possible because the grid has become increasingly digitised. The mandatory role out of smart meters in Victoria has created the potential for aggregators to devise software to communicate with those smart meters, which in turn can communicate with residential batteries (or for that matter, EVs).

Aggregators will be crucial to Victoria's energy future. They will be the 'enabling agents' unlocking DER energy, making Virtual Power Plants (VPPs) and other grid stabilising innovations possible.

Currently, aggregators are not required to be members of EWOV – so if a consumer has a dispute with an aggregator, we are not able to assist.

Table 6.

Summary table – residential batteries

RESIDENTIAL BATTERIES	Current Market Penetration	Projected: 2020 – 2030	Projected: 2030 - 2050
	Minimal CSIRO estimate approximately 200 MWh capacity by end of 2020[115] Smart Energy Council: Under a high penetration scenario, up to 450,000 storage systems could be installed nation-wide by the end of 2020[116] Note: The SEC estimate seems optimistic, but attempts to measure industry size are hampered by a lack of CER data	**Minimal - Moderate** CSIRO moderate growth projection: approx. 700 MWh by 2030[117]	**High - Very High** CSIRO moderate growth projection: approx. 4,250MWh by 2050[118] Note: Across the NEM, the Moderate CSIRO projection for collective residential battery storage by 2050 is approximately 13,700MWh[119]
	Barriers to Growth		
	› Cost › Safety concerns › Australian Standard AS/NZS 5139:2019 › Generous solar feed-in tariffs › Housing status	› Cost (less than current, but still a barrier) › Growth of electric vehicles as a storage alternative › Large grid-scale storage as an alternative › Housing status	› Growth of electric vehicles (EV) as a storage alternative › Large grid-scale storage as an alternative › Housing status
	Existing/anticipated heads of complaint*		
	• Misleading marketing and high-pressure sales • Failed solar and/or grid connections/poor installation • Technical product faults and quality issues • Billing errors, including incorrect feed-in tariffs • Functional issues from interface with HEMS, VPPs, P2P platforms or microgrids.		

- Blue = In EWOV's current jurisdiction
- Orange = Out of EWOV's current jurisdiction

115 Paul Graham, Dongxiao Wang, Julio Braslavsky, & Luke Reedman, Projections for small-scale embedded technologies, CSIRO report for AEMO, (2018): 41. https://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/NEM_ESOO/2018/Projections-for-Small-Scale-Embedded-Technologies-Report-by-CSIRO.pdf

116 Smart Energy Council, Australian Energy Storage Market Analysis, (2018): 1. https://www.smartenergy.org.au/sites/default/files/uploaded-content/field_f_content_file/australian_energy_storage_market_analysis_report_sep18_final.pdf

117 Paul Graham, Dongxiao Wang, Julio Braslavsky, & Luke Reedman, Projections for small-scale embedded technologies, CSIRO report for AEMO, (2018): 43. https://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/NEM_ESOO/2018/Projections-for-Small-Scale-Embedded-Technologies-Report-by-CSIRO.pdf

118 Ibid.

119 Ibid.

Chapter Three: Microgrids

FAST FACTS

- Microgrids are still in their very early development stage, but hold significant future potential for remote and/or fringe communities.
- Microgrid models can vary widely – affecting customer rights. For example, under our current structure EWOV would be able to deal with complaints from customers in distributor-led microgrids, but not with those from customers in third-party microgrids.
- Complaints could include disputes over unclear roles and responsibilities for; microgrid management, billing and tariff disputes, supply and reliability issues due to generation or microgrid infrastructure faults, functional issues from interaction with in-home displays and/or HEMS (amongst others).

Introduction

Microgrids vary considerably in size and function and as such there is no fixed definition – the term 'microgrid' is often used to describe a number of arrangements.

For the purpose of this report, we have adopted AEMO's definition which defines microgrids as *"…a small-scale power system that consists of distributed generation sources that are linked to an intelligent communication and control system to supply power to distributed loads. They are usually operated autonomously to be part of the main electricity network or switched to be 'islanded' depending on their type and operation scenarios…"*[120]

Essentially, microgrids are autonomous electricity networks that generate and distribute supply locally. Microgrid generation sources can include diesel generators, microturbines and fuel cells, but are usually renewable energy generators such as home solar PV systems. A common form of a microgrid is a group of solar PV systems, augmented with battery storage, that provide energy to a small group of connected dwellings. The key advantage of a microgrid is its autonomy – it can function as a "single entity" that can be connected and disconnected from the primary grid (often called 'islanding').[121]

The emphasis on local supply (the electricity generated within the microgrid itself) differentiates microgrids from embedded networks, which typically lack generation capabilities.

Microgrids also differ from VPPs as they can be islanded and optimise local supply, whereas a VPP serves the wholesale market through resource aggregation (see Chapter 5, p.51). Despite these differences, microgrids integrate very well with VPPs and peer-to-peer trading systems because they manage electricity supply and demand[122].

120 AEMO (2018) cited in: Legislative Assembly Parliament of Western Australia, Economics and Industry Standing Committee, *Implications of a Distributed Energy Future: Interim Report* [report No. 5], (2019): 17. https://www.parliament.wa.gov.au/parliament/commit.nsf/(WebInquiries)/B78DC78FC2007FAE482583D7002E3073?opendocument

121 Adam Hirsch, Yael Parag and Josep Guerrero, "Microgrids: A review of technologies, key drivers, and outstanding issues," *Renewable and sustainable energy reviews,* 90. (2018): 402-411. https://doi.org/10.1016/j.rser.2018.03.040

122 Clean Energy Council, *The distributed energy resources revolution: A roadmap for Australia's enormous rooftop solar and battery potential,* (2019): 13. https://www.cleanenergycouncil.org.au/advocacy-initiatives/energy-transformation/the-distributed-energy-resources-revolution

As with the primary electricity grid, multiple parties can make up a microgrid. These include:

- consumers
- prosumers (consumers that generate electricity)
- the microgrid network owner (owns the infrastructure)
- the microgrid operator (operates the microgrid and may be responsible for customer service and billing).[123]

Microgrid ownership can vary and may take the shape of a cooperative of consumers and prosumers, or ownership by the distribution system operator, or ownership by an independent power producer, or an energy supplier in a free market arrangement.[124]

For microgrids connected to the existing grid, the above parties will also need to interact with market regulators, such as the AEMC and Essential Services Commission (ESC), especially when energy is sold to the wholesale market.

The 'islanding' capacity of microgrids enables customers at the fringe of the grid or in remote areas to have an independent and cost-effective supply of electricity. Microgrids can reduce the need for expensive and long-distance grid-connected 'poles and wires' to service those areas.[125] This benefits all electricity customers, who would otherwise share the transmission costs to remote areas in their service-to-property charge.

Microgrids improve the efficiency of supply for their customers, (traditional transmission and distribution systems waste between 5-10% of gross electricity generation)[126] enabling the price of electricity to be closer to a wholesale cost than a standard retail tariff. This is even more beneficial for prosumers who generate their own power, and who may receive an attractive price for the energy they export to the grid in times of high demand.[127]

By utilising solar PV, microgrids can facilitate a transition to renewable energy for both fringe and/or remote communities as well as environmentally conscious communities in the existing network.

Microgrids do afford local voltage control, allowing for variable generation sources to be connected without affecting quality and supply requirements,[128] but the intermittent nature of renewable generation means that they usually require energy storage to guarantee reliable supply. When this is present, microgrids can improve supply reliability for customers when primary grid outages occur, for example, in times of peak demand and severe weather.[129] Microgrids could be especially beneficial for customers in bushfire prone areas.[130]

123 Clean Energy Council, *The distributed energy resources revolution: A roadmap for Australia's enormous rooftop solar and battery potential*, (2019): 3, 28. https://www.cleanenergycouncil.org.au/advocacy-initiatives/energy-transformation/the-distributed-energy-resources-revolution.

124 Adam Hirsch, Yael Parag and Josep Guerrero, "Microgrids: A review of technologies, key drivers, and outstanding issues," *Renewable and sustainable energy reviews,* 90. (2018): 408. https://doi.org/10.1016/j.rser.2018.03.040

125 Clean Energy Council, *The distributed energy resources revolution: A roadmap for Australia's enormous rooftop solar and battery potential,* (2019): 12. https://www.cleanenergycouncil.org.au/advocacy-initiatives/energy-transformation/the-distributed-energy-resources-revolution

126 Adam Hirsch, Yael Parag and Josep Guerrero, "Microgrids: A review of technologies, key drivers, and outstanding issues," *Renewable and sustainable energy reviews,* 90. (2018): 405. https://doi.org/10.1016/j.rser.2018.03.040

127 ARENA, *Latrobe Valley microgrid feasibility assessment,* (2018): 62. https://arena.gov.au/assets/2018/05/latrobe-valley-microgrid-feasibility-assessment.pdf

128 Monash University, *Victorian market assessment for microgrid electricity market operators: White paper,* (2019): 20. https://www.monash.edu/__data/assets/pdf_file/0010/1857313/Monash-Net-Zero_Microgrid-Operator-Whitepaper_20190617-1.pdf

129 Adam Hirsch, Yael Parag and Josep Guerrero, "Microgrids: A review of technologies, key drivers, and outstanding issues," *Renewable and sustainable energy reviews,* 90. (2018): 405. https://doi.org/10.1016/j.rser.2018.03.040

130 AEMC, *Review of stand-alone power systems – Priority 1 final report,* (2019): iii. https://www.aemc.gov.au/market-reviews-advice/review-regulatory-frameworks-stand-alone-power-systems

Microgrids require collaboration between numerous parties – including customers, operators, and regulators – as well as the integration of different energy technologies, and this means customers will likely experience a diverse number of challenges.

How will microgrids interact with the energy grid?

A microgrid's degree of interaction with the primary grid depends on the extent to which it is islanded, or not. Microgrids generally have the following components:

- **local generation**, such as solar PV or diesel fuel,
- **energy storage**, such as batteries,
- **control facilities** for dispatch and a **grid management system** to monitor the local network,
- and for grid-connected microgrids, a point of common coupling (**single connection point**) that connects the microgrid to the primary grid.[131]

Stand-alone microgrids

Microgrids established in remote (or fire prone) communities will usually be distributor led, as it will be in the economic interests of distributors to service customers in remote areas this way.[132] These microgrids must be entirely self-sufficient as they are not connected to the national grid. As they must provide a reliable supply of energy to the community they serve, stand-alone microgrids usually combine renewable generation sources and battery storage with diesel generators.[133]

Grid-connected microgrids

Microgrids connected to the national grid via a single connection point will either be operated by a third-party, or be distributor led when economically feasible. While microgrids connected to the existing grid still have the capability of islanding, there is a strong reliability and business case for maintaining a grid connection.

Microgrids can provide valuable ancillary services including congestion relief, frequency regulation, and power reserves to the existing grid.[134] While microgrids provide the opportunity for efficient load following (where a generator produces only enough power to meet the primary load), excess energy generated can be stored in batteries for later use when demand is high, or sold back to the wholesale energy market providing an income stream to the microgrid operator and prosumers.

Market penetration in Victoria

Microgrids are still a 'fringe technology' worldwide, let alone in Victoria. For context, only 4,475 microgrid projects (either operating, under development or proposed), have been identified *globally* - and 70% of these projects are located in the Asia Pacific and North American regions.[135]

However, an increasing number of initiatives are emerging in Victoria to demonstrate their potential. As part of the *Microgrid Demonstration Initiative*[136], pilot projects have been subsidised by the Victorian Department of Environment, Land, Water and Planning (DELWP) to explore the feasibility of microgrid operation.

131 "What's a community microgrid? A quick guide," CarbonTrack, accessed November 2019. https://carbontrack.com.au/blog/community-microgrid/

132 Ibid.

133 Adam Hirsch, Yael Parag and Josep Guerrero, "Microgrids: A review of technologies, key drivers, and outstanding issues," *Renewable and sustainable energy reviews,* 90. (2018): 406. https://doi.org/10.1016/j.rser.2018.03.040

134 Ibid, 405.

135 Navigant Research (2019) cited in: Megan Farrelly and Sylvia Tawfik, "Engaging in disruption: A review of emerging microgrids in Victoria, Australia," *Renewable and Sustainable Energy Reviews, 117* (109491), (2020): 1-2. https://doi.org/10.1016/j.rser.2019.109491

136 "Microgrids," DELWP, accessed November 2019. https://www.energy.vic.gov.au/microgrids

Projects include:

- **Euroa Environment Group – Euroa Microgrid Demonstration**
  This project aims to demonstrate the economic opportunity in shared renewable generation and energy storage, while reducing local demand on the grid and the use of diesel generators.[137]
- **Monash University – Microgrid Electricity Market Operator (MEMO)**
  "MEMO seeks to address a gap in the current energy market, investigate the business case for the creation of these new entities and provide regulatory recommendations to address potential barriers preventing their establishment in Victoria."[138] (See our Monash "Policy Spotlight", p. 42, for more detail on the project).
- **Origin Energy – Virtual Power Plant (VPP)**
  Origin's VPP can "boost grid stability by discharging power from solar PV and batteries", demonstrating how dispatchable energy technology can be coordinated across Victoria.[139]
- **Ovida – Community Energy Hubs**
  Ovida have installed shared solar PV and battery systems in three buildings in Melbourne to deliver "affordable, dispatchable and reliable energy for occupants of apartment and commercial buildings."[140]
- **SwitchDin – Birchip Cropping Group Microgrid Demonstration**
  This project functions as a working demonstration of a microgrid for farmers, providing a model for other farms and businesses to lower energy costs and improve reliability.[141] Now in operation, the microgrid is equipped with 51kW of solar and 137kWh of battery storage.[142]
- **Totally Renewable Yackandandah (TRY) – Constrained SWER Microgrid Demonstration**
  The Yackandandah microgrid will help cut energy bills for local residents and contribute to the community's renewable energy target.[143]

ARENA have also provided funding for a feasibility study into a virtual microgrid in the LaTrobe Valley. This project will utilise a blockchain based platform and smart metering technology to enable customers, (primarily dairy farmers), to buy and sell locally produced renewable energy.[144]

Additional independent projects include the Mooroolbark Mini Grid funded by AusNet Services[145] and the Deakin University Renewable Energy Microgrid[146].

Clearly, microgrids are currently in the early piloting and testing stage – but that is not to say they won't become mainstream in the short to medium term future.

137 Jaclyn Symes, "New microgrid funding for the Euroa community," Victorian Labor, 3 September 2018. http://www.jaclynsymes.com.au/media-releases/new-microgrid-funding-for-the-euroa-community/

138 Monash University, *Victorian market assessment for microgrid electricity market operators: White paper,* (2019): 11. https://www.monash.edu/__data/assets/pdf_file/0010/1857313/Monash-Net-Zero_Microgrid-Operator-Whitepaper_20190617-1.pdf

139 Minister for Energy, Environment and Climate Change, "Building Victoria's largest virtual power plant," Premier of Victoria, 5 September 2018. https://www.premier.vic.gov.au/building-victorias-largest-virtual-power-plant/

140 Minister for Energy, Environment and Climate Change, "New microgrid finding for multi-tenanted buildings," Premier of Victoria, 27 August 2018. https://www.premier.vic.gov.au/new-microgrid-funding-for-multi-tenanted-buildings/

141 Minister for Energy, Environment and Climate Change, "Microgrid funding for Birchip business," Premier of Victoria, 3 October 2018. https://www.premier.vic.gov.au/microgrid-funding-for-birchip-business/

142 "SwitchDin project selected for Victorian microgrid demonstration," SwitchDin, May 2019. https://www.switchdin.com/blog/2018/10/3/switchdin-project-selected-for-victorian-demonstration-initiative-grant

143 Minister for Energy, Environment and Climate Change, "New microgrid project for Yackandandah," Premier of Victoria, 17 October 2018. https://www.premier.vic.gov.au/new-microgrid-project-for-yackandandah/

144 ARENA, *Latrobe valley microgrid feasibility assessment,* (2018): 7. https://arena.gov.au/assets/2018/05/latrobe-valley-microgrid-feasibility-assessment.pdf

145 AusNet Services, *The Mooroolbark mini grid project: Exploring our energy future,* (2019). https://www.ausnetservices.com.au/-/media/Files/AusNet/Community/Mooroolbark-mini-grid/Mooroolbark-mini-grid-web-info.ashx?la=en

146 "Renewable energy microgrid," Deakin University, accessed November 2019. https://www.deakin.edu.au/microgrid

Identified barriers to uptake

Microgrids require relatively large-scale investment, and major barriers to their uptake exist at the legal, policy, and economic level. For example, while microgrids provide public value in terms of reductions in network losses and downward pressure on wholesale prices, investors in microgrids can't capture a share of this value, and this acts as a barrier to development.[147] A recent review of existing microgrids in Victoria also demonstrated how the unfamiliar nature of microgrids, an uncertain regulatory environment and bureaucratic approvals processes inhibit their uptake.[148]

The same review also highlighted challenges in the Yackandandah Community Mini Grid project regarding "the upscaling of community knowledge and understanding in their role as prosumer", as well as challenges in overcoming community distrust in energy companies.[149] This kind of distrust may prevent consumers from engaging with third-party investors seeking to establish microgrids. On the other hand, customers may be more open to microgrids in order to gain independence from the traditional sector.[150] The *Latrobe Valley Microgrid Feasibility Assessment* has identified the importance of having trusted community members advocate on behalf of proposed microgrid projects.[151]

Additionally, recruiting customers to participate in the feasibility assessment revealed that access to participant energy data is crucial, which requires clear customer consent[152]

Customers that do not own their home but want to join a microgrid face the same challenges as Solar PV customers, as they cannot elect to install solar panels as tenants. This may be overcome if local cooperatives emerge, for example, where a local school or business agrees to install solar panels and sell the energy generated to participating customers in the cooperative.[153] Existing barriers to solar PV uptake by home owners (see Chapter 1, p.14) also play out in attempts to deploy microgrids.

Projected penetration by 2030-2050

It is reasonable to expect that microgrids will increase in prominence by 2030, considering the benefits to remote customers and distributors/providers. To clear the path for growth, the AEMC has conducted a review into the regulatory frameworks for stand-alone power systems (including microgrids) to outline when a microgrid may be effective, and what consumer protections will be required.[154]

The *Priority 1 Final Report* recommends the use of microgrids by NEM distributors, particularly to service customers in remote areas.[155] At the time of writing, AusNet services identified that it could be efficient to implement

147 Monash University, *Victorian market assessment for microgrid electricity market operators: White paper,* (2019): 11. https://www.monash.edu/__data/assets/pdf_file/0010/1857313/Monash-Net-Zero_Microgrid-Operator-Whitepaper_20190617-1.pdf

148 Megan Farrelly and Sylvia Tawfik, "Engaging in disruption: A review of emerging microgrids in Victoria, Australia," *Renewable and Sustainable Energy Reviews, 117* (109491), (2020): 5-6. https://doi.org/10.1016/j.rser.2019.109491

149 Ibid, 6.

150 ARENA, *Latrobe Valley microgrid feasibility assessment,* (2018): 32. https://arena.gov.au/assets/2018/05/latrobe-valley-microgrid-feasibility-assessment.pdf

151 Ibid, 31.

152 Ibid, 31.

153 "What are microgrids?" Energuide.be, accessed October 2019. https://www.energuide.be/en/questions-answers/what-are-microgrids/2129/

154 "Review of the regulatory frameworks for stand-alone power systems," AEMC, accessed November 2019. https://www.aemc.gov.au/market-reviews-advice/review-regulatory-frameworks-stand-alone-power-systems

155 AEMC, *Review of the regulatory frameworks for stand-alone power systems – Priority 1, Final report,* (2019). https://www.aemc.gov.au/sites/default/files/2019-05/SAPS%20Priority%201%20Final%20Report%20-%20FOR%20PUBLICATION.pdf

microgrids or individual power systems for 300-400 of its customers in Victoria.[156] The *Priority 2 Final Report* addresses microgrid implementation by third parties, and encourages a tiered approach to regulation and customer protection in proportion to the scope of the microgrid.[157]

It is also likely that more microgrids will emerge as institutions strive for carbon neutrality. As previously discussed, universities such as Monash and Deakin are uniquely positioned to utilise their research capabilities and campuses that serve as 'mini villages'. Provided that regulatory and market barriers are addressed, (and sufficient load can be aggregated), Monash predicts that microgrids deployed in Victoria could create a levelized value of $22 million per year over the period from 2018-19 to 2022-23.[158]

How could microgrids go wrong?

Technology faults

Customers within microgrids may experience difficulties with the various technologies that make up the microgrid. This could include the reliability of the generation source, supply issues from infrastructure connecting the buildings in the microgrid, and functional issues with the in-home interfaces that enable energy management and trading.

Multiple parties

Customers in microgrids will also need to interact with a number of parties during the installation and ongoing-operation of the microgrid. From local councils and installers of technology, to operators and those responsible for customer service and billing – each interaction serves as a potential complaint source that can be exacerbated when knowledge is limited.

As previously mentioned, existing microgrid projects in Victoria illustrate that unclear roles and responsibilities and the "*upscaling of community knowledge and understanding their role as prosumer*" present challenges.[159]

Under EWOV's current structure, unless the customer's issue is related to the supply and sale of energy by a scheme participant, we will not be able to assist the customer with their complaint. If this is the case, then as with other technologies discussed in this report, non-energy specific dispute resolution services, (such as VCAT), may be the only option. This is further complicated by the fact that we may not identify the true cause of the complaint until our investigation is underway – a time cost for both EWOV and the customer.

Distributor-led vs Third party

Customer protections will differ depending on the type of microgrid established. For example, customers in distributor-led microgrids will be afforded the same service provided by EWOV that customers in Victoria's grid are entitled to, as the sale and supply of energy will be the responsibility of an EWOV member. It is also likely that distributor-led microgrids will fall under the definition of a 'distribution system' in the *Electricity Distribution Code* - affording customers the same protections.[160]

156 AEMC, *Review of the regulatory frameworks for stand-alone power systems – Priority 1, Final report*, (2019), iii. https://www.aemc.gov.au/sites/default/files/2019-05/SAPS%20Priority%201%20Final%20Report%20-%20FOR%20PUBLICATION.pdf

157 AEMC, *Review of the regulatory frameworks for stand-alone power systems – Priority 2, Final report,* (2019). https://www.aemc.gov.au/sites/default/files/2019-10/AEMC%20SAPS%20priority%202%20final%20report%2031%20October%202019.pdf

158 Monash University, *Victorian market assessment for microgrid electricity market operators: White paper,* (2019): 24. https://www.monash.edu/__data/assets/pdf_file/0010/1857313/Monash-Net-Zero_Microgrid-Operator-Whitepaper_20190617-1.pdf

159 Megan Farrelly and Sylvia Tawfik, "Engaging in disruption: A review of emerging microgrids in Victoria, Australia," *Renewable and Sustainable Energy Reviews, 117* (109491), (2020): 6. https://doi.org/10.1016/j.rser.2019.109491

160 AEMC, *Review of the regulatory frameworks for stand-alone power systems – Priority 1 Report,* (2019): 153. https://www.aemc.gov.au/market-reviews-advice/review-regulatory-frameworks-stand-alone-power-systems

But for customers in microgrids run by third-parties, it is unclear what protections will apply. The AEMC advocates a tiered approach depending on the size and scope of the microgrid, with large microgrids subject to the National Electricity Laws and Rules, while smaller microgrids would be subject to regulation determined by each state.[161] This may be problematic as reliability, security and safety standards could differ between tiers, putting some customers at higher risk than others. If third party retailers in microgrids are also made exempt from holding a licence to sell electricity, (in the same manner as embedded networks), then customers may also be at an increased risk of lower levels of consumer protection.

The AEMC also notes that customer consent in the transition process will vary.

Consent would not be required from customers transitioning to distributor-led microgrids, as a distributor would choose to supply a region in this way for reasons of economic efficiency. If customers in such microgrids are not adequately consulted, they may lodge a complaint concerned with the lack of information available, and experience frustration at their lack of choice.

Customers transitioning to third-party microgrids usually do so by choice, so may not have the same sense of being 'dragged in' to a microgrid[162] At the same time, third-party microgrid providers are likely to be smaller and less resourced than distributors.[163] Once a customer is in such a microgrid, available resources to serve their customer experience may be limited. They may not truly understand what they have committed to. As evident in EWOV's experience with embedded network complaints[164], disputes may also arise if customers cannot opt-out of microgrid supply and access the standard network.[165]

Financing arrangements

The installation of microgrid components is expensive. Depending on who is responsible for those costs, leasing agreements and third-party financing may be required.[166] For example, if consumers wishing to participate in a microgrid are responsible for installing necessary technology such as solar PV or home energy management systems, they may turn to lease agreements. This invites the potential for unsustainable and unfair contracts, as evident in the Solar PV space[167] – and could be a source of customer complaints.

Demand response

Finally, and as some have suggested, microgrids provide a valuable opportunity for demand-response management. With the incorporation of smart home energy management systems,[168] complaints could arise when customers fail to receive benefits from participating in demand-response, or if the process is poorly implemented.

It is still very 'early days' for microgrids in Victoria. These systems integrate various energy technologies with traditional features of an energy grid (such as the supply and sale of energy to customers), and each transaction they create serves as a potential source of complaint. Because transactions span numerous parties in the energy sector, the availability of energy-specific dispute resolution services – where staff understand the obligations of distributors, retailers and third party-providers – will be invaluable going forward.

161 AEMC, *Review of the regulatory frameworks for stand-alone power systems – Priority 2 Report,* (2019): 73. https://www.aemc.gov.au/market-reviews-advice/review-regulatory-frameworks-stand-alone-power-systems

162 Ibid, 16.

163 Ibid, i.

164 Energy and Water Ombudsman Victoria, *Coverage of Embedded Networks: Confidential Progress Update,* (2019).

165 Monash University, *Victorian market assessment for microgrid electricity market operators: White paper,* (2019): 37. https://www.monash.edu/__data/assets/pdf_file/0010/1857313/Monash-Net-Zero_Microgrid-Operator-Whitepaper_20190617-1.pdf

166 Adam Hirsch, Yael Parag and Josep Guerrero, "Microgrids: A review of technologies, key drivers, and outstanding issues," *Renewable and sustainable energy reviews,* 90. (2018): 406. https://doi.org/10.1016/j.rser.2018.03.040

167 Consumer Action Law Centre, *Sunny side up: Strengthening the consumer protection regime for solar panels in Victoria* (2019). https://consumeraction.org.au/wp-content/uploads/2019/04/1904_Sunny-Side-Up-Report_FINAL_WEB.pdf

168 Izaz Zunnurain, Md. Nasimul Islam Maruf, Md. Moktadir Rahman, & GM Shafiullah, "Implementation of advanced demand side management for microgrid incorporating demand response and home energy management system," *Infrastructures, 3*(4), (2018): 3. https://doi.org/10.3390/infrastructures3040050

Table 7.

Summary table – microgrids

MICROGRIDS	Current Market Penetration	Projected: 2020 – 2030	Projected: 2030 - 2050
	Very Minimal Microgrids are still in their early days, with the Victorian Government running a *Microgrid Demonstration Initiative*[169] including six projects across the state[170] Distributor-led and university-based microgrid projects have also emerged, notably the Monash Net Zero Initiative (see: Policy Spotlight pg. 42)	**Moderate** It will be standard for distribution-led microgrids to serve remote communities at the fringe of the grid Third-party led microgrids will gain prominence, while almost all universities will operate as microgrids to demonstrate their research and commitment to sustainability	**Moderate - High** Third-parties will own a significant share of the market, establishing microgrids in communities already connected to the grid, that strive to be sustainable
	Barriers to Growth		
	› Cost › Housing status › Lack of investment incentives – third-party investors aren't able to capture a share of the public value of a microgrid. › Community distrust in energy companies › 'Prosumer' knowledge and engagement required › Existing barriers to solar PV and battery storage uptake	› Cost › Housing status › Lack of investment incentives – third-party investors aren't able to capture a share of the public value of a microgrid › Community distrust in energy companies	› Housing status › Lack of investment incentives – third-party investors aren't able to capture a share of the public value of a microgrid. › Community distrust in energy companies
	Existing/anticipated heads of complaint*		
	• A lack of customer consent in the transition to a distributor-run microgrid Unclear roles and responsibilities in the management of the microgrid • Billing and tariff disputes (distributor-run) • Reliability issues related to the generation source (distributor-run) • Supply issues from faults in the microgrid infrastructure (distributor-run) • Functional issues from in-home interfaces and/or the HEMS • Unfair contracts and leasing agreements (for customers that have to finance the installation of microgrid components) • Poor implementation of demand response mechanisms		

- Blue = In EWOV's current jurisdiction
- Orange = Out of EWOV's current jurisdiction

169 "Microgrids," DELWP, accessed October 2019. www.energy.vic.gov.au/microgrids

170 "Net Zero Initiative," Monash University, accessed October 2019. https://www.monash.edu/net-zero-initiative

Policy Spotlight: Monash Microgrid

FAST FACTS

- A key element of the Monash Net Zero Initiative is a fully functioning microgrid based at Monash's Clayton campus (the Monash Microgrid).
- The Monash Microgrid will provide a working example of the market dynamics of DER, and highlight regulatory barriers and implications for customers in microgrids. The Monash Microgrid provides the vehicle for two major projects – the *Smart Energy City Project* and the *Microgrid Electricity Microgrid Operator* (MEMO) project, which will 'test the theory' of grid-connected microgrids from both a technical and an economic perspective
- The Smart Energy City Project will report in mid-2020. Key research themes to be explored are microgrid costs and benefits, microgrid design, deployment and operation, and running a smart energy city.

Context: Monash Net Zero Initiative

Monash University are making the most of their partnerships and research about sustainability by committing to net zero carbon emissions by 2030. The Net Zero Initiative will see the roll-out of five key pillars across Monash's Australian campuses. These include:

- Energy efficiency measures, including the development of smart building technology[171]
- Campus electrification
- Deployment of on and off-site renewable energy
- Offsetting of residual emissions
- A fully functioning microgrid at the Clayton campus.[172]

While environmental concerns are the key drivers behind this initiative, the economic benefits are undeniable. As Monash's energy bills are almost $12 million per annum, and are expected to double in the next two years if energy prices rise, considerable savings can be achieved by generating and storing renewable energy on site.[173]

For the purposes of this report the Clayton campus microgrid is the most significant element of the Net Zero Initiative. The Monash Microgrid will not only provide a working example of the market dynamics of distributed energy resources, but will also highlight regulatory barriers and the implications for end users.

To date, two projects have emerged in the context of the Monash microgrid:

- The *Smart Energy City* project, which will see the development of the microgrid and smart grid management platform. This is supported by a $2.9 million grant from ARENA.
- The *Microgrid Electricity Microgrid Operator* (MEMO) project, which explores the benefits of a microgrid operated by a third-party entity and will provide regulatory recommendations. This project is supported by the Victorian Government's Microgrid Demonstration Initiative.

Additionally, Monash have partnered with redT to deploy a 1MWh commercial energy battery system.[174]

171 "Monash Honeywell Collaboration," Monash University, accessed November 2019. https://www.monash.edu/it/honeywell
172 "Monash Net Zero Initiative," Monash University, accessed November 2019. https://www.monash.edu/net-zero-initiative
173 Monash University, *Monash Net Zero Initiative brochure,* (2019). https://www.monash.edu/__data/assets/pdf_file/0020/1140365/Monash-Net-Zero-Brochure.pdf#
174 "Microgrid," Monash University Net Zero Initiative, accessed November 2019. https://www.monash.edu/net-zero-initiative/microgrid

Smart Energy City project overview

In partnership with global technology company Indra, Monash University will deploy a microgrid that operates as a local electricity network and trading market. The microgrid will consist of 1MW capacity of solar PV, 1MWh of energy storage, 2 EV chargers, and a 3.5MW load of flexible buildings that differ in energy efficiency and represent varied customer demands.[175]

Monash's microgrid is designed to be scalable and replicable to non-campus precincts, so that the findings of this project can inform other areas such as retirement villages, apartment buildings, shopping centres and schools (the project will not be testing functionality of off-grid microgrids)[176]. Departments in the Monash community will be treated as customers and will be able to buy, sell and trade energy.[177]

Underpinning the project are three 'framework layers':

1. **DER integration** ensures that 'internet of things' devices are integrated with DER meters, inverters and controls in a secure network.
2. **Active grid management** monitors the data gathered from DERs and manages voltage and frequency of supply.
3. **Smart energy management** enables flexibility and forecasting, as DERs decrease or increase demand and supply (for example, the scheduled charge and discharge of batteries). This capacity for resource aggregation and orchestration allows for tariff planning in the internal microgrid market, and the provision of demand response to the external energy market.[178]

These layers are dependent upon 'internet of things' technology that monitor, manage and share data. DER integration is supported by Indra's Node #1 and iSpeed, active grid management is supported by Indra's Onesait platform, and smart energy management is supported by Monash's transactive energy market.[179]

The findings of this project will be released mid-2020. Key research themes to be explored are microgrid costs and benefits, microgrid design, deployment and operation, and running a smart energy city.

Microgrid Electricity Market Operator (MEMO) project overview

To coordinate DERs in the microgrid, and act as the interface between wholesale and ancillary markets, Monash has proposed a new business entity called the 'microgrid electricity market operator' (MEMO).

The MEMO will own and finance microgrid assets, including software, hardware and communications. The MEMO will also be responsible for microgrid control services, such as grid maintenance and power quality analytics, market services such as energy trading and settlements, and customer services including billing and tariff design.[180]

Prosumers in the microgrid will own and finance their own DERs, while the MEMO would dispatch these resources to maximise revenue. In return for this service, prosumers will pay a fee.[181]

175 Monash University, *Smart Energy City Introductory Report: Design overview and initial research questions,* (2019): 10-11. https://www.monash.edu/__data/assets/pdf_file/0010/1980496/Smart-Energy-City_Introductory-Report_20190731.pdf

176 Ibid, 10.

177 Ibid, 3.

178 Ibid, 13-15.

179 Ibid, 16-19.

180 Monash University, *Microgrid Electricity Market Operators: Commercialisation Brochure,* (2019): 5. https://www.monash.edu/__data/assets/pdf_file/0011/1980497/Monash-Net-Zero_Microgrid-Operator-Commercialisation-Brochure_20190617.pdf

181 Ibid, 6.

Monash will test the viability of this model within their microgrid, and if successful, will seek to establish contracts and expand the MEMO project to other sites. To identify the value that microgrids can add to Victoria, along with recommendations to overcome regulatory and market barriers, Monash has published the *Victorian Market Assessment White Paper.*[182]

Relevance to customers

These projects will develop a business case for further microgrids, by exploring models and ownership structures, determining what makes microgrids commercially viable, and by highlighting necessary regulatory and market reform.[183] They should also establish an economic case for customers within the microgrid.

The ability to inform and influence regulatory change with a working example of a microgrid and trading market is particularly valuable, considering the AEMC recommendation for a tiered approach to regulation[184]. If small and medium sized regulation for third-party owned microgrids is left up to the states, then it is important to ensure that any risks rising from different reliability, security and safety standards can be overcome by standards upheld by a microgrid operator.

Trends in consumer behaviour will emerge as Monash 'customers' interact with the microgrid operator. These interactions could highlight necessary safeguards and consumer protections currently lacking, especially if the microgrid operator is responsible for customer services such as contracts, billing and collections. Indeed, it is potentially problematic that customers within microgrids will be have a single point of contact – the MEMO – for such a diverse range of services. While this structure may simplify communications between consumers, prosumers and the operator, it also opens up the potential for limited dispute handling when things go wrong and could result in a conflict of interest.

If customers are responsible for owning and financing DERs required to participate in a microgrid (as suggested in the Monash MEMO project), they may be increasingly vulnerable to finance arrangements as mentioned in Chapter 3. When a fault occurs, customers will also have to navigate disputes with technology providers as well as the MEMO intending to dispatch their DERs.

Findings from the *Smart Energy City* project should inform the functionality of the smart technology necessary for DER coordination and dispatch. If Monash customers, (who may be more informed about new energy technologies due to the research environment), find the use of smart technology difficult or confusing, this will speak volumes for the applicability of smart technology in the wider community.

As the projects are still in their early phases, the effectiveness of a microgrid operator and coordination of DERs are yet to be fully understood. The project should shed much needed light on the customer experience of interacting with operators, markets and technologies, and inform the gaps in consumer protection.

182 Monash University, *Victorian market assessment for microgrid electricity market operators: White paper,* (2019). https://www.monash.edu/__data/assets/pdf_file/0010/1857313/Monash-Net-Zero_Microgrid-Operator-Whitepaper_20190617-1.pdf

183 Monash University, *Smart Energy City Introductory Report: Design overview and initial research questions,* (2019): 20. https://www.monash.edu/__data/assets/pdf_file/0010/1980496/Smart-Energy-City_Introductory-Report_20190731.pdf

184 AEMC, *Review of the regulatory frameworks for stand-alone power systems – Priority 2 Report,* (2019): 73. https://www.aemc.gov.au/market-reviews-advice/review-regulatory-frameworks-stand-alone-power-systems

Chapter Four: Electric Vehicles

FAST FACTS

- Current uptake of EVs is very low but is predicted to sky-rocket over the next few decades, until they account of 95% of all vehicles on Australian roads by 2050.
- Vehicles spend 95% of their life-time parked, so collectively, EVs are likely to provide a huge energy storage resource.
- EVs do not only draw from the grid to charge, but also have the capacity to feed back into the grid, to provide grid stabilisation services. Consumers will be incentivised to allow their EV to be used for this purpose.
- Anticipated heads of complaint include access to benefits (feed-in tariffs), product faults, and failed interactions with other forms of new energy technology.

Introduction

An electric vehicle (EV) is technically defined as a vehicle which uses one or more electric or traction motors for propulsion. While there are various types, EVs typically plug in to an electricity source to charge and then use onboard rechargeable batteries (most commonly lithium-ion) to drive their motors, rather than burning petroleum fuel. In common usage, (and for the purposes of this report), the term EV is often used interchangeably with the term electric car. Electric cars are exclusively powered by electricity and are therefore distinguishable from 'hybrid' vehicles - which use a combination of electric and internal combustion propulsion.

It should be noted that in the future many EVs may be powered by hydrogen fuel cells, as opposed to lithium-ion battery. These vehicles are re-fuelled with hydrogen gas – they do not plug into and draw down from the grid to refuel, but they do contain an internal battery (which is fed by their hydrogen tank), just like conventional electric cars.[185] The future of EVs is hotly contested between those who favour batteries, versus those who favour hydrogen fuel cells (for example, Elon Musk, founder of Tesla and a strong proponent of batteries has decried hydrogen fuel cells as "*mind-bogglingly stupid*" and labelled them "*fool cells*" [186]). Hydrogen fuelled EVs are in their very early stages in Australia. The ACT government has recently ordered 20 vehicles, and plans to build the country's first public hydrogen re-fuelling station,[187] and the Queensland State Government has recently announced that it will be trialling hydrogen vehicles across its fleet, with another re-fuelling station to be built at the Queensland University of Technology.[188]

185 Nadine Cranenburgh, "Electric or hydrogen – which will win the clean car race?" *ABC News*, 17 November 2019. https://www.abc.net.au/news/science/2019-11-17/hydrogen-vs-electric-who-will-win-the-clean-vehicle-race/11694400

186 Joe D'Allegro, "Elon Musk says the tech is 'mind-bogglingly stupid' but hydrogen cars may yet threaten Tesla," *CNBC, 24 February 2019*. https://www.cnbc.com/2019/02/21/musk-calls-hydrogen-fuel-cells-stupid-but-tech-may-threaten-tesla.html

187 Nadine Cranenburgh, "Electric or hydrogen – which will win the clean car race?" *ABC News*, 17 November 2019. https://www.abc.net.au/news/science/2019-11-17/hydrogen-vs-electric-who-will-win-the-clean-vehicle-race/11694400

188 "Hydrogen cars to extend Queensland's renewable energy lead," Queensland University of Technology, 27 August 2019. https://www.qut.edu.au/news?news-id=150413

Whether powered by lithium-ion batteries or hydrogen fuel cells, EVs can be powered by renewable energy subject to the fuel mix of the grid, or the means by which the hydrogen has been produced[189] - and will play a major role in de-carbonising the transport sector.

EVs are predicted to supplant internal combustion engine vehicles in the short to medium term. This enormous transition is often described as a transport revolution, perhaps as significant as the introduction of the internal combustion engine itself. Rapid uptake of EVs does present the risk of significantly increased electricity consumption – putting pressure on the grid and requiring additional generation at a time when the energy system must transition to renewable (and potentially less reliable) power.[190]

Fortunately, EVs also have the capacity to interact with the energy grid as a form of energy storage - so they can mitigate this risk by providing energy during periods of high demand, and stabilising the grid during periods of fluctuating power generation.[191]

The introduction of EVs and the array of services that will be necessary to facilitate their connection to the grid will create increased complexity for consumers. This complexity, (along with their predicted ubiquity), means that EVs will almost certainly generate a significant proportion of energy related complaints in the near future.

Current market penetration in Victoria

Market penetration of EVs in Victoria, (and in Australia generally) is currently very low – and lags behind many other countries.[192]

Between 2011 and 2017, Victorians bought only 1,324 EVs – which nevertheless made Victoria Australia's leading state for EV purchases over that period.[193] That being said, in 2017 even Victorians were still only buying 10 EVs for every 10,000 cars sold.[194] Nationwide, EVs account for less than 0.1% of new car sales,[195] whereas in the world's most advanced EV market, Norway, they already account for 50% of new car sales.

Needless to say, there is room for significant and rapid growth of EV sales in Victoria in the short to medium term.

189 Jon Cartwright, "Hydrogen use doesn't emit carbon but its production often does. That could soon change," *Horizon Magazine*, 17 October 2018. https://horizon-magazine.eu/article/hydrogen-use-doesn-t-emit-carbon-its-production-often-does-could-soon-change.html

190 KPMG, *Electric vehicles: Is the energy sector ready?* (2018). https://assets.kpmg/content/dam/kpmg/au/pdf/2018/electric-vehicles-is-the-energy-sector-ready.pdf

191 IRENA, *Innovation Outlook: Smart Charging for Electric Vehicles*, (2019). https://www.irena.org/publications/2019/May/Innovation-Outlook-Smart-Charging

192 Energia, *Australian Electric Vehicle Market Study,* (2018): 3. https://arena.gov.au/assets/2018/06/australian-ev-market-study-report.pdf

193 Climateworks Australia, *The State of Electric Vehicles in Australia*, (2018): 7. https://www.climateworksaustralia.org/sites/default/files/documents/publications/climateworks_australia_state_of_electric_vehicles2_june_2018.pdf

194 Ibid, 26.

195 KPMG, *Electric Vehicles: Is the energy sector ready?* (2018): 2. https://assets.kpmg/content/dam/kpmg/au/pdf/2018/electric-vehicles-is-the-energy-sector-ready.pdf

Identified barriers to uptake

The primary barrier to uptake of EVs is cost, including both the upfront purchase cost and the perceived cost to own. A 2018 study by industry organisation Energia, (part funded by ARENA and the South Australian government) found that 70% of respondents cited purchase price as an issue. At the time of the study the price gap between EV's and an equivalent fuel powered vehicle was between $15,000 and $20,000. Taking fuel cost savings into account over a five-year period, this difference would reduce to between $5,000 and $10,000 – with the 'breakeven point' arriving at the nine-year mark.[196]

The study also found that 60% of respondents were concerned about battery life, and 42% listed concern around insufficient charging infrastructure.[197] Taken together, these concerns are linked to "range anxiety" - the fear that a buyer may be left high and dry, with a battery that has run flat and nowhere accessible to recharge. Range anxiety clearly forms a significant barrier to uptake.

Interestingly, the study also found a significant gap between a stated intention to buy an EV, versus the actual decision to do so. In behavioural economics this is known as the intention-action gap. One factor influencing this gap was that buyers viewed EVs as futuristic, and somehow "foreign" – and not easily integrated into their current lives.[198]

Projected penetration 2030 – 2050

Bloomsburg New Energy Finance have predicted that EVs will be cost competitive with traditional vehicles by 2024[199], removing one of the major barriers to uptake. Several countries (including China, easily the world's largest car market), have announced their intention to ban petrol fuelled vehicles over the coming few decades[200]. As a result, some major car manufacturers have signalled their intention to phase out production of internal combustion engine cars.[201] Given that Australia's car market is dominated by imported vehicles[202], our local market will be determined by these decisions.

Consequently, local uptake of EVs is predicted to rise dramatically. In the near future buying a traditional internal combustion engine vehicle will no longer be rational, or even viable in Australia. Locally, this has been recognised by Infrastructure Victoria who, (in response to a Victorian Government request), recently provided their *Advice on Automated and Zero Emissions Vehicles Infrastructure.* This was published in October 2018.[203]

In these circumstances, it is also to be expected that charging infrastructure will become more common, and buyers will become more informed about EVs (and have more trust in battery capacities, and therefore less range anxiety). As EVs become normalised the notion that they are 'futuristic' will subside, and the intention-action gap will reduce. An April 2019 report by the Australian Academy of Technology and Engineering found that the 'social readiness' for low and zero emissions vehicles in Australia was already high. It is clear that the necessary economic and market factors will soon align with that readiness.[204]

196 Evenergi, *Unlocking demand for renewably powered vehicles*, (2018): 3. https://docs.wixstatic.com/ugd/b76440_6dc6993fe58f4ef3827cd6216e5da4ae.pdf?index=true

197 Ibid, 20.

198 Ibid, 3.

199 KPMG, *Electric Vehicles: Is the energy sector ready?* (2018): 2. https://assets.kpmg/content/dam/kpmg/au/pdf/2018/electric-vehicles-is-the-energy-sector-ready.pdf

200 George Roberts, "China's indication to ban sale of non-electric cars a 'tipping point' for global industry," *ABC News,* 14 September 2017. https://www.abc.net.au/news/2017-09-12/chinas-move-to-ban-sale-of-non-electric-cars-a-tipping-point/8894746

201 Paul A. Eisenstein, "GM is going all electric, will ditch gas and diesel powered cars," *NBC News,* 3 October 2017. https://www.nbcnews.com/business/autos/gm-going-all-electric-will-ditch-gas-diesel-powered-cars-n806806

202 Andrew Chesterton, "Australian car market: Car sales, statistics and figures," CarsGuide, 11 September 2019. https://www.carsguide.com.au/car-advice/australian-car-market-car-sales-statistics-and-figures-70982

203 Infrastructure Victoria, *Advice on automated and zero emissions vehicles infrastructure,* (2018). https://www.infrastructurevictoria.com.au/wp-content/uploads/2019/04/Advice-on-automated-and-zero-emissions-vehicles-October-2018.pdf

204 Australian Academy of Technology and Engineering, *Shifting Gears – Preparing for a Transport Revolution: Transport Industry Technology Readiness*, (2019): 4. https://www.applied.org.au/news-and-events/article/shifting-gears-preparing-for-a-transport-revolution/

Taking all of these factors into account, it is not surprising that the CEFC has forecast that EVs will account for 50% of all new car sales in Australia by 2030, and 100% by 2040.[205]

Collectively, EVs are predicted to account for 95% of all vehicles on Australian roads by 2050.[206]

How EVs will interact with the energy grid

Cars generally spend about 95% of their lifetime parked[207], which means that EVs will soon present a huge potential pool of stored energy. When not being driven, each EV will be capable of acting as a grid-connected storage unit able to interact in a two-way flow with the broader energy system – just like a home battery system.

It is also true that EVs could create extreme peak periods of demand if charging is not co-ordinated and controlled. These peaks would cause grid congestion and force expensive and wasteful distribution upgrades which would be surplus to requirements, most of the time.

To avoid this outcome and to maximise the positive grid management potential of EV's, regulation and business models will be needed to encourage "smart charging".[208] Smart charging will take advantage of different pricing and technical charging options (such as utilising slow charging rather than fast or ultra-fast charging, which do not leave batteries connected to the system long enough to provide flexibility), to ensure that EVs stabilise the grid rather than act as a burden upon it.

Smart charging will include time of use tariffs to incentivise charging during off-peak periods, and is also likely to involve direct control mechanisms (remotely controlling the 'behaviour' of an EV), particularly when market penetration of EVs is very high.[209] Smart charging will involve a complex interaction between vehicles, the broader grid and homes to balance energy flows across the entire system.

Of course, if the majority of EVs are powered by hydrogen fuel cells, the issue of recharging will be much less problematic in this context.

While EVs present enormous positive opportunities for Victoria's electricity system, their interaction with the grid will be complex and inextricably linked with customer behaviour. When things don't work as they are meant to, this will generate energy related complaints.

How EVs could go wrong

Generic heads of complaint

As EV sales accelerate the market will be primed for innovative technologists and opportunists to sell their wares, creating an environment ripe for poor conduct as has occurred in other new and emerging markets, prior to regulatory crackdowns.[210] This activity will likely result in complaints about misleading or deceptive sales, unconscionable conduct, unfair contract terms or other contractual issues such as breaches of warranties, or consumer guarantees. These complaint categories could equally apply to the other technologies and services discussed in this report.

205 CEFC, *Clean Energy Snapshot: Australian Electric Vehicle Market Study*, (2018): 7. https://www.cefc.com.au/media/401922/cefc-snapshot-electric-vehicles-jun2018.pdf

206 KPMG, *Electric Vehicles: Is the energy sector ready?* (2018): 2. https://assets.kpmg/content/dam/kpmg/au/pdf/2018/electric-vehicles-is-the-energy-sector-ready.pdf

207 IRENA, *Innovation Outlook: Smart Charging for Electric Vehicles*, (2019): 1. https://www.irena.org/publications/2019/May/Innovation-Outlook-Smart-Charging

208 Ibid, 2.

209 Ibid.

210 For example, for the past few years the Australian Communications and Media Authority (ACMA) has listed unsolicited tele-marketing of solar panels as one if its key compliance priorities. See: https://www.acma.gov.au/compliance-priorities#_-unsolicited-communications

As with any other product, EVs may also precipitate a range of consumer complaints around product faults or poor workmanship. As with sales and contract related complaints, protections for these issues are provided by the Australian Consumer Law (ACL), and complaint resolution will lie with organisations charged with administering and enforcing that law – namely the Australian Competition Consumer Commission (ACCC) and state based fair trading agencies. In Victoria, the relevant agency is Consumer Affairs Victoria (CAV).

Interaction of generic heads of complaint with energy issues

Beyond general sales, contract and product related complaints there is the potential, in this instance, for issues that are purely product related to also have an impact on the customer's relationship with their energy supply.

For example, poor manufacturing may result in an EV that does not feed-back properly into the grid. From the customer's point of view, this issue will probably present itself in the form of lower than expected earnings on feed-back tariffs, and thus appear to be a billing error. Although there may be no actual billing error, the customer may well contact EWOV for assistance in resolving the issue after they have unsuccessfully attempted to do so directly with their service provider. When we then investigate the issue, we may ultimately determine that it is likely to be a vehicle fault.

It would be up to the customer to pursue their complaint with the vehicle manufacturer, potentially to assert their warranty rights, or consumer guarantee rights under the ACL.

In the meantime, EWOV will have expended time and resources in investigating the issue – and will have charged the retailer in the process, despite the fact that the retailer was not at fault.

It should be noted that EWOV is yet to encounter such a case – but given the projected uptake of EVs, this issue has the potential to become a significant problem.

The possible scale of the issue does raise the question of whether EWOV may be able to offer a better service by liaising directly with the car manufacturer on the customer's behalf. Under current legislative arrangements that would not be possible - but reform to facilitate this could be considered as EVs become increasingly critical to the grid, and therefore to the customer experience of energy.

'Energy only' complaints

Beyond such product related complaints, the interaction of EVs with the energy system will also generate a range of purely energy related complaints.

The capacity to feed back into the grid, along with the requirement to charge will stimulate the introduction of EV specific tariffs - notably feed-in tariffs, but also charging tariffs, which have already been trialled by some retailers.[211]

These tariffs will inevitably generate billing errors, potentially arising from their incorrect application and therefore higher than expected costs or lower than expected feed-in revenue.

Such complaints will not concern the EV itself. They will relate to the integration of an EV into the billing or metering system – and they will require specialist energy industry knowledge to resolve.

These complaints will apply to the service provider issuing the bill, and whether they are an existing licensed provider or an exempt market participant they already fall into EWOV's jurisdiction by virtue of the fact that those entities are required to be EWOV members.

211 AGL and Powershop, for example, currently advertise EV charging plans.

EV interactions with other new energy tech

Beyond those complaints, there is the potential for complaints arising from a failed interaction between an EV and a customer's Home Energy Management System (see Chapter 6, p. 60 for more information), or the Virtual Power Plant a customer may have signed onto, or to glitch in Peer-to-Peer energy trading (see Chapter 5, p. 51 for more on VPPs and P2P). As a form of energy storage, EVs may even play a part in a microgrid (see Chapter 4, p.45 for more). Depending on the entities involved in those interactions, it is much less clear that EWOV would be able to assist a customer with their complaint. In many cases, it is likely that we could not – at least under current arrangements.

Table 8.

Summary table – electric vehicles

EVS	Current Market Penetration	Projected: 2020 – 2030	Projected: 2030 - 2050
	Very Minimal Climateworks Australia report that between 2011 and 2017, Victorians bought only 1,324 EVs – which nevertheless made Victoria Australia's leading state for EV purchases over that period[212]	**High** The CEFC has forecast that EV's will account for 50% of all new car sales in Australia by 2030[213]	**Very High** The CEFC has forecast that EV's will account for 100% of all new car sales in Australia by 2040[214] Collectively, EV's are predicted to account for 95% of all vehicles on Australian roads by 2050[215]
	Barriers to Growth		
	› Cost › Lack of charging infrastructure › Concerns over limited battery life › Perceived as 'futuristic' ie. lack of buyer comfort	› Possible lack of charging infrastructure	› None. Likely to be no alternative
	Existing/anticipated heads of complaint*		
	• Misleading marketing and high-pressure sales • Technical product faults and quality issues • Billing errors, including incorrect feed-in tariffs • Functional issues from interface with HEMS, VPPs, P2P platforms or microgrids.		

- Blue = In EWOV's current jurisdiction
- Orange = Out of EWOV's current jurisdiction

212 Climateworks Australia, *The State of Electric Vehicles in Australia*, (2018): 7. https://www.climateworksaustralia.org/sites/default/files/documents/publications/climateworks_australia_state_of_electric_vehicles2_june_2018.pdf

213 CEFC, *Clean Energy Snapshot: Australian Electric Vehicle Market Study*, (2018): 7. https://www.cefc.com.au/media/401922/cefc-snapshot-electric-vehicles-jun2018.pdf

214 Ibid.

215 KPMG, *Electric Vehicles: Is the energy sector ready?* (2018): 2. https://assets.kpmg/content/dam/kpmg/au/pdf/2018/electric-vehicles-is-the-energy-sector-ready.pdf

Chapter Five: the future of DER storage – Virtual Power Plants (VPPS) and Peer to Peer (P2P) trading

Introduction

Energy storage behind the meter, whether through an EV or a residential battery, is critical to the transition of the energy system – and this transformation will become increasingly essential to effective grid management. The comparatively intermittent nature of renewable power generation, (be it solar or wind power), means that energy storage will be critical to grid reliability as we move towards an increasingly decarbonised, decentralised energy future.

While storage will enable prosumers to sell their energy back into the grid individually (provided the right incentives emerge to encourage them to do so), the real power of energy storage is likely to be realised through aggregating a large number of energy systems both behind the meter, and grid connected, and effectively managing them as one large system - known as a Virtual Power Plant (VPP).

Further, energy storage will open the way for individual prosumers to trade energy directly with each other, (and to other energy consumers), rather than to an energy company. This is known as peer to peer trading (P2P).

Both VPPs and P2P trading are in their early stages in Victoria, and Australia generally.

In recent years ARENA has been funding pilot projects and trials to address the various technical challenges that VPPs face. In addition to these technical issues, VPP's will require changes to regulatory frameworks, and AEMO operation systems and processes to facilitate their smooth integration into the NEM.

If anything, P2P is even less progressed than VPPs are. One notable practical trial is the RENew Nexus Plan being run by Synergy in Western Australia, as part of a now closed Federal Government funding initiative called the "Smart Cities and Suburbs Project".[216]

A number of theoretical, 'virtual trials' have also been undertaken to explore the potential of P2P trading. Perhaps most prominent amongst these was the 2017 AGL Virtual Trial of Peer-to-Peer Energy Trading[217], which was funded by ARENA and used data collected from AGL's previous demand response trial in Carrum Downs, Victoria.

Inevitably, VPP and P2P transactions will not always run smoothly for individual consumers – and will generate complaints that are not currently served by a specialist dispute resolution body. While it is too early to know exactly what these complaints will be, it is possible to survey the current development of both practices in more detail.

VPPs

In April 2019 the Australian Energy Market Operator (AEMO), in conjunction with ARENA, announced the Virtual Power Plant Integration Trial.[218] The project will run for 12 to 18 months and is focussed on demonstrating the operational capability of VPPs to deliver energy and Frequency Control Ancillary Services (FCAS) (i.e. to 'stabilise the grid').

Existing pilot scale VPPs around Australia were invited to participate, including the ARENA-funded AGL and Simply

216 "RENeW Nexus (P2P) Plan," Synergy, accessed December 2019. https://www.synergy.net.au/Our-energy/Future-energy/RENeW-Nexus-Trial

217 "AGL virtual trial of peer-to-peer energy trading," ARENA, accessed December 2019. https://arena.gov.au/projects/agl-virtual-trial-peer-to-peer-trading/

218 "AEMO to trial integrating VPPs into the NEM," ARENA, 5 April 2019. https://arena.gov.au/news/aemo-to-trial-integrating-virtual-power-plants-into-the-nem/

Energy pilot scale VPPs in South Australia. The trial officially opened for enrolments on 31 July 2019.[219]

Lessons learned through the project will enable AEMO to upgrade their systems and processes before VPPs reach 'commercial scale'.

While VPPs are currently only at 5-10MW capacity, AEMO has forecast that VPP capacity may be up to 700 MW by 2022[220] - roughly equivalent to a small coal-fired power station.

For VPPs to be truly successful they must be visible to AEMO as AEMO 'directs traffic' across the NEM. And of course, prosumers must be willing and able to engage – allowing their batteries to be used as part of a VPP. The incentives encouraging prosumer participation in VPPs must be balanced so that individual participants benefit, at the same time as their participation operates to benefit the system as a whole.

It is sobering that the Bruny Island CONSORT Project (discussed on page 57 of this report) found that consumers should not be assumed to be willing to engage with VPPs, and that attitudes towards engagement can vary for a multiplicity of reasons. The study also found that financial incentives should not be assumed to be the primary driver for all consumer decision-making – despite the persistence of economic modelling based on that premise.

These caveats aside, the CONSORT project was notable for its success in achieving a 33% reduction in the use of diesel to supplement power generation on Bruny Island - a clear collective benefit - as well as delivering an additional financial benefit (and therefore at least some incentive) to individual participants.

The project achieved this through the use of algorithms collectively dubbed 'Network-Aware Coordination' (NAC), which operate as an "*advanced battery orchestration platform*". This kind of balancing is key to making VPPs viable. While the CONSORT Project only involved 34 solar PV and battery systems, if the same approach can be shown to work at scale then it could prove very important to mainstreaming VPPs over the medium to long term.

It is also clear that effectively managing the customer experience of VPPs will be essential to their success. In turn, access to an effective external dispute resolution service will be central to that experience - and therefore the overall success of the technology.

P2P Trading

In late 2018 Synergy commenced a P2P trading trial in Western Australia, in conjunction with Curtin University, Power Ledger, Western Power and energyOS, amongst other partners.[221]

The RENew Nexus Plan empowered approximately 40 residents in Fremantle to actively trade their own solar energy with neighbours, and set their own prices.[222] Power Ledger is a block chain enabled platform which allows the transactions to occur in near real time. Not all trial participants owned solar panels – those who did not were able to buy solar power from their neighbours by simply entering the price they were willing to pay and allowing the software to determine if any was available at that price.[223] This meant they were able to purchase power more cheaply than if they had been buying it from Synergy, the local retailer.

The trial ran until June 2019. Curtin University are currently researching the findings, and a report is expected soon.

219 "AEMO's virtual power plant trial opens for enrolments," AEMO, 31 July 2019. https://energylive.aemo.com.au/News/AEMO-VPP-trial-open-for-enrolments

220 "AEMO to trial integrating VPPs into the NEM," ARENA, 5 April 2019. https://arena.gov.au/news/aemo-to-trial-integrating-virtual-power-plants-into-the-nem/

221 Sophie Vorrath, "World-leading rooftop solar trading kicks off in Fremantle," One Step Off the Grid, 6 December 2018. https://onestepoffthegrid.com.au/world-leading-rooftop-solar-trading-trial-kicks-off-fremantle/

222 "Fremantle residents participating in world-first trial, trading solar energy peer-to-peer and setting their own prices," Medium, 14 December 2018. https://medium.com/power-ledger/fremantle-residents_participating-in-world-first-trial-trading-solar-energy-peer-to-peer-and-955b81d438c1

223 "Power switch: The Perth households trading energy with each other," Royal Automobile Club of W.A., 19 February 2019. Available at: https://rac.com.au/home-life/info/future_power-ledger-trial

The RENew Nexus trial is notable for being an actual, practical trial, and has been described as a world first by those who devised it. Prior to RENew Nexus, P2P had been extensively modelled in a number of 'virtual' trials.

The 2017 AGL Virtual Trial of Peer-to-Peer Energy Trading project simulated P2P energy trades between 68 customers, basing predictions on data collected during AGL's previous demand response trial (drawn from Carrum Downs, Victoria). The trial was essentially a feasibility study, which also explored the potential for distributed ledger technology (i.e. 'blockchain') to manage these transactions, (just as later occurred in the RENew Nexus trial). The AGL Virtual Trial concluded that P2P can provide financial benefits to both consumers and prosumers, and that distributed ledger technology can support P2P trading, providing clear process and security benefits.[224]

Earlier modelling conducted by academics at the School of Photovoltaic and Renewable Energy Engineering, at the University of New South Wales, found that in a low penetration solar PV scenario P2P trading could potentially reduce the power bill of solar PV customers from $823 a year, to just $449 per year.[225]

These results should be tempered by a consideration of potential network constraints – namely, the risk of overvoltage. A 2018 study published by the School of Electrical and Information Engineering, at the University of Sydney, modelled a P2P market of 12 users under network constraints to identify whether they still received financial benefits.[226] While the study showed that it was very important to take network constraints into consideration, they did confirm that the market remained viable for P2P trading while respecting the balance between generation and demand.

While all of this indicates that P2P holds significant potential, it also shows that it is very much in the early stages of development. The results of the RENew Nexus trial in WA will likely shed some light on the lived experience of P2P, but even then – it must be remembered that it was only a small trial involving 40 households. P2P still has a long way to go – which is not to say it won't be viable much sooner than anyone expects.

Complexity and Consumer Engagement

Bringing solar PV, energy storage, microgrids, VPPs and P2P trading together - one thing becomes very clear. Energy is going to become more complicated. The shift from being a consumer to prosumer in a dynamic 'two way' energy market is going to put more pressure on households to engage, and potentially make it harder for them to ensure that they do so for their own benefit, depending on their level of knowledge.

To enable this significant shift, and to ensure that households genuinely benefit as a result, it will be critical for people to be able to 'set and forget' their interaction as much as possible – and allow automated processes to operate on their behalf, orchestrating the use and flow of energy into and out of their homes. In this context, Home Energy Management Systems (HEMS) will soon become an essential piece of residential energy infrastructure, and will be particularly relevant to VPPs and P2P. Importantly, the Consumer Data Right (CDR) will also enable consumers to 'outsource' their engagement to a certain extent, although this may bring issues of its own.

HEMS - and to a lesser extent, the CDR - are the subject of Chapter 6 (p.60), following our "Policy Spotlight" on a VPP trial project run from 2016-2018 on Bruny Island, in Tasmania.

224 AGL, ARENA, MHC & IBM, *Peer-to-Peer Distributed Ledger Technology Assessment*, (2017): 7. https://arena.gov.au/assets/2017/10/Final-Report-MHC-AGL-IBM-P2P-DLT.pdf

225 Anubhav Roy, Anna Bruce, & Ian MacGill, *The Potential Value of Peer-to-Peer Energy Trading in the Australian National Electricity Market*, (Asia Pacific Solar Research Conference, 2016): 7 -8. http://ceem.unsw.edu.au/sites/default/files/documents/A%20Roy%2C%20A%20Bruce%2C%20I%20MacGill-Potential%20Value%20of%20Peer-To-Peer%20Energy%20Trading%20in%20the%20Australian%20National%20Electricity%20Market.pdf

226 Jaysson Guerrero, Archie Chapman, & Gregor Verbic, *Peer-to-Peer Energy Trading: A Case Study Considering Network Constraints*, (Asia Pacific Solar Research Conference, 2018). http://apvi.org.au/solar-research-conference/wp-content/uploads/2018/11/010_D-I_Guerrero_J_2018.pdf

Table 9.

Summary Table – VPPs

VPPS	Current Market Penetration	Projected: 2020 – 2030	Projected: 2030 - 2050
	Very Minimal Isolated trials, most notably Bruny Island CONSORT trial 2016-2018 (see: Policy Spotlight pg. 57)[227] Australian Energy Market Operator (AEMO), in conjunction with ARENA, have announced the Virtual Power Plant Integration Trial, enrolments commenced 31 July 2019[228]	**Minimal - Moderate** Is dependent on regulatory reform, uptake of residential batteries and/or electric vehicles and technical innovation	**Potentially High - Very High** Is dependent on regulatory reform, uptake of residential batteries and/or electric vehicles and technical innovation
	Barriers to Growth		
	› Lack of prosumer resources /infrastructure › Regulatory barriers › Lack of consumer knowledge/education › Requires high engagement from prosumer › Lack of prosumer faith/ trust in collective engagement	› Lack of prosumer resources /infrastructure › Regulatory barriers › Lack of consumer knowledge/ education › Requires high engagement from prosumer › Lack of prosumer faith/ trust in collective engagement	› All barriers may potentially be resolved, could be highly automated process
	Existing/anticipated heads of complaint*		
	• Functional issues from interface with HEMS • Software faults potentially causing financial loss • Complaints around unexpectedly poor returns		

- Orange = Out of EWOV's current jurisdiction

227 "CONSORT Bruny Island Battery Trial," Bruny Battery Trial, accessed November 2019. http://brunybatterytrial.org/

228 "AEMO Virtual Power Plant Demonstrations," ARENA, accessed December 2019. https://arena.gov.au/projects/aemo-virtual-power-plant-demonstrations/

Table 10.

Summary table – P2P

P2P	Current Market Penetration	Projected: 2020 – 2030	Projected: 2030 - 2050
	Very Minimal RENeW Nexus P2P Plan – a 2018 trial in Western Australia involving 40 households in Fremantle. Curtin University due to report on the results[229]	**Minimal - Moderate** Is dependent on regulatory reform, uptake of residential batteries and/or electric vehicles and technical innovation	**Potentially High - Very High** Is dependent on regulatory reform, uptake of residential batteries and/or electric vehicles and technical innovation
	Barriers to Growth		
	› Lack of prosumer resources /infrastructure › Significant regulatory barriers › Lack of consumer knowledge /education › Requires high engagement from prosumer	› Lack of prosumer resources /infrastructure › Significant regulatory barriers › Lack of consumer knowledge /education › Requires high engagement from prosumer	› All barriers may potentially be resolved, could be highly automated process
	Existing/anticipated heads of complaint*		
	• Functional issues from interface with HEMS • Software faults potentially causing financial loss • Complaints around unexpectedly poor returns		

- Orange = Out of EWOV's current jurisdiction

229 "RENeW Nexus (P2P) Plan," Synergy, accessed December 2019. https://www.synergy.net.au/Our-energy/Future-energy/RENeW-Nexus-Trial

Policy Spotlight: CONSORT Bruny Island Battery Trial

FAST FACTS

- The CONSORT project connected 34 PV-battery systems on Bruny Island, and co-ordinated their input into the local grid using a Network Aware Coordination (NAC) algorithm.
- Individual participants benefited financially by allowing their assets to be used in this way. Non-participants also benefited through a 33% reduction in the use of diesel generators to augment supply on Bruny Island.
- Participant sentiment varied widely. The project showed that consumers should not be assumed to be willing to participate in DER – even if it seems "rational" to do so.

CONSORT Project Overview

The CONSORT Project[230] (derived from CONsumer energy systems providing cost-effective grid suppORT), ran for three years from 2016 to 2018 inclusive on Bruny Island, a small island off the south-eastern coast of Tasmania. CONSORT was a joint project involving multiple parties – the Australian National University (ANU), University of Tasmania (UTAS), University of Sydney, Australian Renewable Energy Agency (ARENA), Reposit Power and TasNetworks.

Under the project, 34 PV-battery systems (totalling 133kW PV and 128kW/333kWh storage systems) were installed on the Bruny Island[231], where the local distributor (TasNetworks) had been relying on a diesel generator to supplement energy needs during peak periods since 2012.

Each of the 34 installed systems were equipped with the Reposit GridCredits systems, which allow for the collection of high frequency data, solar shifting on behalf of customers and manual control of aggregated batteries during peak loading - to reduce diesel consumption. Essentially, it enabled the systems to be employed as a Virtual Power Plant (VPP).

The resulting network of PV-battery systems were then used to test ANU's Network-Aware Coordination (NAC) algorithms – described as *"an advanced battery orchestration platform"*.[232]

NAC is designed to automatically coordinate a large number of distributed energy resources to balance demand and generation across the network. NAC achieves this while still allowing consumers to use their PV-battery systems to maximise savings on their own bill.

Through the CONSORT project, different consumer incentive structures were tested, and qualitative research was undertaken to gather consumer perspectives and investigate consumer behaviour.

230 Sylvie Thiébaux et al., *CONSORT Bruny Island Battery Trial: Project Final Report* [public dissemination], (2019). http://brunybatterytrial.org/wp-content/uploads/2019/05/consort_public_dissemination.pdf

231 Ibid, 7.

232 Ibid, 9.

Results

Over the course of the trial, NAC reduced the requirements for diesel use in the trial grid by approximately 33% - representing a significant saving across the system[233]. To put this in perspective, in 2018 there were 24 high demand events where diesel would have been used if not for the trial – generally occurring during school holidays and public holidays.

Total energy savings from all installed systems ranged from $630 up to $1,550 per year, with the average participant saving $1,100. Annual savings from solar generation only ranged from $380 to $1,230, with the average being $750, and annual savings attributable to battery systems (excluding Reposit optimisation and network support payments) were $60 up to $350, with $200 as the average.[234]

The savings owing to NAC Network Support Payments were $115 across all participants – while the loss attributable to making their battery available for grid support was no higher than $7 for any participant, with an average of $1.40. [235]

Essentially, the CONSORT project found that NAC could work to coordinate residential home batteries for the purposes of grid support - and could do it without causing any loss or detriment for consumers. In fact, participants made a gain. CONSORT was a powerful and timely demonstration of the potential of DER to be aggregated for both collective and individual benefit.

Consumer insights

Despite the clear success of CONSORT, one of the interesting findings to emerge out of the project was the variance in consumer attitudes and engagement. The research team found that it should not be assumed householders will be willing to participate in DER. In fact, they found that expecting any kind of uniform and predictable response to DER would be unrealistic.[236]

Consumer sentiment towards DER can vary wildly (even amongst a small sample of thirty-four households), and to encourage uptake communication strategies should be devised not only to impart technical information, but to account for the emotional response towards the technology that a consumer may be having. For example, the installation stage is extremely important for householders - so it is important they are provided with clear information and advice at that stage.[237] Confusion, frustration and anxiety can lead to disengagement as a coping mechanism.[238]

Further, it should not be assumed that financial rewards are always the key driver for consumer decision-making. Having a battery available for back-up in the event of a grid outage was considered by many to be more important than receiving a financial benefit for allowing their battery to be used for grid management.[239] The tension between individual need and collective benefit was neatly expressed by one participant when discussing their home battery:

> *"I want to use it all, I don't want to give them any. Why should I give them any? Everybody's response would be like that, they'd want to use every bit of their own power, instead of selling it back at peanuts to Tas Energy [sic]"* [240]

233 Sylvie Thiébaux et al., *CONSORT Bruny Island Battery Trial: Project Final Report* [public dissemination], (2019), 9. http://brunybatterytrial.org/wp-content/uploads/2019/05/consort_public_dissemination.pdf

234 Ibid, 21.

235 Ibid, 21.

236 Ibid, 4.

237 Ibid, 13.

238 Ibid, 13.

239 Ibid, 14.

240 CONSORT *Project Final Report – Social science appendix*, 27.

Clearly, behavioural issues such as low levels of trust (which greatly hinder the current retail energy market), will not necessarily abate as the energy system transforms into a more decentralised, prosumer-led system. These factors can lead to seemingly "irrational" consumer behaviour (from a rational choice theory point of view), which nevertheless makes perfect sense when actual human beings are considered. To this end, behavioural economics may be of more use when designing energy markets than more traditional economic frameworks.

Another participant demonstrated how fluid consumer sentiment can be and how important it is to carefully manage the consumer experience. In this case, the participant was not interested in learning about technical details – yet had no faith in the battery controller. While initially he felt the program was working well, he then received a high winter bill and lost faith so he disengaged, without seeking to understand why it had occurred. Essentially, he did not trust the battery controller - despite retaining his faith in the PV-battery system. [241]

Relevance to Victoria's energy future

The CONSORT project demonstrates that many of the benefits of DER envisaged throughout this report are technically achievable – not in an abstract, theoretical sense, but because they have actually been shown to work on Bruny Island. As the CONSORT Final Report states, the next challenge is to demonstrate the NAC at greater scale, over a wider geographical area – and the researchers are confident this can be achieved.[242]

The technical challenges already overcome by NAC are considerable, and the learnings gained through CONSORT may well open the way for a 'prosumer power station' to integrate with the wholesale energy market, and operate within the physical limits of the grid. This would be of huge benefit to all energy users.

As the CONSORT Final Report states,

> *"Network Aware Coordination (NAC) is an award-winning technology, well-positioned as the marketplace for Australia's rapidly growing fleet of Distributed Energy Resources (DER)… CSIRO and ENA found that a well integrated 'prosumer power station' will deliver the system a $100 billion benefit over coming decades."*[243]

As a major caveat to this positive vision, the CONSORT Final Report does not shy away from the challenges of fully engaging energy consumers as they transition into prosumers, and the need to "sell the benefits" of joining the 'prosumer power station'. This is not a side issue – it is absolutely central to the success of Australia's shift into a decentralised, decarbonised energy system.

The CONSORT Final Report concludes:

> *"Finally, notwithstanding the technical potential of NAC, customer engagement, management and retention will need to be considered explicitly in the design of future market- and network-interactive DER programs. A relatively smooth customer experience is critical for success, as they are the ultimate providers of the service the algorithm is orchestrating."* [244]

There is no doubt that a '*relatively smooth customer experience*' of integrated DER will need to include a free, fair and independent dispute resolution service to handle the complaints that will inevitably arise but are not currently served by a specialist service.

241 CONSORT *Project Final Report – Social science appendix*, 28.

242 Ibid, 24.

243 Sylvie Thiébaux et al., *CONSORT Bruny Island Battery Trial: Project Final Report* [public dissemination], (2019): 24. http://brunybatterytrial.org/wp-content/uploads/2019/05/consort_public_dissemination.pdf

244 Ibid, 27.

Chapter Six: Home Energy Management Systems (HEMS)

FAST FACTS

- While HEMS' are still at early adopter stage, as the energy market becomes more dynamic with demand response mechanisms, solar and battery systems, P2P trading, microgrids, and VPP's, a far higher proportion of homes are likely to have a HEMS by 2050.
- Anticipated heads of complaint include privacy concerns about data security, communication faults and unsuccessful integration with home appliances and external service providers.
- EWOV is currently unable to handle complaints related to HEMS.

Introduction

A Home Energy Management System (HEMS) is a technology platform that allows energy consumers to monitor and manage their home energy use. The key difference between a HEMS and other technologies such as solar or battery storage is that a HEMS is 'human focused' – it does not generate or store energy, but instead drives behavioural change and facilitates the *management* of energy.[245]

HEMS' span a diverse number of products that can be broadly classified according to their function. User interface products seek to facilitate active customer participation, and include products like energy portals and in-home displays. Smart hardware products, such as smart appliances, smart lighting and smart thermostats, work to modify energy demand patterns. Software platforms such as smart home, data analysis, and web services platforms enhance the flow of information between the service provider and/or energy consumer.[246]

A HEMS usually consists of a 'hub' within the home that is installed on the electrical board or wirelessly, which gathers energy use data from a customer's smart meter. This data can be communicated in real-time on different protocols such as Wi-Fi, Bluetooth, Z-Wave, and ZigBee - which users can then access via software, such as an app or online dashboard.[247]

A HEMS can play a diverse role within the household. The most basic HEMS provides data on energy consumption and alerts customers when they should reduce their energy use during times of peak demand. This will be particularly useful as more large-scale renewable energy is deployed. The relatively intermittent nature of renewable generation may prompt consumers to be more aware of fluctuations in energy prices, and prompt them to reduce or increase their energy consumption accordingly (to the extent that they are able to do so).[248]

Other variations of HEMS can manage the flow and storage of electricity without human involvement. They can turn appliances on or off, and distribute excess solar power to heat pumps, home batteries and electric vehicles.[249]

245 Ad Straub and Ellard Volmer, "User's perspective on home energy management systems," *Environments, 5,* 12 (2018). https://doi.org/10.3390/environments5120126

246 Liz Randall, "A comprehensive guide to home energy management systems," Sustainable Now EU, 23 September 2017. https://sustainable-now.eu/guide-to-home-energy-management-systems/

247 Bin Zhou et al., "Smart home energy management systems: Concept, configurations, and scheduling strategies," *Renewable and Sustainable Energy Reviews,* 61, (2016): 36. http://dx.doi.org/10.1016/j.rser.2016.03.047

248 Stephen Jia Wang & Patrick Moriarty, "Energy savings from smart cities: A critical analysis," *Energy Procedia,* 158, (2019): 3274. https://doi.org/10.1016/j.egypro.2019.01.985

249 Bin Zhou et al., "Smart home energy management systems: Concept, configurations, and scheduling strategies," *Renewable and Sustainable Energy Reviews,* 61, (2016): 33. http://dx.doi.org/10.1016/j.rser.2016.03.047

These systems are usually integrated with solar inverters and batteries and require smart hardware to function.[250]

This capacity enables customers to participate in demand response at a micro level within the home, and make the most of time-of-use tariffs.[251] For example, provided a customer has a 'smart' washing machine or cooling system, these could be programmed to automatically turn on during the day when the price of electricity is the cheapest. In that manner, an automated HEMS essentially engages in demand response, shifting energy loads in response to a signal from the distributor or relevant operator.[252] Tailored to a customer's particular preferences and needs, a HEMS can ensure benefits such as lower energy consumption and increased savings.

This feature is particularly vital in the context of a microgrid that runs on renewable power. A HEMS will also play a critical role in the integration of peer-to-peer trading and virtual power plants (as discussed in the previous section), functioning as the customer interface to these transactions.

As HEMS become increasingly standard, and behind-the-meter energy trading becomes common place, customer protections will need to be enhanced.

How a HEMS will interact with the energy grid

A HEMS is integrated with the customer's smart meter which can send and receive signals from distribution companies and other service providers via an Application Planning Interface (API). API's ensure the optimal flow of information between parties and products, enabling different applications to "talk to each other" by fulfilling data requests from the server where the data is stored.[253]

In the case of a HEMS, an API enables real-time data flows between the smart meter and HEMS, and facilitates demand-response requests with smart products, such as solar PV microinverter APIs or smart thermostat APIs.[254] For example, APIs allow distribution companies to send tariff prices via the smart meter to the HEMS, which can respond automatically by turning appliances and hot water systems on or off, or simply alert customers of an increase in price. Customers are also able to access their energy-use data via web-based service platforms that use APIs to collect HEMS product data.

For customers in a microgrid, while the management of energy will most likely be the responsibility of a third-party operator, a HEMS can at least monitor and display how much of a customer's solar-generated power is being distributed throughout the grid.

As smart meters have already been rolled out state-wide, Victoria is essentially 'HEMS ready'. Despite this, very few initiatives exist to encourage the uptake of the HEMS - although some new housing projects are underway which make use of the technology.

250 "A comparison of home energy management systems in Australia," Solar Choice, 26 January 2017. https://www.solarchoice.net.au/blog/comparison-home-energy-management-systems-australia

251 IRENA, *Innovation landscape brief: Internet of things,* (2019): 12. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Sep/IRENA_Enabling-Technologies_Collection_2019.pdf

252 Izaz Zunnurain, Md. Nasimul Islam Maruf, Md. Moktadir Rahman, 7 GM Shafiullah, "Implementation of advanced demand side management for microgrid incorporating demand response and home energy management," *Infrastructures, 3,* 4 (2018). https://doi.org/10.3390/infrastructures3040050

253 "What is an API?" MuleSoft, accessed January 2020. https://www.mulesoft.com/resources/api/what-is-an-api

254 George Koutitas, "The smart grid: Anchor of the smart city," in Stan McClellan, Jesus A. Jimenez and George Koutitas (eds.), *Smart Cities: Applications, Technologies, Standards and Driving Factors,* (Springer, 2017): 66-68.

Market penetration in Victoria

As with most technologies discussed in this report, third-party providers dominate the market share of the HEMS, rather than traditional energy retailers or distributors. Prominent brands offering a meter-board HEMS include Solar Analytics, CarbonTRACK, and SwitchDin. [255] Brands such as Sonnen and Evergen (which utilises technology developed by the CSIRO[256]) provide a battery-integrated HEMS. Distribution company AusNet Services also offer a HEMS, known as 'Ubi', via their commercial business Mondo Power.[257]

Because HEMS are still at early adopter stage, there is limited data on the actual percentage of market penetration. Nonetheless, housing initiatives are emerging state-wide that incorporate a HEMS to improve energy efficiency. Initiatives include:

- *Net Zero Energy Homes*, which is funded by ARENA and led by Mirvac Properties. This project will see the development of 49 townhouses with a minimum 7-star energy rating in Melbourne's Altona North, designed to improve energy efficiency, reduce energy bills for homeowners and reduce the demand on the grid.[258]
- The *Aquarevo* project in Lyndhurst is a development by Villawood Properties in partnership with South East Water. Residents will be able to monitor and manage both their water and energy use via a 'OneBox' system.[259]
- Energy management systems have also been installed in microgrid trials funded by DELWP, such as the Euroa and Yackandandah microgrids, as part of their Microgrid Demonstration Initiative.[260]

Although not a complete HEMS, the Victorian Government's *Victorian Energy Upgrades* program (administered by the Essential Services Commission) provides discounts for residential in-home display units.[261] As of November 2019, eligible in-home display brands under this scheme include Intercel, Powerpal, Secure, and Watts Clever.[262]

It is expected that over time, more customers will embrace a HEMS to achieve their energy needs, such as reducing bills or improving sustainability. More significantly, as our relationship with the energy system becomes more complex a HEMS may well become necessary for many households as a way to provide clarity and a degree of automation for customers seeking to manage their energy use and maximise the value of their home energy infrastructure.

255 "A comparison of home energy management systems in Australia," Solar Choice, 26 January 2017. https://www.solarchoice.net.au/blog/comparison-home-energy-management-systems-australia

256 "CSIRO-developed tech for energy-smart homes," CSIRO news releases and statements, 25 August 2016. https://www.csiro.au/en/News/News-releases/2016/CSIRO-developed-tech-for-energy-smart-homes

257 "Ubi – the brains for your home energy use," Mondo Power: Mini-grids, accessed December 2019. https://mondo.com.au/community/mini-grids/ubi

258 "Net Zero Energy Homes," ARENA, accessed December 2019. https://arena.gov.au/projects/net-zero-energy-homes/

259 "Aquarevo: a new way of living", South East Water: Projects, accessed December 2019. https://southeastwater.com.au/CurrentProjects/Projects/Pages/Aquarevo.aspx

260 "Microgrids," DELWP, accessed November 2019. www.energy.vic.gov.au/microgrids

261 "Appliance activities," Essential Services Commission, accessed December 2019. https://www.esc.vic.gov.au/victorian-energy-upgrades-program/activities-offered-under-veu-program/other-veu-activities/appliance-activities

262 "30(18) – In-home display unit," Essential Services Commission Victorian Energy Upgrades Registry, accessed December 2019. https://www.veu-registry.vic.gov.au/Public/ProductRegistrySearch.aspx

Identified barriers to uptake

As with many new energy technologies, cost is the primary barrier to HEMS uptake. The systems are relatively expensive, and few subsidies are available in Victoria to make them more economically viable.[263] Two common systems on the market, *Solar Analytics – Solar Smart Monitor* and *CarbonTRACK – CT Smart Gateway,* range from $300 to over $1000 for installation respectively, with an additional yearly subscription fee from *CarbonTRACK,* to access their software.[264]

It is not clear what the payback period of a HEMS on the more expensive end is. Until savings can be quantified in real terms, customers will remain reluctant to invest in the technology - especially if they are doubtful about positive changes a HEMS will bring.

Complexity represents another barrier. A HEMS that does not automatically schedule appliances requires a high level of understanding from the customer about relatively obscure information - for example, how the price of electricity fluctuates during the day. This kind of confusion can lead to distrust, and indeed, scepticism about the benefits of a HEMS did emerge as a prominent attitude in a 2018 Dutch study that assessed user responses to HEMS.[265]

In this study, respondents were grouped into five categories representing different types of homeowners and their attitudes towards a HEMS; optimists, privacy-conscious citizens, technicians, sceptics, and the indifferent group.[266] The varying attitudes expressed in these groups reflect the diversity in energy technology engagement noted elsewhere in this report. For example, while 'optimists' and 'technicians' expressed a positive attitude towards a HEMS and would either adopt the technology because they believe energy savings can be made, or because the technology itself is appealing, others such as the sceptics and the indifferent group question the effectiveness of a HEMS. Customers may also resist the uptake of a HEMS due to data privacy concerns, even though they believe a HEMS would be helpful.[267]

Aside from cost and complexity, then, significant barriers to HEMS uptake appear to stem from a lack of information about the capability of a HEMS, or from a fear of imagined, or actual, risks around data security.

How a HEMS could go wrong: Anticipated heads of complaint

HEMS' are centred around data, and as such, are likely to generate data-related complaints. These are likely to arise if a customer's system experiences communication faults that interrupt the display of data, or if there is an error in communications between home appliances, solar systems and batteries. For example, in the event of a communication fault excess solar energy may not be diverted to the home battery. This could be problematic for customers relying on a HEMS to lower their energy costs.

As some variations of a HEMS can receive information from external parties, (such as tariff information from distributors, or real-time meteorological data), customers are susceptible to problems that might arise on 'the other end'. This would render the HEMS temporarily ineffective, and customers may be powerless to fix the problem. Compensation could be called for if a fault results in significant energy consumption during peak demand, which was meant to be avoided. Beneficial engagement with VPPs and P2P trading will also depend upon accurate data being provided to the HEMS - as well as the HEMS being correctly programmed to respond in the customer's best interest. Cause for complaint could arise at either end of that process.

263 As previously discussed, the *Victorian Energy Upgrades* program does provide a discount for residential in-home display units.

264 Alison Potter, "Home energy management systems," CHOICE, 11 September 2017. https://www.choice.com.au/home-improvement/energy-saving/reducing-your-carbon-footprint/articles/home-energy-management-systems#Solar%20Analytics%20monitoring%20system

265 Ad Straub and Ellard Volmer, "User's perspective on home energy management systems," *Environments, 5,* 12 (2018). https://doi.org/10.3390/environments5120126

266 Ibid.

267 Ibid, 8-9.

As with other technologies discussed in this report, if a third party is responsible for the installation and maintenance of a HEMS, customers are not currently protected by an energy-specific dispute resolution service.

Limited information regarding the compatibility of a HEMS with a customer's existing appliances could also cause problems. If customers install a HEMS that runs on Zig-bee, for example, while their smart appliances only operate via Bluetooth, they will not see the value that they should. While we cannot predict the risks associated with misleading marketing and HEMS pressure sales, misinformation and the exploitation of customers is certainly a possibility.

HEMS customers are also vulnerable to privacy breaches, as the data collected by a HEMS is accessible via an online portal or app.[268] Due to such a breach, a dissatisfied customer may lodge a complaint with EWOV alleging that their retailer or distributor did not take reasonable steps to protect their privacy. However, it may be that a third-party tech company is responsible for the HEMS. Unless these companies are EWOV members, customers may be left without an energy-specific dispute resolution service to handle the complaint.

An important caveat to this discussion is the imminent introduction of the Consumer Data Right (CDR) in energy. In broad terms, the CDR will enable customers to authorise accredited third parties to access their energy data and use that data to make decisions on their behalf. While the CDR has great potential to overcome (or at least, circumvent), the lack of consumer engagement that has traditionally dogged retail energy markets, it will also introduce the potential for significant privacy breaches and new types of data-based complaints. The Australia and New Zealand Energy and Water Ombudsman Network (ANZEWON) is currently in discussion with the Australian Government Department of Treasury regarding the appropriate channels for external dispute resolution of CDR related complaints. The CDR is discussed in more detail in the pull-out box below.

WHAT IS THE CONSUMER DATA RIGHT? (CDR)

The Australian Government announced the introduction of the CDR in November 2017 and in May 2018, further announced that energy data would be included in the CDR.

The intent of the CDR is to give consumers more control over their own data, improving their ability to compare and switch between products and services. Consumers will be able to access their data or authorise others to access it on their behalf - and make the best consumer choice for them. This in turn should create positive competitive pressure, leading to better prices and more innovative products and services.

While the initial timetable has been delayed, the CDR for energy is in the active consultation phase and is expected to be introduced in 2022. Under the energy CDR, AEMO will operate as the 'gateway' to consumer energy data, providing data on a consumer's current electricity arrangements to accredited third parties, who have been authorised by the consumer. Those accredited data recipients will then be able to advise consumers of their best option, or be authorised to simply act on the consumers behalf and make the purchasing decision for them.

Timeframes

While a HEMS may never be a state-mandated requirement for each home, it is easier to imagine a roll out of in-home displays (IHDs) - which would at least make some use of Victoria's already installed, and arguably under-utilised, smart meters. This already occurs in the UK, where IHDs are automatically provided to customers by energy suppliers when a smart meter is installed.[269]

Energy retailers may potentially gain responsibility for providing IHDs or HEMS' in any mandated roll-out, rather than distributors. Problems may then arise if the retailer retains ownership of the IHD/HEMS infrastructure, and

268 "Home energy management systems – a smart way to save?" Solar Choice, 4 November 2019. https://www.solarchoice.net.au/blog/home-energy-management-systems-a-smart-way-to-save/

269 "Guidance: Smart meters", United Kingdom Government Digital Service (Gov.UK), 4 January 2018. https://www.gov.uk/guidance/smart-meters-how-they-work#benefits-of-smart-meters

it makes switching more complex for customers. While one would hope this issue would be dealt with in the policy development stage, we raise it here to illustrate the wide range of issues that HEMS may potentially cause – depending on how they are introduced into the system.

Ultimately, while a HEMS serves as a valuable tool to meet a customer's energy needs and preferences, the availability of clear and accurate information about energy data will be central to their success. Without this, we anticipate a number of complaints relating to misconceptions about what a HEMS can deliver, and confusion regarding the range of energy interactions managed by a HEMS.

Table 11.

Summary table – HEMS

HEMS	Current Market Penetration	Projected: 2020 – 2030	Projected: 2030 - 2050
	Very Minimal HEMS' are still at early adopter stage, as the lack of data on market penetration speaks to the novelty of the technology	**Moderate** As the price of electricity increases, more households are likely to install a HEMS to manage their energy use and maximise benefits As aggregators and 'disruptor' technology enters the market, customers may also utilise a HEMS to monitor exchanges	**Very High** Almost all homes will have a HEMS as P2P trading, VPPs and demand response are potentially widely adopted
	Barriers to Growth		
	› Cost › Scepticism surrounding the benefits of a HEMS › Fear of data security risks › High level of user knowledge and engagement required (for non-automated HEMS')	› Cost › Scepticism surrounding the benefits of a HEMS › Fear of data security risks › High level of user knowledge and engagement required (for non-automated HEMS')	› Scepticism surrounding the benefits of a HEMS › Fear of data security risks
	Existing/anticipated heads of complaint*		
	• Customer privacy concerns about data security risks • Inaccuracies in data (especially for those integrated with VPPs and P2P trading) • Product faults and communication errors that result in missed savings • Compensation claims for missed savings • Unsuccessful integration with home appliances		

- Orange = Out of EWOV's current jurisdiction

Bibliography

"A comparison of home energy management systems in Australia," Solar Choice, 26 January 2017. https://www.solarchoice.net.au/blog/comparison-home-energy-management-systems-australia

"A guide to Solar farms Australia," Canstar Blue, accessed October 2019. https://www.canstarblue.com.au/solar-power/solar-farms-australia/

Ad Straub and Ellard Volmer, "User's perspective on home energy management systems," *Environments, 5,* 12 (2018). https://doi.org/10.3390/environments5120126

Adam McHugh, "Are solar panels a middle-class purchase? This survey says yes," *The Conversation,* (2018). https://theconversation.com/are-solar-panels-a-middle-class-purchase-this-survey-says-yes-97614

Adam Hirsch, Yael Parag and Josep Guerrero, "Microgrids: A review of technologies, key drivers, and outstanding issues," *Renewable and sustainable energy reviews,* 90. (2018). https://doi.org/10.1016/j.rser.2018.03.040

AEMC, *Review of the regulatory frameworks for stand-alone power systems – Priority 1 final report,* (2019). https://www.aemc.gov.au/market-reviews-advice/review-regulatory-frameworks-stand-alone-power-systems

AEMC, *Review of the regulatory frameworks for stand-alone power systems – Priority 2 final report,* (2019). https://www.aemc.gov.au/sites/default/files/2019-10/AEMC%20SAPS%20priority%202%20final%20report%2031%20October%202019.pdf

AEMO (2018) cited in: Legislative Assembly Parliament of Western Australia, Economics and Industry Standing Committee, *Implications of a Distributed Energy Future: Interim Report* [report No. 5], (2019). https://www.parliament.wa.gov.au/parliament/commit.nsf/(WebInquiries)/B78DC78FC2007FAE482583D7002E3073?opendocument

AEMO, *DER register overview & Victorian DNSP implementation – Victorian installers seminars* [presentation], 12 & 13 November (2019). https://www.aemo.com.au/-/media/Files/Electricity/NEM/DER/2019/DER-Register-Implementation/Introducing-DER-Register-to-VIC-Solar-Installers_12-November-Werribee.pdf

"AEMO to trial integrating VPPs into the NEM," ARENA, 5 April 2019. https://arena.gov.au/news/aemo-to-trial-integrating-virtual-power-plants-into-the-nem/

"AEMO Virtual Power Plant Demonstrations," Australian Renewable Energy Agency (ARENA), accessed December 2019.
https://arena.gov.au/projects/aemo-virtual-power-plant-demonstrations/

"AEMO's virtual power plant trial opens for enrolments," AEMO, 31 July 2019. https://energylive.aemo.com.au/News/AEMO-VPP-trial-open-for-enrolments

AGL, ARENA, MHC & IBM, *Peer-to-Peer Distributed Ledger Technology Assessment*, (2017). https://arena.gov.au/assets/2017/10/Final-Report-MHC-AGL-IBM-P2P-DLT.pdf

"AGL virtual trial of peer-to-peer energy trading," ARENA, accessed December 2019. https://arena.gov.au/projects/agl-virtual-trial-peer-to-peer-trading/

Alison Potter, "Home energy management systems," CHOICE, 11 September 2017. https://www.choice.com.au/home-improvement/energy-saving/reducing-your-carbon-footprint/articles/home-energy-management-systems#Solar%20Analytics%20monitoring%20system

Andrew Chesterton, "Australian car market: Car sales, statistics and figures," CarsGuide, 11 September 2019. https://www.carsguide.com.au/car-advice/australian-car-market-car-sales-statistics-and-figures-70982

Anubhav Roy, Anna Bruce, & Ian MacGill, *The Potential Value of Peer-to-Peer Energy Trading in the Australian National Electricity Market*, (Asia Pacific Solar Research Conference, 2016). http://ceem.unsw.edu.au/sites/default/files/documents/A%20Roy%2C%20A%20Bruce%2C%20I%20MacGill-Potential%20Value%20of%20Peer-To-Peer%20Energy%20Trading%20in%20the%20Australian%20National%20Electricity%20Market.pdf

"Appliance activities," Essential Services Commission, accessed December 2019. https://www.esc.vic.gov.au/victorian-energy-upgrades-program/activities-offered-under-veu-program/other-veu-activities/appliance-activities

"Aquarevo: a new way of living", South East Water: Projects, accessed December 2019. https://southeastwater.com.au/CurrentProjects/Projects/Pages/Aquarevo.aspx

ARENA, *Latrobe Valley microgrid feasibility assessment,* (2018). https://arena.gov.au/assets/2018/05/latrobe-valley-microgrid-feasibility-assessment.pdf

AusNet Services, *The Mooroolbark mini grid project: Exploring our energy future,* (2019). https://www.ausnetservices.com.au/-/media/Files/AusNet/Community/Mooroolbark-mini-grid/Mooroolbark-mini-grid-webinfo.ashx?la=en

Australian Academy of Technology and Engineering, *Shifting Gears – Preparing for a Transport Revolution: Transport Industry Technology Readiness*, (2019). https://www.applied.org.au/news-and-events/article/shifting-gears-preparing-for-a-transport-revolution/

Australian Energy Council, *Solar report: Quarter 2 2019,* (2019). https://www.energycouncil.com.au/media/16671/australian-energy-council-solar-report_-june-2019_final.pdf

Australian PV Institute, *National survey report of PV power applications in Australia 2018,* (2019). http://apvi.org.au/wp-content/uploads/2019/08/NSR-Guidelines-2019_AUSTRALIA_AU.pdf

"Average solar panel costs by city & system size," Solar Choice, accessed October 2019. https://www.solarchoice.net.au/blog/solar-power-system-prices

Bin Zhou et al., "Smart home energy management systems: Concept, configurations, and scheduling strategies," *Renewable and Sustainable Energy Reviews,* 61, (2016). http://dx.doi.org/10.1016/j.rser.2016.03.047

CEFC, *Clean Energy Snapshot: Australian Electric Vehicle Market Study,* (2018). https://www.cefc.com.au/media/401922/cefc-snapshot-electric-vehicles-jun2018.pdf

Cheryl Hall and Bridget Rollason, "Victorian solar companies reeling after popular rebate scheme halted temporarily," *ABC News,* 25 April 2019. https://www.abc.net.au/news/2019-04-25/vic-solar-installer-staff-laid-off-after-temporary-halt-rebate/11045054

Clean Energy Council, *The distributed energy resources revolution: A roadmap for Australia's enormous rooftop solar and battery potential,* (2019). https://www.cleanenergycouncil.org.au/resources/resourceshub/the-distributed-energy-resources-revolution-a-roadmap-for-australias-enormous-rooftop-solar-andbattery-potential

Climate Council, *Fully Charged: Renewables and Storage Powering Australia*, (2018). https://www.climatecouncil.org.au/resources/battery-storage-2018/

Climateworks Australia, *The State of Electric Vehicles in Australia*, (2018). https://www.climateworksaustralia.org/sites/default/files/documents/publications/climateworks_australia_state_of_electric_vehicles2_june_2018.pdf

Colmar Brunton, *Community attitudes and barriers to rooftop solar: Final report*, prepared for City of Melbourne, (2015). https://www.melbourne.vic.gov.au/sitecollectiondocuments/attitudes-rooftop-solarfinal-report.pdf

"CONSORT Bruny Island Battery Trial," Bruny Battery Trial, accessed November 2019. http://brunybatterytrial.org/

CONSORT *Project Final Report – Social science appendix*.

Consumer Action Law Centre, *Sunny side up: Strengthening the consumer protection regime for solar panels in Victoria,* (2019). https://consumeraction.org.au/wp-content/uploads/2019/04/1904_Sunny-Side-Up-Report_FINAL_WEB.pdf

"CSIRO-developed tech for energy-smart homes," CSIRO news releases and statements, 25 August 2016. https://www.csiro.au/en/News/News-releases/2016/CSIRO-developed-tech-for-energy-smart-homes

David Stringer, "A deluge of batteries is about to rewire the power grid," *Bloomberg,* 5 August 2019. https://www.bloomberg.com/news/features/2019-08-03/a-deluge-of-batteries-is-about-to-rewire-the-power-grid

"DER register implementation," AEMO, accessed November 2019. https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/DER-program/DER-Register-Implementation

Ed Hanson, "Solar panels: Thousands of customers complain," *BBC News Online,* 9 September 2019. https://www.bbc.com/news/uk-england-49566130

Electricity Industry Act 2000 (Vic). https://www.legislation.vic.gov.au/in-force/acts/electricity-industry-act-2000-67/084

Energia, *Australian Electric Vehicle Market Study,* (2018). https://arena.gov.au/assets/2018/06/australian-evmarket-study-report.pdf

Energy and Water Ombudsman Victoria, *Coverage of Embedded Networks: Confidential Progress Update,* (2019).

Energy and Water Ombudsman Victoria, Annual Report 2019. https://www.ewov.com.au/files/ewov_2019_annual_report_0.pdf

Evenergi, *Unlocking demand for renewably powered vehicles*, (2018). https://docs.wixstatic.com/ugd/b76440_6dc6993fe58f4ef3827cd6216e5da4ae.pdf?index=true

"Four charts that show the future of battery storage," ARENA, 21 August 2017. https://arena.gov.au/blog/future-of-battery-storage/.

"Fremantle residents participating in world-first trial, trading solar energy peer-to-peer and setting their own prices," Medium, 14 December 2018. https://medium.com/power-ledger/fremantle-residents participating-in-world-first-trial-trading-solar-energy-peer-to-peer-and-955b81d438c1

George Koutitas, "The smart grid: Anchor of the smart city," in Stan McClellan, Jesus A. Jimenez and George Koutitas (eds.), *Smart Cities: Applications, Technologies, Standards and Driving Factors,* (Springer, 2017).

George Roberts, "China's indication to ban sale of non-electric cars a 'tipping point' for global industry," *ABC News,* 14 September 2017. https://www.abc.net.au/news/2017-09-12/chinas-move-to-ban-sale-of-non-electric-cars-a-tipping-point/8894746

"Guidance: Smart meters", United Kingdom Government Digital Service (Gov.UK), 4 January 2018. https://www.gov.uk/guidance/smart-meters-how-they-work#benefits-of-smart-meters

"Home energy management systems – a smart way to save?" Solar Choice, 4 November 2019. https://www.solarchoice.net.au/blog/home-energy-management-systems-a-smart-way-to-save/

"Hydrogen cars to extend Queensland's renewable energy lead," Queensland University of Technology, 27 August 2019. https://www.qut.edu.au/news?news-id=150413

Infrastructure Victoria, *Advice on automated and zero emissions vehicles infrastructure,* (2018). https://www.infrastructurevictoria.com.au/wp-content/uploads/2019/04/Advice-on-automated-and-zero-emissionsvehicles-October-2018.pdf

IRENA, *Innovation landscape brief: Internet of things,* (2019). https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Sep/IRENA_Enabling-Technologies_Collection_2019.pdf

IRENA, *Innovation outlook: Smart charging for electric vehicles*, (2019). https://www.irena.org/publications/2019/May/Innovation-Outlook-Smart-Charging

Izaz Zunnurain, Md. Nasimul Islam Maruf, Md. Moktadir Rahman, & GM Shafiullah, "Implementation of advanced demand side management for microgrid incorporating demand response and home energy management system," *Infrastructures, 3*(4), (2018). https://doi.org/10.3390/infrastructures3040050

Jaclyn Symes, "New microgrid funding for the Euroa community," Victorian Labor, 3 September 2018. http://www.jaclynsymes.com.au/media-releases/new-microgrid-funding-for-the-euroa-community/

Jaysson Guerrero, Archie Chapman, & Gregor Verbic, *Peer-to-Peer Energy Trading: A Case Study Considering Network Constraints*, (Asia Pacific Solar Research Conference, 2018). http://apvi.org.au/solar-researchconference/wp-content/uploads/2018/11/010_D-I_Guerrero_J_2018.pdf

Jim Malo, "Proposed Brunswick apartment tower could overshadow elderly neighbour's solar panels, making them less effective," *Domain,* 17 November 2019. https://www.domain.com.au/news/proposed-brunswickapartment-tower-could-overshadow-elderly-neighbours-solar-panels-making-them-less-effective-909131/

Joe D'Allegro, "Elon Musk says the tech is 'mind-bogglingly stupid' but hydrogen cars may yet threaten Tesla," *CNBC, 24 February 2019.* https://www.cnbc.com/2019/02/21/musk-calls-hydrogen-fuel-cells-stupid-but-techmay-threaten-tesla.html

Jon Cartwright, "Hydrogen use doesn't emit carbon but its production often does. That could soon change," *Horizon Magazine*, 17 October 2018. https://horizon-magazine.eu/article/hydrogen-use-doesn-t-emit-carbonits-production-often-does-could-soon-change.html

Katherine Murphy, "Australia told to prepare for a 'completely new' two-sided energy market," *The Guardian*, 14 November 2019. https://www.theguardian.com/australia-news/2019/nov/14/australia-told-to-prepare-for-completely-new-two-sided-energy-market

KPMG, *Electric Vehicles: Is the energy sector ready?* (2018). https://assets.kpmg/content/dam/kpmg/au/pdf/2018/electricvehicles-is-the-energy-sector-ready.pdf

"Large-scale solar," ARENA, accessed October 2019.
https://arena.gov.au/renewable-energy/what-is-large-scale-solar/

Larissa Nicholls, Paula Arcari, Andrew Golver, Rex Martin, & Yolande Strengers, *Engaging households towards the Future Grid: Experiences, expectations and emerging trends*, (RMIT University, 2019). https://cur.org.au/cms/wp-content/uploads/2019/03/future-grid-homes-household-report-final-1-1.pdf

Liz Hobday, "Victorian solar rebates never had hope of meeting demand, figures show," *ABC News,* (2019). https://www.abc.net.au/news/2019-05-28/victorian-solar-rebates-never-had-hope-of-meeting-demand/11156712

Liz Hobday and Sybilla Gross, "Australia's obsession with cheap solar is derailing the market, insiders say," *ABC News,* 27 May 2019. https://www.abc.net.au/news/2019-05-27/australias-obsession-with-cheap-solar-derailing-market-insiders/11139856

Liz Randall, "A comprehensive guide to home energy management systems," Sustainable Now EU, 23 September 2017. https://sustainable-now.eu/guide-to-home-energy-management-systems/

"Mapping Australian photovoltaic installations," Australian PV Institute, accessed 15 October 2019. https://pv-map.apvi.org.au/historical#11/-37.8282/144.9646.

Megan Farrelly and Sylvia Tawfik, "Engaging in disruption: A review of emerging microgrids in Victoria, Australia," *Renewable and Sustainable Energy Reviews, 117* (109491), (2020).
https://doi.org/10.1016/j.rser.2019.109491

"Microgrid," Monash University Net Zero Initiative, accessed November 2019.
https://www.monash.edu/net-zero-initiative/microgrid

"Microgrids," Department of Environment, Land, Water and Planning, accessed October 2019.
www.energy.vic.gov.au/microgrids

Mike Roberts, Anna Bruce and Ian MacGill, "Collective prosumerism: Accessing the potential of embedded networks to increase the deployment of distributed generation on Australian apartment buildings," *IEEE International Energy Conference,* (2018): 2. http://unsworks.unsw.edu.au/fapi/datastream/unsworks:50745/bin8da51ea6-91d5-4498-810d-17a1d82542ca?view=true

Mike Roberts, Kriti Nagrath, Chris Briggs, Jessie Copper, Anna Bruce, & John Mckibben, *How much rooftop solar can be installed in Australia?* report for the CEFC and the Property Council of Australia, (2019). http://apvi.org.au/wp-content/uploads/2019/06/isf-rooftop-solarpotential-report-final_.pdf

Minister for Energy, Environment and Climate Change, "Building Victoria's largest virtual power plant," Premier of Victoria, 5 September 2018. https://www.premier.vic.gov.au/building-victorias-largest-virtual-power-plant/

Minister for Energy, Environment and Climate Change, "New microgrid finding for multi-tenanted buildings," Premier of Victoria, 27 August 2018. https://www.premier.vic.gov.au/new-microgrid-funding-for-multi-tenanted-buildings/

Minister for Energy, Environment and Climate Change, "Microgrid funding for Birchip business," Premier of Victoria, 3 October 2018. https://www.premier.vic.gov.au/microgrid-funding-for-birchip-business/

Minister for Energy, Environment and Climate Change, "New microgrid project for Yackandandah," Premier of Victoria, 17 October 2018. https://www.premier.vic.gov.au/new-microgrid-project-for-yackandandah/

"Misleading claims about solar," DELWP: Renewable Energy, (2017). https://www.energy.vic.gov.au/renewable-energy/victorian-feed-in-tariff/whats-involved-in-going-solar/misleading-claims-about-solar

"Monash Honeywell Collaboration," Monash University, accessed November 2019. https://www.monash.edu/it/honeywell

Monash University, *Microgrid Electricity Market Operators: Commercialisation Brochure,* (2019). https://www.monash.edu/__data/assets/pdf_file/0011/1980497/Monash-Net-Zero_Microgrid-Operator-Commercialisation-Brochure_20190617.pdf

Monash University, *Monash Net Zero Initiative brochure,* (2019). https://www.monash.edu/__data/assets/pdf_file/0020/1140365/Monash-Net-Zero-Brochure.pdf#

Monash University, *Smart Energy City Introductory Report: Design overview and initial research questions,* (2019). https://www.monash.edu/__data/assets/pdf_file/0010/1980496/Smart-Energy-City_Introductory-Report_20190731.pdf

Monash University, *Victorian market assessment for microgrid electricity market operators: White paper,* (2019). https://www.monash.edu/__data/assets/pdf_file/0010/1857313/Monash-Net-Zero_Microgrid-Operator-Whitepaper_20190617-1.pdf

Monishka Narayan, "Could the solar boom bust the grid," *Energy Insider,* Energy Networks Australia, (2019). https://www.energynetworks.com.au/news/energy-insider/could-the-solar-boom-bust-the-grid/

Nadine Cranenburgh, "Electric or hydrogen – which will win the clean car race?" *ABC News,* 17 November 2019. https://www.abc.net.au/news/science/2019-11-17/hydrogen-vs-electric-who-will-win-the-clean-vehicle-race/11694400

"Net Zero Initiative," Monash University, accessed October 2019. https://www.monash.edu/net-zero-initiative

"Net Zero Energy Homes," ARENA, accessed December 2019. https://arena.gov.au/projects/net-zero-energy-homes/

Nick Toscano, "Huge Tesla battery in South Australia primed for big upgrade," *Sydney Morning Herald,* 19 November 2019. https://www.smh.com.au/business/companies/huge-tesla-battery-in-south-australia-primedfor-big-upgrade-20191119-p53byo.html

NRMA, *The future of car ownership*, (2017). https://www.mynrma.com.au/-/media/documents/reports/thefuture-of-car-ownership.pdf?la=en&hash=9AF4B0574E4FFD3F1A371551D89D182F

Paul A. Eisenstein, "GM is going all electric, will ditch gas and diesel powered cars," *NBC News,* 3 October 2017. https://www.nbcnews.com/business/autos/gm-going-all-electric-will-ditch-gas-diesel-powered-cars-n806806

Paul Graham, Dongxiao Wang, Julio Braslavsky, & Luke Reedman, *Projections for small-scale embedded technologies*, CSIRO report for AEMO, (2018). https://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/NEM_ESOO/2018/Projections-for-Small-Scale-Embedded-Technologies-Report-by-CSIRO.pdf

"Positive new standard for battery storage sector," Standards Australia, accessed November 2019. https://www.standards.org.au/news/positive-new-standard-for-battery-storage-sector

"Postcode data for small-scale installations: June 2019," Clean Energy Regulator, accessed October 2019. http://www.cleanenergyregulator.gov.au/RET/Forms-and-resources/Postcode-data-for-small-scale-installations

"Power switch: The Perth households trading energy with each other," Royal Automobile Club of W.A., 19 February 2019. Available at: https://rac.com.au/home-life/info/future_power-ledger-trial

"Premium feed-in tariff," DELWP, accessed November 2019.
https://www.energy.vic.gov.au/renewable-energy/victorian-feed-in-tariff/premium-feed-in-tariff

"RENeW Nexus (P2P) Plan," Synergy, accessed December 2019.
https://www.synergy.net.au/Our-energy/Future-energy/RENeW-Nexus-Trial

Renew, *Household Battery Analysis*, (2015).
https://renew.org.au/wp-content/uploads/2018/11/ATAHousehold-Battery-Study.pdf

"Renewable energy microgrid," Deakin University, accessed November 2019.
https://www.deakin.edu.au/Microgrid

Rohan Best, Paul J Burke and Shuhei Nishitateno, "Understanding the determinants of rooftop solar installation: Evidence from household surveys in Australia," *CCEP working paper 1902* (Crawford School of Public Policy, The Australian National University 2019).
https://ccep.crawford.anu.edu.au/sites/default/files/publication/ccep_crawford_anu_edu_au/2019-04/1902_0.pdf

Rohan Best, Paul J Burke and Shuhei Nishitateno, "Evaluating the effectiveness of Australia's small-scale renewable energy scheme for rooftop solar," *CCEP Working Paper 1903,* (Crawford School of Public Policy, The Australian National University 2019). https://ccep.crawford.anu.edu.au/sites/default/files/publication/ccep_crawford_anu_edu_au/2019-08/wp_1903.pdf

Smart Energy Council, *Australian Energy Storage Market Analysis*, (2018). https://www.smartenergy.org.au/sites/default/files/uploaded-content/field_f_content_file/australian_energy_storage_market_analysis_report_sep18_final.pdf

"Solar battery storage comparison table," Solar Quotes, accessed October 2019.
https://www.solarquotes.com.au/battery-storage/comparison-table/

"Solar battery rebate," Solar Victoria, accessed November 2019.
https://www.solar.vic.gov.au/solar-battery-rebate

"Solar energy," Clean Energy Council, accessed October 2019.
https://www.cleanenergycouncil.org.au/resources/technologies/solar-energy

"Solar panel rebate," Solar Victoria, accessed October 2019. https://www.solar.vic.gov.au/solar-panel-rebate

"Solar water heaters," Energy Rating, accessed 31 October 2019.
http://www.energyrating.gov.au/products/water-heaters/solar-water-heaters

"Solar water heating," Clean Energy Council, accessed October 2019.
https://www.cleanenergycouncil.org.au/resources/technologies/solar-water-heating

Sophie Vorrath, "Is this the end of household battery storage in Australia?" *Renew Economy*, 11 October 2019.
https://reneweconomy.com.au/is-this-the-end-of-household-battery-storage-in-australia-79766/

Sophie Vorrath, "World-leading rooftop solar trading kicks off in Fremantle," One Step Off the Grid, 6 December 2018. https://onestepoffthegrid.com.au/world-leading-rooftop-solar-trading-trial-kicks-off-fremantle/

Stephen Jia Wang & Patrick Moriarty, "Energy savings from smart cities: A critical analysis," *Energy Procedia,* 158, (2019): 3274. https://doi.org/10.1016/j.egypro.2019.01.985

SunWiz, accessed November 2019. http://www.sunwiz.com.au/

"SwitchDin project selected for Victorian microgrid demonstration," SwitchDin, May 2019. https://www.switchdin.com/blog/2018/10/3/switchdin-project-selected-for-victorian-demonstration-initiative-grant

Sylvie Thiébaux, Archie Chapman, Evan Franklin, Andrew Fraser, Dan Gordon, Veryan Hann, Andrew Harwood, Laura Jones, Heather Lovell, Sleiman Mhanna, Luke Osborne, Hedda Ransan-Cooper, Alan Reid, Paul Scott, Gregor Verbič, & Phillipa Watson, *CONSORT Bruny Island Battery Trial: Project Final Report* [public dissemination], (2019). http://brunybatterytrial.org/wp-content/uploads/2019/05/consort_public_dissemination.pdf

"The evolving investment case for home battery storage: Incentives & virtual power plant programs," SwitchDin, 25 July 2019. https://www.switchdin.com/blog/2019/battery-storage-incentives-virtual-power-plants

"The Renewable Energy Target (RET) scheme," Australian Government Department of Environment and Energy, accessed October 2019. https://www.environment.gov.au/climate-change/government/renewable-energy-target-scheme

Toby Crockford, "Solar home battery warnings after Brisbane housefire," *Brisbane Times,* 27 December 2018. https://www.brisbanetimes.com.au/national/queensland/solar-home-battery-warning-after-brisbane-housefire-20181227-p50od1.html

"Ubi – the brains for your home energy use," Mondo Power*:* Mini-grids, accessed December 2019. https://mondo.com.au/community/mini-grids/ubi

"Victorian solar industry in crisis as August solar homes rebates run out within hours," Clean Energy Council, accessed October 2019. https://www.cleanenergycouncil.org.au/news/victorian-solar-industry-in-crisis-as-august-solar-homes-rebates-run-out-within-hours

"What are microgrids?" Energuide.be, accessed October 2019. https://www.energuide.be/en/questions-answers/what-are-microgrids/2129/

"What is an API?" MuleSoft, accessed January 2020. https://www.mulesoft.com/resources/api/what-is-an-api

"What is the difference between power and energy?" Solar Quotes, accessed 31 October 2019. https://www.solarquotes.com.au/good-solar-guide/power-energy-difference/

"What's a community microgrid? A quick guide," CarbonTrack, accessed November 2019. https://carbontrack.com.au/blog/community-microgrid/

"30(18) – In-home display unit," Essential Services Commission Victorian Energy Upgrades Registry, accessed December 2019. https://www.veu-registry.vic.gov.au/Public/ProductRegistrySearch.aspx