



Economics and Industry Standing Committee

Report 5

# IMPLICATIONS OF A DISTRIBUTED ENERGY FUTURE

Interim Report

Presented by Ms J.J. Shaw, MLA April 2019

# Committee Members

Chair	Ms J.J. Shaw, MLA	
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Deputy Chair	MrSK l'Estrange MLA	
	Member for Churchlands	
Members	Mr Y. Mubarakai, MLA	
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WEST PERTH WA 6005		
Published by the Parliament of We	stern Australia, Perth.	
April 2019.		
ISBN: 978-1-925724-14-1		
(Sorios: Western Australia Darliame	ant Logiclative Assembly Committees	
Economics and Industry Standing	Committee, Report 5)	

328.365



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Report No. 5 11 April 2019 Legislative Assembly Parliament of Western Australia

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# Published by the Legislative Assembly, Parliament of Western Australia, Perth. April 2019.

ISBN: 978-1-925724-14-1

(Series: Western Australia. Parliament. Legislative Assembly. Committees. Economics and Industry Standing Committee. Report 5)

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# **Economics and Industry Standing Committee**

# Implications of a Distributed Energy Future Interim Report

Report No. 5

Presented by

Ms J.J. Shaw, MLA

Laid on the Table of the Legislative Assembly on 11 April 2019

# **Chair's Foreword**

estern Australia is home to some of the world's most innovative, groundbreaking energy technologies – technologies that could radically change the way we produce and consume electricity and contribute to more secure, affordable, reliable and sustainable power supply.

Western Australians have embraced renewable energy, installing household-scale solar panels at an incredible rate, right across the State. Household solar is now the single largest source of generation capacity on the State's largest network, the South West Interconnected System, and is three times larger than our single largest power station.

As advances are made in information and communications technology and unit costs come down, there is also a growing level of interest in household and grid-scale batteries, as people see the value in storing the energy they produce. Microgrids and associated distributed energy resource technologies are changing the face of electricity production and system management across the globe, and WA is exceptionally wellpositioned to benefit.

The move towards decentralised energy production and consumption is fundamentally changing the model upon which the electricity sector has traditionally been based. The industry previously operated on the unidirectional flow of electricity from centrally-controlled large-scale, fossil fuelled power stations to largely passive consumers. The sector's dynamics are now fundamentally changing as the 'prosumer' emerges – individuals both producing and consuming their own energy within and at the fringes of the network – presenting both operational, engineering and commercial challenges.

There are a range of innovators in the WA energy sector, facilitating these changes and developing large and small-scale renewable energy projects, with the State's energy utilities pleasingly leading the way. There are companies exploring local co-operatives and block-chain platforms for energy trading. There are entire subdivisions and communities aiming towards more sustainable energy solutions, combining local renewable generation and battery technologies with traditional grid-sourced power.

New energy technologies are increasingly cost competitive with traditional energy sources; can operate to increase the efficiency of existing network infrastructure; and represent new opportunities for economic diversification, jobs and the export of Intellectual Property, services and products to the world. Most importantly, however, they can reduce the carbon intensity of WA's energy sector and assist us to tackle climate change in a meaningful and effective way.

This Interim Report provides an overview of the Microgrid and distributed energy resource technologies being developed in the State and discusses opportunities along the battery production value chain. It also considers the potential impact of electric vehicles.

Undoubtedly, the emergence of these technologies presents both opportunities and challenges for the energy sector. WA's ability to capitalise on the energy system optimisation opportunities presented by Microgrids and associated technologies depends on the complex interplay between physics, technology, markets and regulation and will be considered in the Final Report.

I would like to take this opportunity to acknowledge the contribution to this Inquiry over the past year of my fellow committee members Mr Sean L'Estrange MLA, Deputy Chair; Mr Yaz Mubarakai MLA; Mr Stephen Price MLA; and Hon Terry Redman MLA.

The Committee has consulted widely throughout WA and other jurisdictions. I would like to thank those organisations who have provided submissions and provided staff to attend our nearly 40 hearings. Special thanks go those organisations which briefed us in WA: the Australian Energy Market Operator and Western Power in Perth; Nickel West at its Kwinana refinery; and Horizon Power at its Carnarvon depot. I would particularly like to thank the 17 US agencies in San Francisco, Sacramento and New York who allowed their staff time away from their work to brief us for this Inquiry.

I would also like to thank the Committee's Principal Research Officer, Dr David Worth, and Research Officers, Mr Lachlan Gregory and Ms Franchesca Walker, for their advice and assistance throughout this Inquiry.

MS J.J. SHAW, MLA CHAIR

# Contents

Findings		
1	Exciting New Power Developments for WA	1
1.1	The new power environment	1
1.2	Why this Inquiry?	5
1.3	Establishment of the Inquiry	6
1.4	Committee consultation	7
1.5	The State's current electricity infrastructure	8
	Generators	8
	Networks	9
1.6	Changes to the State's energy mix	12
2	What is a Microgrid?	15
2.1	The changing nature of power supply	15
2.2	Defining a 'Microgrid'?	17
2.3	Different types of Microgrids	20
3	WA Microgrid Innovations and Applications	23
3.1	Current research and industry initiatives	23
3.2	Operational context	
3.3	3.3 Islanded system projects	
	Carnarvon- Horizon Power's Microgrid trial	25
	Marble Bar- Hybrid Microgrid	26
	Onslow- Microgrid uses gas as a primary fuel	27
	Karratha- Airport Microgrid	28
	Mackerel Islands- Microgrid project	29
	Meekatharra- Sandfire's DeGrussa Mine PV project	29
	Newman- Alinta Energy's lithium-ion battery	29

	3.4	'Fringe-of-Grid' applications	30
		Ravensthorpe- Western Power's original stand-alone power systems trial	30
		Kalbarri- Western Power's large Microgrid trial	31
		Kalgoorlie- Virtual power plant	33
		Perenjori- Community-scale battery back-up	33
		Western Power- Stand-alone power systems Stage Two trials	34
	3.5	Metropolitan projects	36
		Mandurah- Western Power's PowerBank community battery	36
		Bentley- Curtin University's Energy Park	37
		Vasse- ATCO's unique trial with gas and distributed energy resources integration	38
		Two Rocks- Off-grid school	38
	3.6	Innovations in energy retailing and consumer relationships	38
		Dunsborough- Virtual power plant	39
		Geraldton- Mixed-generation energy hub	39
		Peel- Landcorp Business Park Microgrid	40
		Alkimos Beach- Synergy's new energy retail model	40
		Fremantle- Block-chain technology trial	41
		Busselton- Power Ledger peer-to-peer trading trial	43
		Perth- Embedded network for apartments	43
		White Gum Valley- Neighbours trading power	43
4		Economic Opportunities for WA Associated with the Development of DER Technologies	45
	4.1	Introduction	45
	4.2	Battery technology	45
	4.3	Rapid development of WA's lithium industry	47
		Other mineral inputs to batteries	50

4.4	Mineral processing	53
	Private sector developments	53
	Recent reports on the State's lithium industry	56

		Advanced manufacturing and battery assembly	57
4.5 State Gove		State Government planning and support	58
		The WA Government's Future Battery Industry Strategy	60
		The development of a new Cooperative Research Centre	62
5		The Coming Wave of Electric Vehicles	65
5	5.1	An uncertain future	65
5	5.2	Electric vehicles in the Australian market	66
5	5.3	The rapid decline in battery prices	67
5	5.4	International initiatives to develop electric vehicles	67
5	5.5	Response from the car industry	70
5	5.6	E-buses to lead the revolution?	72
5	5.7	Why are there so few electric vehicles in Australia, especially WA?	73
		Government support to lower electric vehicle ownership costs	76
		Development of charging infrastructure	79
		A more positive view?	82
5	5.8	Initiatives to encourage greater electric vehicle use in WA	83
5	5.9	Likely impact of electric vehicles on WA's grid	84
		Electric vehicles' impact on total electricity consumption	84
		Electric vehicles' impact on peak demand and electricity load	
		profiles	85
		The development of autonomous vehicles	87
6		Conclusion	89
е	5.1	Microgrids already demonstrating their value in WA	89
۸pr	oondi		02
<u>~</u> µŀ	penul		33
1	1	Committee's Functions and Powers	93
2	2	Inquiry's Terms of Reference	95
Э	3	Submissions Received	97

4	Briefings		
5	Public Hearings		
6	Closed Hearing		
7	Scheduled and Semi-scheduled (Large-scale Renewable) Generators in SWIS	the 113	
	Scheduled generators and their capacity credits	113	
	Semi-scheduled (large-scale renewable) generators and their capacity credits	114	
8	Rapid Growth of Microgrids in Other Jurisdictions	115	
	Introduction	115	
	Australian Jurisdictions	115	
	ACT	115	
	Northern Territory	115	
	Tasmania	116	
	Victoria	117	
	International projects	118	
	Antarctica	118	
	Canada	119	
	Caribbean	119	
	China	119	
	India	119	
	Japan	120	
	Korea	120	
	Puerto Rico	120	
	Singapore	121	
	Sweden	121	
	Thailand	121	
	United Kingdom	122	
	United States of America	123	
9	Glossary	125	

i

# Findings

# Finding 1

Western Australia's energy system is undergoing a period of significant transition and the rapid uptake of large and small-scale renewable resources is having an everincreasing impact on the State's transmission and distribution systems.

# Finding 2

There are world-leading Microgrid and distributed energy resources projects on Stateowned isolated networks in regional Western Australia.

# Finding 3

Horizon Power's vertical integration provides it with visibility and control over the complete energy value chain. Its control over the power system enables it to manage generation and network assets. Its direct customer relationships allow it to access information, install and trial small-scale assets, and form commercial relationships to roll-out Microgrid and distributed energy resources technologies.

# Finding 4

Private sector entities have demonstrated significant capability and interest in the development of Microgrid and associated technologies.

# Finding 5

Government Trading Enterprises have successfully partnered with a range of private sector entities to trial Microgrid and distributed energy resource solutions in 'fringe-of-grid' areas and isolated networks.

# Finding 6

A number of innovative stand-alone power systems, distributed energy resources and Microgrid trials are currently operating in Western Australia, particularly in regional and remote areas of the State. Notably, many of them demonstrate that power can be provided to consumers in a more cost-effective and reliable manner than via their traditional supply arrangements.

# Finding 7

Western Australia has a distinct global competitive advantage in lithium production on account of its hard rock reserves, mature mining industry and stable political environment.

#### Page 35

# Page 44

# Page 50

# Page 13

# Page 30

# Page 27

Page 28

## **Finding 8**

The rapid development of lithium exports from Western Australia over the past five years places it in a position to supply about 60% of the world's annual consumption. The development of projects to refine the lithium and move along the lithium-ion battery value chain could provide the State with tens of thousands of new jobs, placed close to residential areas in the South West.

#### **Finding 9**

Collaborative effort between the Government, industry and the research community is essential to successfully develop the battery supply chain in Western Australia.

## Finding 10

In other jurisdictions, government assistance, such as priority access lanes, free parking, reductions in import and stamp duties and registration fees, have encouraged electric vehicle ownership.

## Finding 11

Electric vehicles have the potential to lift electricity consumption and flatten network load profiles, improving the security and stability of the power system.

# Page 63

Page 63

Page 79

# **Page 87**

# **Exciting New Power Developments for WA**

...by 2022, whole regions of our electricity system must be capable of operating securely, reliably and efficiently with 100% of instantaneous demand met by [renewable energy resources].<sup>1</sup>

# **1.1** The new power environment

This Inquiry has occurred at a historic time for Western Australia's energy industry. In 2019, the volume of installed photovoltaic (PV) panels generating capacity on the rooves of homes in the State's largest network, the South West Interconnected System (SWIS), exceeded 1GW, with over 280,000 installations on approximately 26% of houses.<sup>2</sup> Solar PV is now the single largest source of generation capacity on the SWIS. Australian Energy Market Operator's Chief Executive Officer, Ms Audrey Zibelman, recently noted that installed rooftop solar capacity is now three times larger than the single largest generator on the SWIS.<sup>3</sup>

Small-scale solar PV capacity is increasing rapidly and in 2017 approximately 180MW of new capacity was added to the SWIS.<sup>4</sup> The total rooftop solar capacity in the SWIS increased from 50MW to 700MW over the period 2010-17.<sup>5</sup> At the same time as this rapid growth of installed small-scale PV capacity and generated energy, the cost of power produced by both solar and wind in Australia is now cheaper than other, more traditional, fossil fuel sources, as illustrated in Figure 1.1 below.

Figure 1.2 confirms the rapid growth in the production of electricity from renewable sources in Australia over the past decade.

<sup>1</sup> Submission No. 30 from Horizon Power, 19 April 2018, p82.

<sup>2</sup> Clean Energy Council, Number of Australian homes with rooftop solar tops 2 million...and counting, 3 December 2018. Available at: www.cleanenergycouncil.org.au/news/2018/December/2-million-solar-households.html. Accessed on 10 December 2018.

<sup>3</sup> Ms Audrey Zibelman, Managing Director and Chief Executive Officer, Australian Energy Market Operator, *Managing the Energy Transition*, 8 March 2019, p4. Available at: <u>https://ceda.com.au/CEDA/media/Attachments/2019/PDF/03/W190308 Zibelman Presentation</u>.<u>pdf</u>. Accessed on 15 March 2019.

<sup>4</sup> ACIL Allen, *Peak Demand and Energy Forecasts for the South West Interconnected System-Western Australia*, 13 June 2018, p60. Available at: <u>http://www.aemo.com.au/-</u> /media/Files/Electricity/WEM/Planning\_and\_Forecasting/ESOO/2018/2018-WEM-ESOOmethodology-report---Peak-demand-and-energy-forecasts-for-the-SWIS.pdf</u>. Accessed on 29 March 2019.

<sup>5</sup> Ibid.



Figure 1.1- Renewable energy is now the cheapest source in Australia<sup>6</sup>

Figure 1.2- Australian renewable electricity generation – 1994-2017<sup>7</sup>



<sup>6</sup> Clean Energy Council, 29 November 2018. Available at: <u>https://twitter.com/cleannrgcouncil/status/1068310115793522688</u>. Accessed on 10 December 2018.

<sup>7</sup> Mr Philip Soos, LF Economics, Email, 12 December 2018.

The rapid uptake of rooftop PV has exceeded many industry forecasts. Figure 1.3 shows that in 2013 the global installation of PV panels was significantly greater than the estimates made just three years earlier by both the environment group Greenpeace and the International Energy Agency.



Figure 1.3- Underestimates of global cumulative installed solar PV capacity<sup>8</sup>

The following graph in Figure 1.4 shows the rapid increase in solar PV installations in Western Australia's SWIS.

The rate of installation growth in the SWIS is also extremely high. Figure 1.5 shows the total annual installed capacity for residential PV in the SWIS, and Figure 1.6 shows the recent growth rates in both residential and commercial installations.

<sup>8</sup> Zachary Shahan, Clean Technica, 'Will US Solar Growth Continue To Shock, Explode, & Demolish Under Trump/Bannon/Pence?', 28 February 2017. Available at: <u>https://cleantechnica.com/2017/02/28/will-us-solar-growth-continue-shock-explode-demolish-trumpbannonpence/</u>. Accessed on 12 December 2018.



Figure 1.4- Historical small-scale rooftop PV capacity in the SWIS – 2010-179

Figure 1.5- Total small-scale rooftop PV annual installed capacity in the SWIS – 2012-17<sup>10</sup>



<sup>9</sup> ACIL Allen, Peak Demand and Energy Forecasts for the South West Interconnected System-Western Australia, 13 June 2018, p60. Available at: <u>http://www.aemo.com.au/-</u> /media/Files/Electricity/WEM/Planning\_and\_Forecasting/ESOO/2018/2018-WEM-ESOOmethodology-report---Peak-demand-and-energy-forecasts-for-the-SWIS.pdf. Accessed on 29 March 2019.

10 Ibid, p61.



Figure 1.6- Annual growth in residential and commercial rooftop PV uptake – 2012-17<sup>11</sup>

# 1.2 Why this Inquiry?

The exponential increase in small-scale PV installations is having a significant impact on both the production and consumption of electricity in Western Australia (WA) and given rise to a range of economic opportunities. There have also been a range of environmental and operational drivers towards Microgirds and the deployment of distributed energy resources.

In November 2015 catastrophic bushfires in the Esperance region burned nearly a million acres, created over \$60 million in crop losses and killed four people – the worst fatalities from a Western Australian bushfire since 1958. The fire also destroyed over 300 wooden power poles and hundreds of kilometres of power lines, causing extended power outages for an entire community.<sup>12</sup>

<sup>11</sup> ACIL Allen, *Peak Demand and Energy Forecasts for the South West Interconnected System-Western Australia*, 13 June 2018, p62. Available at: <u>http://www.aemo.com.au/-/media/Files/Electricity/WEM/Planning and Forecasting/ESOO/2018/2018-WEM-ESOO-methodology-report---Peak-demand-and-energy-forecasts-for-the-SWIS.pdf</u>. Accessed on 29 March 2019.

<sup>12</sup> *WA Today,* 'Esperance bushfires: firefighters battle through the night,' 20 November 2015. Available at: <u>www.watoday.com.au/national/western-australia/esperance-bushfire-raging-blaze-slows-as-community-grapples-with-loss-20151119-gl2nod.html</u>. Accessed on 29 March 2019.

In 2016 Horizon Power, the Western Australian Government-owned power utility servicing the Esperance region, adapted off-grid stand-alone power systems (SPS) in preference to rebuilding the distribution network infrastructure destroyed by the fire.<sup>13</sup>

For some time, utilities had been considering whether SPS were a more capital and operationally efficient power supply solution for remote, 'fringe-of-grid' communities. The destruction of the traditional asset base in Esperance provided an ideal opportunity to test the theory.

Five test systems were installed to utility-grade safety and engineering standards, and have now operated successfully for more than two years.<sup>14</sup> These SPS use a combination of solar panels, lithium-ion batteries and back-up diesel generators and have proven to provide more reliable electricity for the five trial participants than their previous grid-based supply.<sup>15</sup>

This Inquiry was established to investigate and report on the emergence and impact of these new technologies in WA. The Inquiry's Terms of Reference (see Appendix Two) capture a range of associated issues such as the emergence of electric drive vehicles (EVs) and the rapid growth of the State's lithium mining industry, as these factors will also have a major impact on the future development of the State's electricity grids and associated work force.

This report focuses on the development and deployment of these technologies across WA, the potential benefits and opportunities presented by Microgrids, the opportunities along the mining and manufacturing value chain, and the implications of the greater use of EVs.

The Inquiry's Final Report will examine barriers to the technologies and will consider the State's existing power regulations and legislation. Given the significant operational, consumer and economic development potential posed by Microgrids, it is vital that WA does all it can to ensure that these new technologies bring lower power prices to customers and maximise economic development opportunities, while providing the high levels of reliability found in the current grids serving Western Australians.

# **1.3 Establishment of the Inquiry**

The Inquiry commenced on 21 February 2018 after the Committee was briefed by the Public Utilities Office on the impact of new energy developments in WA. The Committee placed an advertisement calling for public submissions in *The West Australian* on Saturday 3 March 2018 and also placed a full-page advertisement in the

<sup>13</sup> Submission No. 30 from Horizon Power, April 2018, pp36–37.

<sup>14</sup> Ibid.

<sup>15</sup> Ms Tristy Fairfield, New Projects and Stakeholder Engagement, Energy Made Clean, *Transcript of Evidence*, 13 June 2018, p4.

March 2018 issue of the Australian Institute of Energy's official journal, *Energy News*. The Inquiry's establishment also gained exposure on a number of energy-related social media platforms, including Twitter and LinkedIn.

# **1.4** Committee consultation

The Inquiry generated great interest from a diverse range of stakeholders. The Committee received a total of 41 submissions and 9 supplementary submissions (see Appendix Three), including from:

- Key government agencies, including the Department of Mines, Industry Regulation and Safety, Building and Energy; the Public Utilities Office; the Australian Energy Market Operator (AEMO) and the Australian Energy Market Commission;
- The three Western Australian energy sector Government Trading Enterprises – Horizon Power, Synergy and Western Power;
- Leading research institutions, including Curtin University, Murdoch University and the WA Technology and Industry Advisory Council;
- Private sector industry participants, including Alinta Energy, ATCO Australia, Perth Energy, Power Ledger, Tesla Energy, VSUN Energy and Woodside Energy;
- Individuals and community groups with an interest in sustainability and establishing locally-driven energy projects; and
- A wide range of industry organisations including the Australian Electric Vehicle Association, Chamber of Commerce and Industry (WA), the Association of Mining and Exploration Companies, and the Clean Energy Council.

The Committee also received briefings (see Appendix Four) from AEMO and Western Power in Perth, Nickel West at its Kwinana refinery and Horizon Power at its Carnarvon depot. Briefings were also held with 17 US agencies in San Francisco, Sacramento and New York.

The Committee held 38 public hearings at which 84 witnesses appeared (see Appendix Five) and a closed hearing with Tesla Motors Australia Pty Ltd. Public hearings were held in Perth and Carnarvon and hearings were held via videoconference with interstate witnesses.

# **1.5** The State's current electricity infrastructure

WA's electricity supply chain has traditionally been broken down in to three distinct sections:

- Generation: the production of electricity;
- Network operation: the movement of electricity from generation source through transmission and distribution networks to end consumers; and
- Retail: the on-sale of electricity to consumers.

In WA, generators and retailers are able to buy and sell electricity in the SWIS through the Wholesale Electricity Market managed by the AEMO. Western Power manages network operations and AEMO manages system operations.

Outside of the SWIS, the vertically integrated Horizon Power manages the entire energy chain in a number of islanded systems. Private networks and SPS also exist, primarily for supply to individual resource projects.

## Generators

Generation capacity falls into three broad categories: scheduled, semi-scheduled and unscheduled:

- Scheduled generators are generally large, fossil fuel fired power stations capable of centralised dispatch into the energy system;
- Semi-scheduled generators are typically large-scale renewable facilities. Given the intermittent availability of their primary 'fuel' source, large renewable facilities only produce energy when the sun shines or wind blows. Their injection of energy into the network can, however, be controlled and centrally dispatched; and
- Unscheduled resources (such as small-scale rooftop solar PV systems) are not scheduled or controlled in real time on the SWIS – when they produce energy, it is consumed at the host premises and/or injected into the network in an uncontrolled manner.

AEMO's scheduled generators in the SWIS have an installed capacity in 2019-20 of 4.64GW, 340MW less than the previous year after the retirement of four scheduled generation assets. The semi-scheduled (or renewable) large-scale generators will have a capacity of 183MW in 2019-20, 73MW more than the previous year. Wind generators

will provide 73% of this renewable capacity. The location of all large-scale generators in the SWIS is shown in Appendix Seven.<sup>16</sup>

In December 2018, Western Power announced connection approvals for a further 8 large-scale renewable energy projects, required to acquit obligations under the Federal Government's Renewable Energy Target. These projects will add a further 1GW of capacity to the State's grid. The largest of these will be Alinta Energy's 210MW Yandin wind farm in the Mid West, costing about \$500 million.<sup>17</sup>

#### Networks

Western Australia has two electricity transmission networks: the SWIS and the North West Interconnected System (NWIS), with a range of small distribution-scale Non-Interconnected Systems serving communities throughout regional WA, such as in Carnarvon and Esperance.<sup>18</sup> There is also a small privately-owned transmission grade system in the Pilbara, serving iron ore projects.



#### Figure 1.7- The beginning of the SWIS- 1950<sup>19</sup>

<sup>16</sup> Australian Energy Market Operator, *Electricity Statement of Opportunities*, June 2018, pp14–15. Available at: <u>http://www.aemo.com.au/-</u> /media/Files/Electricity/WEM/Planning and Forecasting/ESOO/2018/2018-WEM-ESOO-Report.pdf. Accessed on 12 December 2018.

<sup>17</sup> Daniel Mercer, *The West Australian*, 'State poised for \$1b green power blitz', 6 December 2018, p11.

<sup>18</sup> Clean Energy Council, Grid, 2014. Available at: www.cleanenergycouncil.org.au/technologies/grid.html. Accessed on 5 February 2018.

<sup>19</sup> Ms Claire Smith, Senior Government Relations Specialist, Western Power, E-Mail, 15 May 2018.

The SWIS is the State's largest grid and extends from Kalbarri in the north to Kalgoorlie in the east and Bremer Bay in the south. In 1950, the SWIS was a small collection of interconnected transmission lines, mainly in metropolitan Perth, as shown in Figure 1.7. It reached its current geographical extent by 1993, as shown in Figure 1.8.





<sup>20</sup> The SWIS boundary is defined in Clause 2.5 of the Transmission and Distribution Licences granted by the Economic Regulation Authority (e.g. see <u>www.erawa.com.au/cproot/19300/2/ETL02%20Electricity%20Networks%20Corporation%20(We</u> <u>stern%20Power)%20effective%202018.07.01.pdf</u>). Western Power, Western Power Network Boundary, 3 July 2013. Available at: <u>https://westernpower.com.au/media/1431/swis-towns-locations.pdf</u>. Accessed on 5 February 2018.

The SWIS incorporates over 101,000 km of transmission lines.<sup>21</sup> The State Governmentowned Western Power owns, builds, maintains and operates the SWIS' transmission and distribution network. The Government-owned Synergy is the State's largest licensed retailer and provides 52% of the electricity sold to households and business customers in the SWIS through seven scheduled generators, connected to the SWIS.<sup>22</sup> Synergy also supplies about 55% of the contestable gas load in the industrial and commercial markets.<sup>23</sup> The SWIS is subject to economic regulation by the Economic Regulation Authority under the *Electricity Networks Access Code 2004* (WA) (ENAC).<sup>24</sup>



Figure 1.9- The NWIS<sup>25</sup>

The NWIS comprises several interconnected privately and publicly-owned and operated networks, and was established in 1985. It extends across an area measuring 400km east to west and 350km north to south, and services a wide range of Pilbara communities through the Government-owned Horizon Power and Alinta Networks; and the communities of Goldsworthy and Shay Gap through the BHP Billiton Network (see

<sup>21</sup> Western Power, *What we do*, 2018. Available at: <u>https://westernpower.com.au/about/what-we-do/</u>. Accessed on 5 February 2018.

<sup>22</sup> Synergy, *Power stations*, 2018. Available at: <u>www.synergy.net.au/About-us/Who-we-are/What-we-do/Electricity-generation/Power-stations</u>. Accessed on 4 December 2018.

<sup>23</sup> Synergy, Who we are, 2018. Available at: <u>https://www.synergy.net.au/About-us/Who-we-are</u>. Accessed on 5 February 2018.

<sup>24</sup> State of Western Australia, *Electricity Networks Access Code 2004*, 23 December 2016. Available at:<u>www.treasury.wa.gov.au/uploadedFiles/Site-</u> <u>content/Public\_Utilities\_Office/Regulatory\_framework/ElecNetworksAccessCode.pdf</u>. Accessed on 29 March 2019.

<sup>25</sup> Horizon Power, *The NWIS*, 2014. Available at: <u>https://nwis.com.au/the-nwis/</u>. Accessed on 5 February 2018.

Figure 1.9). There are two additional islanded transmission networks, crossing over (but not interconnecting with) the NWIS, which are owned and operated by BHP Billiton and Alinta.<sup>26</sup>

Following a 2017 application by Alinta under the ENAC, in February 2018 Treasurer and former-Minister for Energy, Hon Ben Wyatt MLA, announced that Horizon Power will be obliged to facilitate third-party access to its portion of the NWIS grid. Under the auspices of the ENAC, a 'light-handed' regulatory access framework is currently under development with the intention that from 1 January 2020 Horizon Power's Pilbara network will be regulated by the ERA, albeit in a modified manner to the regulatory regime it applies to the SWIS.<sup>27</sup>

Horizon Power is the main licensed network operator, generator and retailer for the area outside of the SWIS and is one of the last remaining vertically integrated utility companies in Australia. In 2018 there were over 1.1 million customers connected to the SWIS,<sup>28</sup> compared to approximately 47,000 customers in the NWIS.<sup>29</sup>

# 1.6 Changes to the State's energy mix

Public Utilities Office's data in Table 1.1 below highlights the change over the past decade to the State's energy sources for the generation of electricity, with a large increase in gas and renewables over the past decade and a significant drop in the use of distillate.

Microgrids and their associated technologies are key to WA's ability to maximise the benefits presented by this transition. This report describes Microgrids, considers the transition that is currently underway in WA's energy economy and discusses the opportunities they present.

<sup>26</sup> Horizon Power, *The NWIS*, 2014. Available at: <u>https://nwis.com.au/the-nwis/</u>. Accessed on 5 February 2018.

<sup>27</sup> Hon Ben Wyatt MLA, Minister for Energy, *Media Statement,* 'Minister announces regulatory coverage of Pilbara electricity network,' 2 February 2018. Available at: <a href="http://www.mediastatements.wa.gov.au/Pages/McGowan/2018/02/Minister-announces-regulatory-coverage-of-Pilbara-electricity-network.aspx">www.mediastatements.wa.gov.au/Pages/McGowan/2018/02/Minister-announces-regulatory-coverage-of-Pilbara-electricity-network.aspx</a>. Accessed on 5 February 2018.

<sup>28</sup> Western Power, Annual Planning Report 2018/19- Overview, 2019, p2. Available at: <u>https://westernpower.com.au/media/3191/annual-planning-report-overview-2018-19-20190305.pdf</u>. Accessed on 29 March 2019.

<sup>29</sup> Horizon Power, *The NWIS*, 2014. Available at: <u>https://nwis.com.au/the-nwis/</u>. Accessed on 5 February 2018.

Source	Output (GWh)	Proportion	Output (GWh)	Proportion
	January 2007		March 2018	
Coal	629	58%	784	50%
Gas	379	35%	602	38%
Landfill gas	6.5	0.6%	12	0.8%
Distillate	10	0.9%	6.9	0.4%
Wind	62	5.7%	159	10%
Solar	0	0%	1.8	0.1%

# Table 1.1- Changes to WA energy mix to generate electricity – 2007-18<sup>30</sup>

# Finding 1

Western Australia's energy system is undergoing a period of significant transition and the rapid uptake of large and small-scale renewable resources is having an everincreasing impact on the State's transmission and distribution systems.

<sup>30</sup> Public Utilities Office, Improving access to the Western Power Network: Proposed Approach to Implement Constrained Network Access, 9 August 2018, p8. Available at: www.treasury.wa.gov.au/uploadedFiles/Sitecontent/Public\_Utilities\_Office/Industry\_reform/Consultation-Paper-Two-Improving-access-tothe-Western-Power-Network.pdf. Accessed on 20 December 2018.

# What is a Microgrid?

Microgrids encompass a range of applications that can provide safer, more reliable and affordable electricity supply to many electricity consumers.<sup>31</sup>

# 2.1 The changing nature of power supply

Traditionally, Western Australia's electricity system has been highly centralised. Largescale thermal generation plants (fuelled by coal, gas and diesel) produced electricity which was transported via high-voltage transmission and low-voltage distribution networks to distant load centres. Over time, power systems also saw increased levels of large-scale renewable generation (wind and solar farms). End-users were largely passive consumers of the electricity, and the power system was designed around a centrally dispatched and controlled, uni-directional flow of energy.

As discussed in the previous chapter, over the past decade, this model has begun to change, with an increasing take-up of small-scale renewable energy resources (predominantly rooftop solar photovoltaic (PV)),<sup>32</sup> advances in communications technology and the introduction of new types of battery storage.

Some households and businesses are now both consuming and actively producing their own energy (so-called 'prosumers'), utilising these 'distributed energy resources' (DER). In this new power system dynamic, energy flows have now become bi-directional and a growing proportion of the State's generation assets are neither centrally dispatched nor centrally controlled.

The shift to more localised energy production and consumption has created an opportunity for a range of new energy management technologies, which have already demonstrated the potential for lower energy costs and improved energy supply reliability and security. Several Australian and international companies have designed and developed solutions such as Microgrids, smart grids, peak-shaving and energy storage options utilising DER.

<sup>31</sup> Submission No. 14 from Lendlease and Energy Made Clean, 13 April 2018, p1.

<sup>32</sup> The Australian Energy Market Operator defines rooftop PV to constitute "installed residential and commercial systems that have a capacity of less than 100 kW and are eligible for the Small-Scale Technology Certificates under the Small Scale Renewable Energy Scheme." Australian Energy Market Operator, 2017 Electricity Statement of Opportunities, September 2017, p1. Available at: <u>http://www.aemo.com.au/Media-Centre/2017-Electricity-Statement-of-Opportunities</u>. Accessed on 26 March 2019.

Horizon Power described this transformation as:

...being driven by the combined forces of the three D's: decentralisation, digitisation, and decarbonisation. From a whole-of-system standpoint, the transformation is occurring in an increasingly ad hoc, and at times chaotic manner, disrupting traditional business models ... and our electricity systems are now increasingly being stretched beyond their original architectural boundaries.<sup>33</sup>

A recent report from the Australian Energy Market Operator (AEMO) forecasts that renewable energy sources will provide nearly 50% of Australia's electricity by 2030.<sup>34</sup> AEMO's first *Integrated System Plan* evaluated the likely changes that will occur over the next 20 years across the East Coast's National Electricity Market. Low-cost solar and wind will replace about 60% of the coal-generated electricity in the next 20 years, with the total demand for electricity remaining at about 40GW, changing little from what it is today (see Figure 2.1).





<sup>33</sup> Submission No. 30 from Horizon Power, 19 April 2018, p4.

Giles Parkinson, *Renew Economy*, 'Bad news for coal-huggers: Renewables at 50% by 2030', 17 July 2018. Available at: <u>https://reneweconomy.com.au/bad-news-for-coal-huggers-renewables-at-50-by-2030-2030/</u>. Accessed on 20 July 2018.

<sup>35</sup> Australian Energy Market Operator, Integrated System Plan: For the National Electricity Market, July 2018, p37. Available at: <u>www.aemo.com.au/-</u> /media/Files/Electricity/NEM/Planning\_and\_Forecasting/ISP/2018/Integrated-System-Plan-2018\_final.pdf. Accessed on 17 July 2018.

As can be seen in Figure 2.1 above, a growing proportion of this capacity will be provided from DER, including rooftop PV and storage. By 2033, , and unless some form of orchestration for small scale assets is introduced, less than 50% of this capacity will be scheduled and dispatchable.



Figure 2.2- Schematic of a simple Microgrid

# 2.2 Defining a 'Microgrid'?

The concept of a Microgrid was first proposed in 2001 by the Institute of Electrical and Electronics Engineers (IEEE) *Power and Energy Society*. The first guidelines for the connection of DER to grids and

the control of Microgrids was also developed by IEEE in 2010.<sup>36</sup> The US Department of Energy's Microgrid Exchange Group defines a Microgrid as:

A group of interconnected loads and distributed energy resources (DERs) with clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid [and can] connect and disconnect from the grid to enable it to operate in both grid-connected or islanded mode.<sup>37</sup>

The AEMO defines a Microgrid as being:

...a small-scale power system that consists of distributed generation sources that are [sic] 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 operational scenarios...<sup>38</sup>

The schematic in Figure 2.2 shows the simplest Microgrid,<sup>39</sup> with a home powered by renewable energy resources while remaining connected to an external grid.

38 Submission No. 19 from Australian Energy Market Operator, 13 April 2018, p10.

<sup>36</sup> Submission No. 25 from Murdoch University, School of Engineering and Information Technology 13 April 2018, p1.

<sup>37</sup> Christopher Villarreal and David Erickson. *California Public Utilities Commission*, 'Microgrids: A Regulatory Perspective', April 2014, p4. Available at: www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=5118. Accessed on 28 March 2019.

<sup>39</sup> Wikipedia, *Microgrid*, 14 July 2018. Available at: <u>https://en.wikipedia.org/wiki/Microgrid</u>. Accessed on 17 July 2018.

Microgrids rely on Supervisory Control and Data Acquisition (SCADA) systems to coordinate distributed generation, including intermittent renewables (e.g. small-scale solar PV), small-scale thermal generation (e.g. micro gas turbines or small diesel units), battery storage units and demand response operations. Collectively, these resources are known as distributed energy resources.

The presence of multiple load and generation sources, potentially owned or operated by many parties, within an electrical boundary, also distinguishes Microgrids from a stand-alone power system (SPS). A Microgrid connects to the grid at a point of common coupling and maintains a frequency and voltage at the same level as the main grid.

The ability to both operate within, or disconnected from, the main interconnected electricity network is shown in a schematic of a larger Microgrid in Figure 2.3.



#### Figure 2.3- Schematic of a larger Microgrid<sup>40</sup>

Microgrids can utilise both renewable and fossil-fuelled generation technologies. However, much of the impetus behind the recent increase in interest follows the falling cost of renewable energy resources relative to fossil fuel sources, and particularly, electricity generated by solar panels installed in residential housing.

<sup>40</sup> Giles Parkinson, *Renew Economy*, 'Australia's energy future could be network of renewable micro-grids', 13 October 2015. Available at: <u>https://reneweconomy.com.au/australias-energy-future-could-be-network-of-renewable-micro-grids-84534/</u>. Accessed on 17 July 2018.

Professor Peter Newman from Curtin University described this extraordinary change, "[s]olar has come down in price by 66%, wind by 30% and batteries by 50% in a fiveyear period."<sup>41</sup> The Clean Energy Finance Corporation confirmed to the Committee that they "expect and anticipate that the cost of solar and storage technologies will continue to decrease."<sup>42</sup>

Reduced fossil fuel consumption also assists to lower a community's carbon footprint. Murdoch University submitted that "[w]e are currently in the transition stage of converting our fossil-dominated electricity grids into sustainable Microgrids."<sup>43</sup>

Horizon Power currently operates 37 Microgrids in Western Australia (WA) (see Chapter 3 for a description of several of Horizon's projects).<sup>44</sup> It highlighted the shift to renewable power in Australia:

Australia's electricity system operators are now recognising that by 2022, whole regions of our electricity system must be capable of operating securely, reliably and efficiently with 100% of instantaneous demand met by DER.<sup>45</sup>

Alinta Energy highlighted the unique, and immediate, potential offered by Microgrids to the State's electricity system:

Western Australia is well placed to expand the use of Microgrid technologies. About one quarter of WA electricity customers already have solar PV installed and there are a number of Microgrids in operation today, for example at the edge of grid (for example, Kalbarri) and in urban areas (for example, the White Gum Valley energy sharing trial).<sup>46</sup>

At the heart of an 'advanced' Microgrid lies specialised software systems- the distributed energy resources management system (DERMS). DERMS optimises the technical operations of thousands of grid-connected DER to dynamically manage supply and demand, maintain system stability and optimise its long-term economic efficiency.<sup>47</sup>

<sup>41</sup> Professor Peter Newman, Professor of Sustainability, Curtin University, *Transcript of Evidence*, 18 June 2018, p10.

<sup>42</sup> Mr Ian Learmonth, Chief Executive Officer, Clean Energy Finance Corporation, *Transcript of Evidence*, 18 June 2018, p2.

<sup>43</sup> Submission No. 25 from Dr Farhad Shahnia, Senior Lecturer, School of Engineering & Information Technology, Murdoch University, 13 April 2018, p2.

<sup>44</sup> Ibid, p6.

<sup>45</sup> Submission No. 30 from Horizon Power, 19 April 2018, p82.

<sup>46</sup> Submission No. 15 from Alinta Energy, 13 April 2018, p3.

<sup>47</sup> Submission No. 22 from Synergy, 13 April 2018, p5.

The Australian Energy Regulator submitted that:

...Microgrids and 'off-grid' technologies offer great potential for enhancing economic efficiencies in relation to the energy market. These technologies may be able to provide more efficient solutions for many customers in the provision of affordable, secure reliable and sustainable energy supply.<sup>48</sup>

# 2.3 Different types of Microgrids

The term 'Microgrid' can be used to describe a range of different asset, customer and IT configurations.

The US Department of Energy's definition (see section 2.2) is increasingly accepted as an industry standard term, with Microgrids characterised by multiple, individually metered prosumers, consumers and producers within an electrically defined segment of the wider legacy grid, often also within identified geographic boundaries (e.g. local government area, suburb, subdivision or industrial area).

The loads and DERs within the Microgrid may be able to be controlled through a local or larger network SCADA system, and the Microgrid itself can also present to a network or system operator as a single controllable unit on the larger network's SCADA system.<sup>49</sup>

This definition of the term 'Microgrid' should be distinguished from:

- Stand-Alone Power Systems: dedicated power systems, wholly situated on one site (e.g. a mine site or rural property) and usually supplying a single customer.
- Embedded Networks (EN): dedicated power systems, wholly situated on one site (e.g. a university campus, airport, defence facility or hospital), and usually supplying a single customer with single or multiple meter points at the interface with the network. An EN may exist within a Microgrid.
- Virtual Power Plants: not necessarily contained within an electrical or geographically defined boundary. Can include DERs located at multiple, disparate sites throughout the wider transmission and distribution networks. The individual DER assets are coordinated by an advanced SCADA system and may present to the grid as a single, controlled system or 'plant' akin to traditional generation sources. Virtual systems can also

<sup>48</sup> Submission No. 1 from Australian Energy Regulator, 8 March 2018, p1.

<sup>49</sup> Microgrids at Berkeley Lab, *About Microgrids*, 2019. Available at: <u>https://building-microgrid.lbl.gov/about-microgrids</u>. Accessed on 16 July 2018.

be used within Microgrids, and can again enable a Microgrid to present to the broader network as a single controllable point to the wider network operator.

Non-Interconnected Systems (NIS): distribution-grade networks (usually remote power systems) associated with regional townships or communities centres, that are not connected to a transmission network. NIS may nonetheless contain many of the ICT and generation technologies seen in SPS and Microgrids and much of the innovation in Microgrid technology in WA originates in regional WA.

Navigant Research estimated in 2017 that there were about 1,870 Microgrid projects in 123 countries, producing nearly 21GW of power. A description of some of these projects in other Australian and overseas jurisdictions is contained in Appendix Eight.<sup>50</sup>

In their submission, Western Power discussed their need to look outside of traditional network investments, as "[o]ur evolving energy landscape has created considerable change to how electricity is generated, distributed and consumed."<sup>51</sup> They define the different forms of Microgrids as:

A **connected Microgrid** is a section of the Western Power network that is:

- a) still connected to the meshed network;
- b) has the ability to be islanded as an autonomous system; and
- c) requires local storage and/or generation.

An **autonomous Microgrid** is a section of the Western Power network that is:

- a) not connected to the meshed network, but which is within Western Power's network service area; and
- b) requires local generation.

An **embedded network** is a privately-owned electricity network that sits behind a single connection point serving two or more customers/ consumers.

<sup>50</sup> Navigant Research, Microgrid Deployment Tracker 4Q17, 19 February 2018. Available at: <u>www.navigantresearch.com/research/microgrid-deployment-tracker-4q17</u>. Accessed on 6 June 2018.

<sup>51</sup> Submission No. 4 from Western Power, 10 April 2018, p1.

A **stand-alone power system (SPS)** is a self-sufficient electrical power system that services a single customer, household or business and is not connected to another network.<sup>52</sup>

The following chapter provides an overview of a range of Microgrid projects across the State.

<sup>52</sup> Submission No. 4 from Western Power, 10 April 2018, pp1–2.
### WA Microgrid Innovations and Applications

...we are going to have a very highly distributed energy future and of the trillion dollars that will be spent by 2050, some 20 to 40% of that is actually going to be spent by customers ... putting in distributed energy because that is the most affordable way of providing some of those issues around reliability, resilience and affordability.<sup>53</sup>

#### 3.1 Current research and industry initiatives

Western Australia (WA) currently has a number of established and pilot stand-alone power system (SPS) and Microgrid projects operating throughout the State. The Clean Energy Council stated that WA:

...is leading the nation on the use of Microgrids. Trials in WA have already demonstrated that Microgrids can supply electricity more cheaply, more safely and more reliably than the traditional 'poles and wires' approach.<sup>54</sup>

Microgrids have been well received within the State's power industry, with entities including Western Power and Synergy arguing that the emergence and future potential of Microgrids will benefit Western Australian consumers. Mr Guy Chalkley, Chief Executive Officer (CEO) of Western Power, told the Committee that "[e]ven two years ago we said we had something called emerging technology. I think we know it has emerged; it is not emerging anymore."<sup>55</sup>

Leading institutions including Curtin University and the Australian Renewable Energy Agency (ARENA) are working in conjunction with industry, to undertake research and trials to best assist the further development of Microgrids throughout the State, especially at the edge of the South West Interconnected System (SWIS). Mr Seán McGoldrick, Executive Manager, Asset Management at Western Power, stated in evidence:

With the way technology has now developed, it gives us an alternative option. So instead of just building poles and wires everywhere, we can also build poles and wires if they are required, but we can have an

<sup>53</sup> Mr Frank Tudor, Chief Executive Officer (CEO), Horizon Power, *Transcript of Evidence*, 11 April 2018, p3.

<sup>54</sup> Submission No. 9 from Clean Energy Council, 13 April 2018, p1.

<sup>55</sup> Mr Guy Chalkley, CEO, Western Power, Transcript of Evidence, 11 April 2018, p4.

opportunity through stand-alone power systems – nanogrids and Microgrids – to service the community out there.<sup>56</sup>

Furthermore, Mr McGoldrick said that technology "has developed to the point that we are very confident that stand-alone power systems ... are an appropriate solution for Western Australia, and we are heavily investing in Microgrids."<sup>57</sup>

#### 3.2 Operational context

*Location* is integral to any examination of the opportunities and barriers for Microgrids and distributed energy resources (DER). In WA, there are significant regulatory and operational implications depending on where technologies are deployed.

The following discussion outlines a range of innovative projects in remote islanded systems, on the fringes of the SWIS and within the metropolitan area. Where projects have both regional and metropolitan implications or the location is less relevant to the benefits and opportunities of technology deployment, they are described in sections 3.5 and 3.6.

This chapter focusses on the operational rollout of Microgrids and DER. Benefits and opportunities are discussed in the next chapter. Regulatory considerations relating to location will be examined in the Final Report of this Inquiry.

#### 3.3 Islanded system projects

Microgrids and associated DER technologies are being trialled and applied throughout regional WA, typically serving remote townships and mine sites through SPS.

In many diesel-fuelled islanded systems, renewable energy sources, often combined with Microgrid technologies, now deliver lower electricity production costs. A Curtin University study into electricity usage at Laverton concluded that if the town "moves from a purely fossil fuel–based system into a combined fossil fuel and renewable and energy storage, the levelized cost of energy for them almost becomes half."<sup>58</sup>

Horizon Power developed its first Microgrid in 2005 and a strategic review in 2011-12 reported:

...with the purpose of cutting as much cost as it could from the business in order to launch into the development of Microgrids to drive further value through the uptake of technology and incorporation of distributed

<sup>56</sup> Mr Seán McGoldrick, Executive Manager, Asset Management, Western Power, *Transcript of Evidence*, 11 April 2018, p3.

<sup>57</sup> Ibid.

<sup>58</sup> Dr Farhad Shahnia, Senior Lecturer, School of Electrical Engineering, Murdoch University, *Transcript of Evidence*, 18 June 2018, p6.

energy resources. We were able to test this new technology on our Microgrids before anybody else because of our vertical integration, advanced metering platform and our inherited high cost to serve systems.<sup>59</sup>

#### **Carnarvon- Horizon Power's Microgrid trial**

Horizon Power chose Carnarvon for a substantial Microgrid trial as it already had a high penetration of household solar panels, providing 1.3MW of generating capacity, relative to a daily power load of about 5MW. The high penetration of rooftop photovoltaic (PV) panels had implications for network management, prompting Horizon to institute a moratorium on new rooftop solar panels and initiate DER and Microgrid management trials.<sup>60</sup>

Horizon Power's vertical integration and control over the Carnarvon system's generation, distribution and retail functions enabled a high degree of visibility and control over the trials and removed any constraints that may have arisen through traditional disaggregated contractual arrangements for power station operations. Horizon Power's direct relationship with customers also enabled direct community and consumer engagement for trial participation and rollout. Horizon stated:

We own and operate the power station so we do not have any issues in terms of being able to back the power station off and any contractual impediments there. That enabled us to explore the full value chain. The community here in Carnarvon is quite receptive to exploring these things with us, because they are probably more informed than other areas because they have just been in this space for quite some time.<sup>61</sup>

The Carnarvon project has three elements. The first two are funded by ARENA and the third is funded entirely by Horizon. In the first trial Horizon has recruited some of its customers to volunteer their PV information via small smart-monitoring devices. The second phase of the trial allows Horizon Power to monitor and control energy storage in household batteries. 'Proving up' this technology is intended to facilitate larger-scale orchestration of DER and facilitate the presentation and dispatch of these technologies as a single dispatchable unit in the system. The third trial will segregate "part of the

<sup>59</sup> Mr Frank Tudor, CEO, Horizon Power, Answers to Questions on Notice, 4 May 2018.

<sup>60</sup> Mr David Edwards, Technical Visionary, Advanced Microgrid Development, Horizon Power, *Transcript of Evidence*, 4 April 2018, p2.

<sup>61</sup> Mr Laurie Curro, General Manager, Power System Services, Horizon Power, *Transcript of Evidence*, 4 April 2018, p1.

network away from the main feeder and creating an inverter-only environment to test very high penetration DER and diesel-off technology."<sup>62</sup>

Horizon Power has engaged the local community through community forums, radio advertisements and household letter drops. It will give away a number of battery systems to customers who sign up to the trials for three years. The new PV and battery systems will be installed by local electrical contractors who have qualified through the Clean Energy Council.<sup>63</sup>

Horizon Power has also installed a utility-scale battery (2MW, 2MWh) in Carnarvon, which has already reduced the total cost of the Town's power system by 5%, representing savings of \$1.4 million per annum.<sup>64</sup> The battery will reduce spinning reserve but more importantly, support higher levels of PV panels being connected to the grid as more of this energy can be stored.<sup>65</sup>

One major challenge the trial has exposed is the impact of the high ambient temperatures on the Microgrid's electrical equipment, especially the battery, which is not such a problem in other locations such as Esperance.<sup>66</sup>

For the trials, participants were asked to sign an agreement that gives Horizon Power permission to collect more detailed data from the participants' premises than the traditional aggregated kilowatt hour data collected for billing purposes. The agreement also gives Horizon Power permission to share that data to third party institutions, such as ARENA, for analysis.<sup>67</sup>

#### Marble Bar- Hybrid Microgrid

Horizon Power has also innovated for the supply of electricity to the remote Pilbara township of Marble Bar – 1,500km from Perth.

Marble Bar has historically had among the highest energy costs in regional WA. Following Horizon Power's introduction of a hybrid Microgrid, 60% of the Town's power requirements are now supplied by a 300kW solar plant. The system consists of the solar array, four 320kW diesel generators, and a 500kW flywheel stabilisation system and has significantly reduced the Town's operating costs. These technologies have considerably improved power supply reliability: power outages have reduced

<sup>62</sup> Mr David Edwards, Technical Visionary, Advanced Microgrid Development, Horizon Power, *Transcript of Evidence*, 4 April 2018, p2.

<sup>63</sup> Ibid, pp2–3.

<sup>64</sup> Submission No. 30 from Horizon Power, 19 April 2018, p50.

<sup>65</sup> Mr Frank Tudor, CEO, Horizon Power, *Answers to Questions on Notice*, 4 May 2018.

<sup>66</sup> Mr Laurie Curro, General Manager, Power System Services, Horizon Power, *Transcript of Evidence*, 4 April 2018, p5.

<sup>67</sup> Ms Rebekah Spencer, Communications Consultant, Horizon Power, *Answers to Questions on Notice*, 20 April 2018.

from an average of approximately 38 minutes per year to fewer than 8 minutes per year.<sup>68</sup>

#### **Onslow- Microgrid uses gas as a primary fuel**

Horizon Power's Onslow Power Project is its most ambitious and innovative to date and demonstrates the integration of Microgrid technology into a gas-based system. Stage One of the project comprises a 5.25MW gas-fired power station supplied by gas from the Dampier to Bunbury Natural Gas Pipeline.<sup>69</sup>

Stage Two of the project commenced in March 2019 and includes a 1MW solar farm, battery storage systems and rooftop solar panels throughout Onslow, working collectively to provide about 50% of the town's energy requirements. Residents will be offered a 75% discount on solar and battery storage systems under the project.<sup>70</sup>

Building on the learnings from the Carnarvon trial, Horizon intends to operate batteries and household-scale PV as dispatchable units within the broader power system, achieving integrated DER orchestration. On completion, Onslow will have the largest renewable energy-based Microgrid in the Asia-Pacific region.

The gas fired generation on the system is modular and scalable – its size can be efficiently reduced as renewable energy contribution increases or expanded to meet future load growth requirements.

Horizon Power is also installing a new transmission line, zone substation and distribution network extension as part of the project. Advanced metering infrastructure will also be installed in customers' homes to allow software to balance the generation and energy consumption during the day. The project commenced in 2014 with the installation of a temporary diesel generator. A formal agreement was signed by Horizon, Chevron Australia and the State Government in August 2016.<sup>71</sup>

#### Finding 2

There are world-leading Microgrid and distributed energy resources projects on Stateowned isolated networks in regional Western Australia.

<sup>68</sup> Submission No. 9 from Clean Energy Council, 13 April 2018, p3.

<sup>69</sup> Tom Zaunmayr, *Pilbara News*, 'Onslow's gas power switches on, solar on the way', 11 July 2018. Available at: <u>www.pilbaranews.com.au/?news/pilbara-news/onslows-gas-power-switches-on-solar-on-the-way-ng-b88883968z</u>. Accessed on 11 July 2018.

<sup>70</sup> Alicia Perera, *Pilbara News*, 'Onslow to embrace renewable energy for microgrid project stage 2', 20 March 2019. Available at: <u>www.pilbaranews.com.au/?news/pilbara-news/onslows-gas-power-switches-on-solar-on-the-way-ng-b88883968z</u>. Accessed on 26 March 2019.

<sup>71</sup> Horizon Power, *Onslow distributed energy resource microgrid*, nd, p2. Available at: <u>https://horizonpower.com.au/media/2763/onslow-fact-sheet.pdf</u>. Accessed on 12 July 2018.

#### Finding 3

Horizon Power's vertical integration provides it with visibility and control over the complete energy value chain. Its control over the power system enables it to manage generation and network assets. Its direct customer relationships allow it to access information, install and trial small-scale assets, and form commercial relationships to roll-out Microgrid and distributed energy resources technologies.

#### Karratha- Airport Microgrid

Microgrids are not the sole purview of WA's Government Trading Enterprises. Considerable innovation is demonstrated in the private sector, by both developing and procuring DER solutions.

An ARENA-supported Microgrid project is currently being constructed by Karratha Solar Power No 1 Pty Ltd at Karratha Airport, (WA's second largest airport). ARENA is contributing \$2.3 million to the \$6.8 m total project cost.<sup>72</sup>

The project involves the design, construction, commissioning and operation of a 1MW, 3,100-panel, solar PV facility with cloud predictive technology (CPT).

CPT uses an interconnected network of cameras, pointed towards the sky, to sense approaching cloud cover. As cloud cover approaches, the CPT management system preemptively and slowly transitions power supply from the solar panels to a traditional power source, before the sun is blocked out, ensuring supply continuity and mitigating the intermittency traditionally associated with solar PV systems.

The successful demonstration of solar with CPT has the potential to further accelerate solar PV development in the State's north, and in other markets.<sup>73</sup> The CPT system was developed by MPower, an Australian-owned and operated subsidiary of Tag Pacific Limited. The software will allow smaller batteries to be installed, hence saving costs.

The City of Karratha, which owns Karratha Airport, will enter into a 21-year power purchase agreement (PPA) with the project proponent. The PPA provides a significant hedge against energy price volatility and it is anticipated that the City of Karratha will receive significant savings in actual electricity expenditure from this development.<sup>74</sup>

<sup>72</sup> Australian Renewable Energy Agency, Submission to Australian Energy Market Commission's Stand-alone Power Systems Review, 8 October 2018, p8. Available at: www.aemc.gov.au/sites/default/files/2018-10/ARENA%20-%20181009 0.PDF. Accessed on 20 March 2019.

<sup>73</sup> Submission No. 35 from Arena Renewable Energy Agency, 23 May 2018, p3.

<sup>74</sup> MPower, Solar Storage and Cloud Prediction Reducing Capital Expenditure Of Hybrid Systems, 10 August 2017. Available at: <u>www.mpower.com.au/blog/2017/08/10/solar-storage-and-cloud-prediction-reducing-capital-expenditure-of-hybrid-systems</u>. Accessed on 12 July 2018.

#### Mackerel Islands- Microgrid project

A privately-owned and operated SPS on Thevenard Island, just offshore from Onslow, is remotely monitored and controlled from Perth. The system consists of 320kW of solar panels, four 110kVA diesel generators and a 614kWh lithium-ion battery.<sup>75</sup>

#### Meekatharra- Sandfire's DeGrussa Mine PV project

Sandfire Resources is a Western Australian company which has added a large 10.6MW solar power system to its DeGrussa copper-gold mine near Meekatharra (900km north-east of Perth). The mine had previously relied on a 19MW diesel-fired power station.<sup>76</sup>

The innovative \$40 million solar project was successfully commissioned in June 2016 and comprises 34,080 solar PV panels that track the sun to increase efficiency. The PV panels are connected to a 6MW lithium-ion battery storage facility and supply around 20% of the mine's annual power requirements. This will cut fuel use by 5 million litres a year, and cut 15% of its carbon dioxide emissions.<sup>77</sup>

Sandfire Resource's Chief Commercial Officer said that the new solar project had created a lot of interest in the mining sector and he regularly hosted visits from companies within WA, as well as international companies to review the facility.<sup>78</sup>

#### Newman- Alinta Energy's lithium-ion battery

In April 2018, Alinta installed WA's largest lithium-ion battery at its Newman power station in the Pilbara. The asset is designed to improve the performance of Alinta's islanded high voltage network in the area and is also the largest battery to be developed for an industrial application.

The 30MW/11.4MWh Kokam battery supports the 178MW open-cycle gas turbines by emulating a 30MW gas turbine and providing spinning reserve. It also delivers other services such as frequency control, voltage regulation and reduces peak demand, demonstrating battery technology's capacity to provide grid support services, in addition to performing an energy storage function.<sup>79</sup>

<sup>75</sup> Carnegie Clean Energy, Mackerel Islands Stand Alone Power Station, 2018. Available at: www.carnegiece.com/project/mackerel-islands-stand-alone-power-station/. Accessed on 23 July 2018.

<sup>76</sup> Sandfire, *Solar Power Project*, nd. Available at: <u>www.sandfire.com.au/operations/degrussa/solar-power-project.html</u>. Accessed on 12 July 2018.

<sup>77</sup> Ibid.

<sup>78</sup> Mr Robert Klug, Chief Commercial Officer, Sandfire Resources, *Transcript of Evidence*, 16 May 2018, p2.

<sup>79</sup> Alinta Energy, Alinta Energy switches on big Pilbara battery, 12 April 2018. Available at: www.alintaenergy.com.au/about-us/news/alinta-energy-switches-on-big-pilbara-battery. Accessed on 11 December 2018.

The battery has a world-first capability to enter a 'grid forming' mode in an islanded system (where the system is rated in excess of 40MW) and power a 220kV high voltage power system (consisting of 120km of overhead transmission lines, high voltage substations and an iron ore mine) with up to 30MW of load, without support from any other generation source.<sup>80</sup>

#### Finding 4

Private sector entities have demonstrated significant capability and interest in the development of Microgrid and associated technologies.

#### 3.4 'Fringe-of-Grid' applications

Approximately 52% of Western Power's SWIS assets serve only 3% of its customer base. These customers are located in the outer spans of the SWIS in 'distributed' parts of the network, typically in regional, rural or peri-urban areas. Small communities, and often individual properties, are served by lengthy, 'skinny' radial lines that often experience power supply reliability and quality issues.<sup>81</sup>

As these assets age (or are destroyed by weather and other events), hard questions arise about the most efficient deployment of capital to ensure utility-grade power supply. Western Power has been trialling Microgrids and associated technologies as an alternative to traditional 'poles and wires' based supply solutions for these 'fringe-ofgrid' areas.

Western Power trialled its first Microgrid in Bremer Bay in 2005 and told the Committee it was developed to address "a forecast capacity constraint, where the Microgrid provided a more cost-effective solution than network reinforcement. The Bremer Bay Microgrid was also used to provide enhanced reliability over peak tourism (i.e. Easter and Christmas) periods."<sup>82</sup>

#### Ravensthorpe- Western Power's original stand-alone power systems trial

Western Power trialled six SPS in the Ravensthorpe region in 2009 to address regional reliability issues during periods of peak demand, with frequent outages being experienced. Power reliability was an ongoing concern for the towns of Ravensthorpe, Lake King, West Lake and Ongerup in the State's south as they were serviced by long

<sup>80</sup> Giles Parkinson, *Renew Economy*, 'The "other" big battery that has quietly changed thinking about the grid', 15 October 2018. Available at: <u>https://reneweconomy.com.au/the-other-bigbattery-that-has-quietly-changed-thinking-about-the-grid-15291/</u>. Accessed on 11 December 2018.

<sup>81</sup> Mr Seán McGoldrick, Executive Manager, Asset Management, Western Power, *Transcript of Evidence*, 11 April 2018, p3.

<sup>82</sup> Mr Guy Chalkley, CEO, Western Power, Answers to Questions on Notice, 4 May 2018.

stretches of power lines at the mercy of wind, rain, vegetation and lightning-caused fires.<sup>83</sup>

The batteries installed in the trial allowed enough storage to provide two days' supply of electricity, after which a diesel generator started.

After the first 12 months, the trial was rated a success by customers with:

- 92% of their electricity generated by solar panels;
- an average of 65 hours of power outages avoided; and
- high customer satisfaction with the new system.<sup>84</sup>

The Ravensthorpe SPS withstood a major storm in January 2017 and the SPS customers experienced better reliability than those connected to the 'traditional' network.<sup>85</sup>

The town of Ravensthorpe now has the ability to be switched off from the feeder line and operate as an islanded Microgrid, supplied by local diesel generation to avoid outages during peak demand periods. Additionally, with further enhancements, the Microgrid can provide improved reliability service to the town through automatic islanding and resynchronising to the grid.<sup>86</sup>

#### Kalbarri- Western Power's large Microgrid trial

Building on the success of the Ravensthorpe trials, in 2016 Western Power commenced a project to construct one of Australia's largest Microgrids with the aim of facilitating a more stable energy supply for the town of Kalbarri. Kalbarri has a population of about 1,600 people but its population is significantly boosted by tourists during holiday periods.<sup>87</sup>

Kalbarri is "on the end of an enormously long 140-kilometre distribution line" from Geraldton that is often impacted by storms.<sup>88</sup> The Microgrid will include a utility-scale battery as its centre-piece charged by a combination of network, wind and solar

<sup>83</sup> Western Power, *Innovative connections in Ravensthorpe improve reliability*, 2018. Available at: <u>https://westernpower.com.au/energy-solutions/projects-and-trials/stand-alone-power-system-trial-stage-1/</u>. Accessed on 12 July 2018.

<sup>84</sup> Ibid.

<sup>85</sup> Submission No. 26 from S&C Electric Company, 16 April 2018, p2.

<sup>86</sup> Submission No. 4 from Western Power, 10 April 2018, p5.

Australian Bureau of Statistics, 2016 Census QuickStats, 23 October 2017. Available at: http://quickstats.censusdata.abs.gov.au/census\_services/getproduct/census/2016/quickstat/SSC 50704. Accessed on 12 July 2018.

<sup>88</sup> Mr Guy Chalkley, CEO, Western Power, *Transcript of Evidence*, 11 April 2018, p5.

sources (see Figure 3.1). The project is expected to be completed by mid-2019.<sup>89</sup> The Committee was told by Western Power that:

Kalbarri is a particularly large Microgrid. If we can make that work, we can make any Microgrid work here in the West. There is a lot of international attention on it, there is a lot of international participation in the procurement as well...It is a very sophisticated Microgrid with renewable energy at the heart of it. It is real innovative stuff.<sup>90</sup>



Figure 3.1- Kalbarri Microgrid project<sup>91</sup>

Western Power's CEO confirmed that the Economic Regulation Authority approved the expenditure for the two-year trial as a 'reliability issue' for Kalbarri.<sup>92</sup> It had argued that reliability would be improved whilst the town was still connected to the SWIS, and:

If in two years' time we are saying that from a reliability perspective it has worked on its own and you have actually never used that line, then you have to question, as I say, when you are running parallel legislation, "Do you really need that line?" But at the moment it is still there.<sup>93</sup>

<sup>89</sup> Submission No. 4 from Western Power, 10 April 2018, p4.

<sup>90</sup> Mr Seán McGoldrick, Executive Manager, Asset Management, Western Power, *Transcript of Evidence*, 11 April 2018, p11.

<sup>91</sup> Western Power, *Kalbarri microgrid*, 2019. Available at: <u>https://westernpower.com.au/energy-solutions/projects-and-trials/kalbarri-microgrid/</u>. Accessed on 9 April 2019.

<sup>92</sup> Mr Guy Chalkley, CEO, Western Power, *Transcript of Evidence*, 11 April 2018, p10.

<sup>93</sup> Ibid.

The Kalbarri trial is being undertaken by Western Power in partnership with Lendlease and Energy Made Clean, demonstrating that the roll-out of these technologies can be undertaken by Government Trading Enterprises working with private sector companies.

#### Kalgoorlie- Virtual power plant

The State Government announced in May 2018 that it will commit \$500,000 to develop a proposal for a virtual power plant trial (VPP) in Kalgoorlie-Boulder.<sup>94</sup>

The project comprises a distributed solar and battery system centrally controlled by a software platform. The rooftop PV and battery assets will be installed at a household-scale, but will present to the power system operator and network operator as a dispatchable unit. Department of Primary Industries and Regional Development (DPIRD) states that the software "enables an operator to control the collective energy from the batteries as if it were from a single generator."<sup>95</sup>

Central control distinguishes this project from 'normal' household PV and battery assets which operate autonomously behind the meter, independent of any form of central orchestration by a network or system operator. Installing the panels on rooftops is a potential alternative to the construction of a 'normal' large-scale solar farm on a large plot of land.

A Preliminary Assessment has been completed and DPIRD will now collaborate with Western Power to develop a proposal for a VPP trial. The DPIRD will also make land available for future large-scale solar projects and support private sector companies pursuing 'behind the meter' solar projects.<sup>96</sup>

This project will include public housing to assist in reducing electricity bills for socioeconomically disadvantaged residents.

#### Perenjori- Community-scale battery back-up

Western Power, in conjunction with private company Balance Utility Solutions, has installed a 1MWh network battery storage system on its network just outside of Perenjori (350km north of Perth), to provide a back-up power supply.

<sup>94</sup> Zach Relph, *Kalgoorlie Miner*, 'Virtual power plant trial for Kalgoorlie-Boulder', 31 May 2018. Available at: <u>https://thewest.com.au/news/kalgoorlie-miner/virtual-power-plant-trial-for-kalgoorlie-boulder-ng-b88852368z</u>. Accessed on 17 December 2018.

<sup>95</sup> Department of Primary Industries and Regional Development, Goldfields Solar Energy Project-Frequently Asked Questions, nd, p2. Available at: www.drd.wa.gov.au/Publications/Documents/Goldfields%20Solar%20Energy%20Project%20FAQ s.pdf. Accessed on 17 December 2018.

<sup>96</sup> Ibid.

Perenjori is located at the end of a lengthy stretch of transmission line exposed to a range of environmental factors. The community has experienced a range of power quality and reliability issues.

Since installation in August 2018, the battery has already improved supply reliability to address faults on the main electricity network, and eliminated up to 80% of outages. Perenjori customers can opt-in to receive SMS notifications when a fault on the line has triggered the network battery to start working; the network battery is running low and a power outage is likely; and the fault has been fixed and power has been restored on the main line.<sup>97</sup>

The installation of this asset demonstrates the application of grid-scale (as opposed to household-scale) battery technology and its capacity to provide backup power. It is expected that rooftop solar PVs and battery storage will be included later as part of the trial.<sup>98</sup>

#### Western Power- Stand-alone power systems Stage Two trials

Given the success of the original Ravensthorpe pilot of six SPS units, Western Power moved in 2018 to Stage Two of its project, which will see a further 58 SPS units installed in regional areas across the SWIS (see Figure 3.2). These locations are serviced by around 260km of power lines, and poles which need to be replaced at a significant cost within the next two years.<sup>99</sup>

The locations for the new trials were chosen not only because they are located at the fringes of the grid, but also on account of the age of the assets and their performance.<sup>100</sup> The geography and the demographics of the location were also a key factor. Western Power has selected participants from a range of areas with varied energy consumption backgrounds. It has partnered with WA-based renewable energy companies Hybrid Systems Pty Ltd and BayWA r.e. Solar Systems Pty Ltd to deliver 56 of the SPS units, and with Victorian company Optimal Group to install a specialist solution for a Water Corporation site.<sup>101</sup>

<sup>97</sup> Western Power, Perenjori: From blackout town to energy innovation crown, 2019. Available at: <u>https://westernpower.com.au/energy-solutions/projects-and-trials/perenjori-network-battery/</u>. Accessed on 14 February 2019.

<sup>98</sup> Submission No. 19 from Australian Energy Market Operator, 13 April 2018, p13.

<sup>99</sup> Western Power, Creating the rural network of the future, November 2018, p2. Available at: <u>https://westernpower.com.au/media/3061/stand-alone-power-systems-demonstration-project.pdf.</u> Accessed on 10 December 2018.

<sup>100</sup> Mr Seán McGoldrick, Executive Manager, Asset Management, Western Power, *Transcript of Evidence*, 23 November 2018, p4.

<sup>101</sup> Western Power, Extending a proven solution to more customers, 2019. Available at: <u>https://westernpower.com.au/energy-solutions/projects-and-trials/stand-alone-power-systems-round-1/</u>. Accessed on 14 February 2019.

Western Power said that the new SPS units would give the customers "a reliability factor that is as good as metro; that is a fantastic proposition to give somebody."<sup>102</sup> The trial will last for three years, and (assuming its success), residents can register with Western Power to participate in later stages of the project.



# Figure 3.2- Proposed locations of Western Power's Stage Two stand-alone power systems trials<sup>103</sup>

#### Finding 5

Government Trading Enterprises have successfully partnered with a range of private sector entities to trial Microgrid and distributed energy resource solutions in 'fringe-of-grid' areas and isolated networks.

<sup>102</sup> Mr Guy Chalkley, CEO, Western Power, *Transcript of Evidence*, 23 November 2018, p3.

<sup>103</sup> Western Power, Creating the rural network of the future, November 2018, p2. Available at: https://westernpower.com.au/media/3061/stand-alone-power-systems-demonstrationproject.pdf. Accessed on 10 December 2018.

#### 3.5 Metropolitan projects

While Microgrids and DER clearly offer benefits to regional customers, there are also a number of Microgrid projects underway in metropolitan Perth testing and demonstrating the benefits in the 'meshed' parts of the SWIS.

Metropolitan applications can deliver discreet individual consumer benefits and also provide system-wide operational benefits, to the benefit of all users.

#### Mandurah- Western Power's PowerBank community battery

Grid-scale battery technologies have the potential to offer system benefits and also provide households with access to energy storage where they may otherwise struggle to afford individual household-scale batteries.

Western Power has partnered with Synergy and the City of Mandurah to trial 'PowerBank', Australia's first integrated large battery storage system into the existing grid at Meadow Springs.

One in four homes in Mandurah have solar panels installed – the postcode is Australia's second highest solar region. Such high PV capacity concentrations lead to high local electricity production during daylight hours.

Much of the electricity produced by rooftop PV is either consumed at the premises (making that building's demand effectively 'disappear' from the network) or exported onto the grid, forcing other traditional generators on the system to reduce production, to balance out PV production.

As PV generation declines at sun down, a major supply source is removed and household demand from the grid 'reappears' on the network. Demand also typically increases at these times of day as people return home from work and utilise appliances such as air conditioners. Alternative generation sources are then required to quickly ramp-up to maintain supply.

Power system operators have produced demand curves showing the significant changes in demand and supply over such short periods of time. On account of the shape of the curve (with a belly and a head), the phrase 'duck curve' has been coined to describe the effect. Figure 3.3 below from Western Power shows the interplay between average customer demand (termed 'Export Consumption') against solar PV generation (termed 'Import Consumption') on the SWIS.

In the Mandurah trial, the 105kW (420kWh) Tesla battery allows 52 households to each store up to 8kWh of excess solar energy from their own PV panels, at a cost of \$1 per

day. They can then draw down on this energy at night time. The battery will also support the region's grid during periods of peak demand.<sup>104</sup>

The decision to proceed with the trial of the PowerBank was made in 2013 as an alternative to providing an expensive new substation for the region's expanding population. It is also aimed at trialling whether individuals will defer or avoid the more expensive purchase of their own individual batteries, in favour of a simple, more cost-effective, grid-scale asset.<sup>105</sup>



#### Figure 3.3- SWIS 'duck curve'106

Grid-scale batteries can be deployed by the central network and system operators, presenting to the grid as dispatchable, controllable assets. They can provide a range of network support services, assisting the system and network operators to maintain power quality and electricity supply, and also defer capital expenditure on traditional network asset upgrades at distinct locations in the SWIS.

The Mandurah Battery Trial proved incredibly popular with consumers and commenced three months ahead of schedule, following the full subscription to the 52 participants in less than two weeks.<sup>107</sup>

#### **Bentley- Curtin University's Energy Park**

The Green Electricity Energy Park has been operating at Curtin University's Bentley campus for the past five years. This has allowed the University to gain a valuable understanding of Microgrids operating in various configurations. The University's

105 Mr Guy Chalkley, CEO, Western Power, *Transcript of Evidence*, 23 November 2018, p5.

<sup>104</sup> Western Power, *PowerBank community battery*, 2018. Available at: <u>https://westernpower.com.au/energy-solutions/projects-and-trials/powerbank-community-battery-storage/</u>. Accessed on 11 December 2018.

<sup>106</sup> Western Power, The duck effect, 2019. Available at: <u>https://westernpower.com.au/community/news-opinion/the-duck-effect/</u>. Accessed on 5 April 2019.

<sup>107</sup> Hon Ben Wyatt MLA, Minister for Energy, *Media Statement*, 'PowerBank trial goes live three months early after families snap up spots', 5 November 2018. Available at: www.mediastatements.wa.gov.au/Pages/McGowan/2018/11/PowerBank-trial-goes-live-three-months-early-after-families-snap-up-spots.aspx. Accessed on 14 February 2019.

laboratory features state of the art technology in renewable-based electric power generation, including solar PV arrays, wind turbines, micro-hydro turbines and fuel cell stacks.<sup>108</sup>

#### Vasse- ATCO's unique trial with gas and distributed energy resources integration

Significant synergies exist where electricity network constraints occur alongside underutilised gas pipeline networks. Localised gas-network connected generation can meet an area's power supply needs and defer the augmentation or installation of additional electricity network capacity.

Since June 2016, ATCO Australia has been trialling the integration and optimisation of the gas and electricity networks at the residential level in Vasse in the South West. The GasSola trial has successfully demonstrated a residential Hybrid Energy System involving natural gas fired power generation paired with 3 and 5kW solar panels and 9.6kWh of battery storage in 9 houses.<sup>109</sup>

The trial was amongst the first of its kind in Australia and tests whether a natural gas powered generator, in combination with solar and battery technologies, can act as the peak hours' back-up system to an off-grid electrical solution, or provide peaking generation/ancillary services to the electrical grid and address power intermittency issues.<sup>110</sup>

#### Two Rocks- Off-grid school

Atlantis Beach Baptist College in Two Rocks is the first school in Australia to be off-grid and fully powered by rooftop solar and battery storage. It sources all of its power through 20kW of rooftop PV and 30kWh of battery storage. The system was installed by Sydney-based company Upstream Energy and the College purchases its power from them at a fixed cost, which is substantially lower than being connected to the grid.<sup>111</sup>

#### 3.6 Innovations in energy retailing and consumer relationships

Microgrids and DER present the market with an opportunity to reconsider the way energy is retailed, and innovative commercial structures are evolving that do not necessarily involve Synergy (the State-owned energy retailer) holding a direct relationship with the consumer.

<sup>108</sup> Mr Jason Waters, CEO, Synergy, Transcript of Evidence, 9 May 2018, p7.

<sup>109</sup> Submission No. 13 from ATCO Australia, 13 April 2018, p8.

<sup>110</sup> Ibid.

<sup>111</sup> Sophie Vorrath, *One Step Off the Grid*, 'Off-grid school Australia's first to run 100% on solar, battery storage', 26 October 2018. Available at: <u>https://onestepoffthegrid.com.au/off-grid-school-australias-first-run-100-solar-battery-storage/</u>. Accessed on 11 December 2018.

#### **Dunsborough- Virtual power plant**

The Dunsborough Community Energy Project (DCEP) is Australia's first privately-funded VPP proposal. It aims to be a community built, owned and managed facility with the goal of reducing the town's household energy costs and moving toward a 90% renewable energy target. The VPP will consist of the solar panels on 1,000 households and Redback inverter/battery systems. Houses will be connected by advanced aggregation and control software developed in Australia.<sup>112</sup>

The VPP will provide 6.5MW of solar power at peak output and 9.6GWh of energy a year. The project costs of \$12.5 million will be provided by investment company SUSI with VPP participants paying \$36 per week over 10 years for their home systems. At the end of this period the assets are fully owned by DCEP, who will then substantially reduce the lease payments.<sup>113</sup> One hundred households have signed up to the project, enabling the formation of the not for profit entity DCEP. Detail is yet to be made public concerning how the project would operate analogously to a traditional power plant and its commercial and operational relationships with the electricity market, network and system operators.

#### Geraldton- Mixed-generation energy hub

Residents in Geraldton have also been active in forming a locally-based energy cooperative.

Tersum Energy had been planning for five years on installing a 35MW gas-fired power station on a 200 hectare site at Narngulu, an outer suburb of Geraldton. Tersum had identified an opportunity to defer significant transmission system upgrades through providing a local generation alternative.

Having taken a more considered look at DER, Tersum now proposes to install a large battery and a predominately solar mixed-energy park with approximately 10MW of gas. This VPP project will cost approximately \$60 million and provide 100 jobs.<sup>114</sup> Tersum is also investigating the use of renewable energy to create hydrogen and the use of fuel cell technology.

Tersum has been in discussions with Western Power regarding access to connect its project to the grid. Tersum believes that their development will allow Western Power

<sup>112</sup> Dunsborough Community Energy Project, 'About us'. Available at: www.dunsboroughcommunityenergyproject.com.au/. Accessed on 11 December 2018.

<sup>113</sup> Sophie Vorrath, One Step Off the Grid, 'WA VPP project promises 90% solar self-consumption for cost of "a coffee a day"', 15 October 2018. Available at: <u>https://onestepoffthegrid.com.au/waprivate-vpp-promises-90-solar-self-consumption-cost-coffee-day/</u>. Accessed on 11 December 2018.

<sup>114</sup> Mr Rod Littlejohn, Managing Director, Tersum Energy, *Transcript of Evidence*, 17 October 2018, pp2, 6, 11.

to defer approximately \$150-400 million in replacing Mid West power lines between Geraldton to Three Springs that are nearing their end of their life.<sup>115</sup>

Tersum has been working with the local community to develop Geraldton Community Energy (GCE), a community-owned retailer. Similar to DCEP, GCE hopes to establish a VPP in Geraldton that would include residential rooftop solar and batteries. Tersum's plans would complement the VPP and would not preclude GCE from utilising other generators or energy retailers.<sup>116</sup>

GCE's Board consists of members of the local community and the Gascoyne Development Commission. GCE was formed to promote economic growth in the Mid West and profits from the VPP will be fed back into the community.<sup>117</sup>

#### Peel- Landcorp Business Park Microgrid

In October 2018, the State Government announced the release of the first land for the Peel Business Park – an industrial and agri-business precinct being developed by Landcorp 70km south of Perth<sup>118</sup>. The business park will be powered by one of the State's largest industrial renewable Microgrids, supplied by a consortium formed between Synergy, Enwave Australia and Sunrise Energy Group. The 1MW facility will be capable of operating independent of the grid. Construction is anticipated for late 2019, with operation in 2020.<sup>119</sup>

#### Alkimos Beach- Synergy's new energy retail model

Different energy retail models are currently being trialled by Synergy at a newly established residential development at Alkimos Beach, north of Perth. Three new energy retail models have been developed and a community-scale 250kW battery and high penetration of rooftop solar PV have been deployed. The advantages of this model is that it not reliant upon individual households having their own battery. At least

<sup>115</sup> Mr Rod Littlejohn, Managing Director, Tersum Energy, *Transcript of Evidence*, 17 October 2018, p3.

<sup>116</sup> Miss Erin Stone, Energy Economist, Tersum Energy, Transcript of Evidence, 17 October 2018, p4.

<sup>117</sup> Mr Murray Hadley, Chair, Steering Committee, Geraldton Community Energy, *Transcript of Evidence*, 17 October 2018, pp1–2.

<sup>118</sup> Hon Rita Saffioti MLA, Minister for Planning, *Media Statement*, 'First land released within Peel region's future employment hub', 31 October 2018. Available at: www.mediastatements.wa.gov.au/Pages/McGowan/2018/10/First-land-released-within-Peel-regions-future-employment-hub-.aspx. Accessed on 14 February 2019.

<sup>119</sup> Caitlyn Rintoul, Mandurah Mail, 'Consortium appointed to fill Peel Business Park's renewable energy needs', 5 February 2019. Available at: www.mandurahmail.com.au/story/5889215/consortium-appointed-to-fill-peel-business-parksrenewable-energy-needs/. Accessed on Accessed on 14 February 2019.

100 homes will be included in the trial, which has received half of its \$7 million funds from ARENA.<sup>120</sup>

Synergy's CEO said that the approach at Alkimos is particularly important for people renting their homes who may not be in a position to directly fund a battery to lower their energy costs.<sup>121</sup> He went on to say that:

...if the incentives are right and if the collaboration is right, ... I can envisage a world where there is more greatly optimised potential between the distribution or the grid operation and the household basis of the installation of community-based facilities, as opposed to the behind-the-meter household-based facilities.<sup>122</sup>

#### Fremantle- Block-chain technology trial

The City of Fremantle, in partnership with Curtin University and LandCorp, has developed the Knutsford Precinct in a new 11 hectares housing redevelopment district. This is considerably larger than the White Gum Valley project (described below).

The Precinct contains a Western Power substation, allowing for different types of energy trials. The focus will be on low-cost, low-carbon energy solutions, and an integrated sustainability plan for energy, water and waste.<sup>123</sup>

#### What is blockchain technology?

A system to record transactions across several computers where electronic trading occurs in a peer-to-peer network using a cryptocurrency such as bitcoin. The records (or blocks) are linked by secure communication techniques based on cryptography, which ensures that it is currently infeasible to hack a blockchain.

The RENeW Nexus project received \$2.57 million in funding from the Australian Government to allow Power Ledger to use its innovative block-chain technology for approximately 40 residents to trade energy and water. The site will also integrate electric car charging.<sup>124</sup>

<sup>120</sup> Australian Renewable Energy Agency, *Solar and Storage Trial at Alkimos Beach Residential Development*. Available at: <u>https://arena.gov.au/projects/solar-and-storage-trial-at-alkimos-beach-residential-development/</u>. Accessed on 11 July 2018.

<sup>121</sup> Mr Jason Waters, CEO, Synergy, Transcript of Evidence, 9 May 2018, p6.

<sup>122</sup> Ibid, pp6–7.

<sup>123</sup> Submission No. 28 from Curtin University, 18 April 2018, p6.

<sup>124</sup> Power Ledger, Australian Government Awards Grant to \$8 Million Project In The City Of Fremantle Using The Power Ledger Platform, 16 November 2018. Available at: <u>https://medium.com/power-ledger/australian-government-awards-grant-to-8-million-project-in-the-city-of-fremantle-using-the-power-2dbadfad50ae</u>. Accessed on 12 July 2018.

The trial commenced on 5 December 2018 and will run until June 2019.<sup>125</sup>

Power Ledger stated that both Western Power and Synergy have been involved with the project since its commencement and are:

...really supportive of the concept of peer-to-peer trading in the way that we are proposing it and really interested to find out how, from their perspective, they can incentivise consumers to stay connected [to the grid].<sup>126</sup>

Power Ledger had not settled on its final fee arrangement but stated that it might consist of a monthly fixed-fee to stay connected to the grid, plus the net value of their energy trading, based on the value of the energy.<sup>127</sup> A schematic of the project is shown in Figure 3.3.





127 Ibid.

<sup>125</sup> Hon Ben Wyatt MLA, Minister for Energy, *Media Statement*, 'New trial enables customers to buy and sell solar energy', 5 December 2018. Available at: <u>www.mediastatements.wa.gov.au/Pages/McGowan/2018/12/New-trial-enables-customers-tobuy-and-sell-solar-energy.aspx</u>. Accessed on 17 December 2018.

<sup>126</sup> Mr David Martin, Managing Director, Power Ledger, *Transcript of Evidence*, 17 October 2018, p12.

<sup>128</sup> Energy Matters, 'Fremantle solar/renewable energy and blockchain project gets \$8 million grant', 20 November 2017. Available at: <u>https://www.energymatters.com.au/renewablenews/fremantle-solar-renewable-energy-blockchain/</u>. Accessed on 17 December 2018.

#### **Busselton- Power Ledger peer-to-peer trading trial**

Power Ledger undertook a 6 month trial of its block chain peer-to-peer energy trading software at the National Lifestyle Village in Busselton in 2016-17. The trial involved 15 houses in the village and was classed as a "resounding success".<sup>129</sup>

#### Perth- Embedded network for apartments

Source Energy Co (owned by ATCO Australia) purchases electricity from the retail market and blends it with energy generated by solar panels it installs in apartment buildings. Energy is delivered and sold to each apartment via an 'Embedded Network'. Each building has a gate meter and individual tenants have their own smart meters that allow them to track how much power they're using and how much it's costing.<sup>130</sup>

Electricity is provided at a lower cost to residents due to the purchase of wholesale energy and the use of solar panels and batteries. Each building presents to Western Power as one connection point. Source Energy currently has embedded networks in six apartment buildings housing approximately 400 tenants.<sup>131</sup>

#### White Gum Valley- Neighbours trading power

In 2015, Curtin University in partnership with LandCorp, Western Power, the Cooperative Research Centre for Low Carbon Living Ltd, City of Fremantle and Balance Utility Solutions commenced a research project to develop governance models to allow the sharing of power from solar PV panels, the use of battery storage and monitoring systems to be utilised in medium density apartments located in White Gum Valley (near Fremantle). The Microgrid incorporates behind-the-meter software that allows residents to trade excess solar energy between themselves, and importing or exporting it to the SWIS.<sup>132</sup>

This method of sharing electricity is referred to as 'peer to peer trading'. Mr Aden Barker, from the Public Utilities Office told the Committee:

Shared PV and battery capacity is managed through peer-to-peer trading, so effectively, you get the share of the battery's output. If somebody else is using your share because you are not home, you will

<sup>129</sup> Taelor Pelusey, *Busselton Dunsborough Times*, 'Trial attracts international attention', 17 March 2017. Available at: <u>https://thewest.com.au/news/regional/trial-attracts-international-attention-ng-b88414054z</u>. Accessed on 17 December 2018.

<sup>130</sup> Source Energy Co, *How it works*, 2016. Available at: <u>http://sourceenergyco.com.au/how-it-works/</u>. Accessed on 21 December 2018.

<sup>131</sup> Mr Steve Lewis, General Manager, Business Development, ATCO Australia, *Transcript of Evidence*, 10 October 2018, p11.

<sup>132</sup> Submission No. 28 from Curtin University, 18 April 2018, p6.

get paid for that by the peer-to-peer trading system. We are talking about 80 dwellings.<sup>133</sup>

A unique aspect of this trial is that the solar panels and the battery sit on common areas of the strata and are owner-managed. This provides apartment owners with an additional revenue stream. Tenants will pay their electricity fees to the strata. It is predicted that this process will provide approximately 70% of the energy requirements for trial participants<sup>134</sup> and will cut their energy and water bills by about \$1,200 per year.<sup>135</sup>

This chapter has outlined some of the exciting Microgrid and DER projects already completed or underway in WA. They have the potential to be an important component of the State's future energy economy and offer opportunities for both private and public enterprises.

#### Finding 6

A number of innovative stand-alone power systems, distributed energy resources and Microgrid trials are currently operating in Western Australia, particularly in regional and remote areas of the State. Notably, many of them demonstrate that power can be provided to consumers in a more cost-effective and reliable manner than via their traditional supply arrangements.

<sup>133</sup> Mr Aden Barker, Acting Director, Retail and Consumer Policy, Public Utilities Office, Department of Treasury, *Transcript of Evidence*, 14 February 2018, p13.

<sup>134</sup> Submission No. 19 from Australian Energy Market Operator, 13 April 2018, p13.

<sup>135</sup> ABC News, Green energy for White Gum Valley development 'an Australian first', to benefit residents and investors, 17 June 2015. Available at: <a href="http://www.abc.net.au/news/2015-06-17/green-energy-for-new-white-gum-valley-residents/6553896">www.abc.net.au/news/2015-06-17/green-energy-for-new-white-gum-valley-residents/6553896</a>. Accessed on 12 July 2018.

# Economic Opportunities for WA Associated with the Development of DER Technologies

Countries around the world, international business and technological innovation are not waiting for WA to take advantage of the New Energy opportunity. Globally, there is intense competition to secure supply chains and dominate the New Energy metals markets.<sup>136</sup>

#### 4.1 Introduction

The rising demand for Microgrids and associated technologies – both in Western Australia (WA) and around the world – will provide the impetus for a range of broader economic and industrial initiatives, which is especially important for workers who may be displaced from jobs associated with the traditional energy industry model.

Opportunity exists right along the energy value chain – from raw materials production, minerals processing, chemical production and component manufacturing, battery assembly, technology development, Microgrid infrastructure rollout and ongoing operations and maintenance.

This chapter identifies opportunities in the minerals, resources, processing and manufacturing industries and highlights the benefits they could provide to the WA economy.

#### 4.2 Battery technology

Battery technology is key to the success of Microgrids. Batteries are also a key component in electric vehicles (EVs), and the role of EVs is explored in the next chapter. Rising global demand for batteries will have obvious repercussions for the commodities required for battery production.

While all of the current Microgrids in WA use lithium-ion batteries, there are alternate forms of battery storage available. VSUN Energy described to the Committee their efforts to develop vanadium redox flow batteries (VRFB). It claims that VRFB batteries

<sup>136</sup> Regional Development Australia (Perth), *Lithium Valley: Establishing the Case for Energy Metals and Battery Manufacturing in Western Australia*, 13 July 2018, p18. Available at: <u>www.rdaperth.org/rda-projects/lithium-valley/</u>. Accessed on 26 July 2018.



#### Figure 4.1- Lithium-ion battery value chain

are particularly useful in locations such as WA due to their ability to cope with high temperatures and the fact that they are nonflammable.<sup>137</sup>

In 1996, the then-State Government announced the commissioning of a zincbromine battery which had been developed in WA. The battery was installed at ZBB Australia Ltd's laboratory at Murdoch University, where the first research on this type of battery had occurred in 1979.<sup>138</sup>

Research has begun into using sodium-ion in rechargeable batteries as it is inexpensive and is found in seawater. The Australian Renewable Energy Agency has provided \$2.7 million in funding for a trial by Sydney Water, where the sodium-ion batteries will replace the existing lithium-ion ones.<sup>139</sup>

<sup>137</sup> Submission No. 2 from VSUN Energy, 6 April 2018, p1.

<sup>138</sup> Hon Hendy Cowan MLA, Minister for Commerce and Trade, *Official commissioning of revolutionary new zinc bromine battery*, 30 January 1996. Available at: <u>www.mediastatements.wa.gov.au/Pages/Court/1996/01/Official-commissioning-of-</u> <u>revolutionary-new-zinc-bromine-battery.aspx</u>. Accessed on 25 July 2018.

<sup>139</sup> ARENA, Sodium-ion battery pilot in Bondi could change the way we store energy, 26 October 2018. Available at: <u>https://arena.gov.au/news/sodium-ion-battery-pilot-in-bondi-could-change-the-way-we-store-energy/</u>. Accessed on 10 December 2018.

Currently, lithium-ion appears to be the world's preferred battery technology. Professor Peter Newman from Curtin University stated:

We know the winner now. Lithium-ion batteries have won. They are so significantly cheaper and easier to put in place. They are light. They are being adopted by everyone.<sup>140</sup>

The Association of Mining and Exploration Companies (AMEC) also acknowledged the primacy of lithium-ion technology:

Certainly there are other potential competitors to lithium-ion batteries but they are not as advanced... we do not think there is likely to be a substantive competitor in that space for 15-20 years.<sup>141</sup>

Lithium-ion battery production presents opportunities along a multi-step value chain and across a range of commodities and processes, as shown in Figure 4.1.<sup>142</sup>

#### 4.3 Rapid development of WA's lithium industry

Over the past four years there has been a significant focus from the State Government and the State's resource sector on lithium exports, with many suggesting that the State is well positioned to create a 'lithium valley'.<sup>143</sup>

Australian exports, primarily from WA, now provide approximately 60% of the world's lithium output (see Figure 4.2).<sup>144</sup> The price paid per tonne in that time has jumped by a Figure 4.2- Australia's market share of lithium output (%) – 2000-20



<sup>140</sup> Professor Peter Newman, Professor of Sustainability, Curtin University, *Transcript of Evidence*, 18 June 2018, p5.

<sup>141</sup> Mr Warren Pearce, Chief Executive Officer (CEO), Association of Mining and Exploration Companies, *Transcript of Evidence*, 16 May 2018, p5.

<sup>142</sup> Government of Western Australia, *Future Battery Industry Strategy*, 31 January 2019, p5. Available at: <u>https://www.jtsi.wa.gov.au/docs/default-source/default-document-library/future-battery-industry-strategy-wa-0119.pdf?sfvrsn=ccc7731c\_4</u>. Accessed on 14 February 2019.

<sup>143</sup> Noel Dyson, *Mining Monthly*, 'Creating Lithium Valley in WA', 23 March 2018. Available at: <u>www.miningmonthly.com/operational-excellence/news/1335704/creating-lithium-valley-in-wa</u>. Accessed on 21 June 2018.

<sup>144</sup> Peter Ker, *Australian Financial Review*, 'Lithium superpower: How Australia's penny-dreadfuls stole a march on the world', 15 June 2018. Available at: <u>www.afr.com/business/mining/how-australias-pennydreadfuls-stole-a-march-on-the-lithium-world-20180606-h112ka</u>. Accessed on 25 July 2018.

factor of four and there has been an increase in the number of employees in WA to over 2,600 in just three years (see Figure 4.3).





Figure 4.4- Largest sources of demand for lithium-ion batteries – 1995-2018<sup>146</sup>



Much of the recent increase in demand has been driven by Chinese companies manufacturing lithium-ion batteries for the storage of solar energy and to power EVs (see Figure 4.4). Lithium's great advantage as a battery component is that it is the thirdlightest element and is the metal with the highest energy density by weight. A lithium-

<sup>145</sup> Peter Ker, *Australian Financial Review*, 'Lithium superpower: How Australia's penny-dreadfuls stole a march on the world', 15 June 2018. Available at: <u>www.afr.com/business/mining/how-</u> <u>australias-pennydreadfuls-stole-a-march-on-the-lithium-world-20180606-h112ka</u>. Accessed on 25 July 2018.

<sup>146</sup> PowerOre, Energy Revolution, 2018. Available at: <u>www.powerore.com/energy-revolution/</u>. Accessed on 25 July 2018.

ion battery can generate approximately 3 volts per cell, compared with 2.1 volts for lead-acid and 1.5 volts for a zinc-carbon battery.<sup>147</sup>

The current world market for lithium remains small, at about 40,000 tonnes, with WA supplying about 24,300 tonnes in 2017. These exports were valued at \$780 million and the industry employed more than 2,600 workers. WA's original lithium mine is at Greenbushes south of Perth and is the world's largest producer of lithium.<sup>148</sup>

The State's seventh mine opened at Pilgangoora near Port Hedland in September 2018 and employs 130 workers.<sup>149</sup> As shown in Figure 4.5, Australia's current known resources amount to around 11% of the world's reserves, with 67% held in Chile and Argentina.





<sup>147</sup> Wikipedia, *Lithium*, 22 July 2018. Available at: <u>https://en.wikipedia.org/wiki/Lithium</u>. Accessed on 25 July 2018.

<sup>148</sup> Sean Smith, *The West Australian*, 'Tiny WA town of Greenbushes is ground zero for global lithium energy revolution', 3 September 2018. Available at: <a href="https://thewest.com.au/business/mining/tiny-wa-town-of-greenbushes-is-ground-zero-for-business/mining/tiny-wa-town-of-greenbushes-is-ground-zero-for-business/mining/tiny-wa-town-of-greenbushes-is-ground-zero-for-business/mining/tiny-wa-town-of-greenbushes-is-ground-zero-for-business/mining/tiny-wa-town-of-greenbushes-is-ground-zero-for-business/mining/tiny-wa-town-of-greenbushes-is-ground-zero-for-business/mining/tiny-wa-town-of-greenbushes-is-ground-zero-for-business/mining/tiny-wa-town-of-greenbushes-is-ground-zero-for-business/wining/tiny-wa-town-of-greenbushes-is-ground-zero-for-business/wining/tiny-wa-town-of-greenbushes-is-ground-zero-for-business/wining/tiny-wa-town-of-greenbushes-is-ground-zero-for-business/wining/tiny-wa-town-of-greenbushes-is-ground-zero-for-business/wining/tiny-wa-town-of-greenbushes-is-ground-zero-for-business/wining/tiny-wa-town-of-greenbushes-is-ground-zero-for-business/wining/tiny-wa-town-of-greenbushes-is-ground-zero-for-business/wining/tiny-wa-town-of-greenbushes-is-ground-zero-for-business/wining/tiny-wa-town-of-greenbushes-is-ground-zero-for-business/wining/tiny-wa-town-of-greenbushes-is-ground-zero-for-business/wining/tiny-wa-town-of-greenbushes-is-ground-zero-for-business/wining/tiny-wa-town-of-greenbushes-is-ground-zero-for-business/wining/tiny-wa-town-of-greenbushes-is-ground-zero-for-business/wining/tiny-wa-town-of-greenbushes-is-ground-zero-for-business/wining/tiny-wa-town-of-greenbushes-is-ground-zero-for-business/wining/tiny-wa-town-of-greenbushes-is-gree

global-lithium-energy-revolution-ng-b88932998z. Accessed on 10 December 2018.
149 Hamish Hastie, WAToday, 'WA's newest lithium mine plans to double down', 5 September 2018. Available at: www.watoday.com.au/business/companies/wa-s-newest-lithium-mine-plans-to-double-down-20180905-p501v3.html. Accessed on 10 December 2018.

<sup>150</sup> Laura Lombrana and Jonathan Gilbert, *Bloomberg*, 'It's Hard to Keep Up With All That Lithium Demand', 22 August 2017. Available at: <u>www.bloomberg.com/news/articles/2017-08-</u>21/supplying-lithium-gets-trickier-as-electric-revolution-guickens. Accessed on 25 July 2018.

WA's great advantage, and the reason it has established itself as a major lithium producer so quickly, is that it has deposits of hard-rock lithium as opposed to the brine-sourced lithium extracted by evaporation in the Latin America countries of Chile, Argentina, and Bolivia. WA's lithium is mined using technology similar to that deployed for other commodities by a large, skilled, and efficient mining industry.<sup>151</sup>

WA's reserves provide certainty of supply at a very high quality over a known period of time, whereas brine-sourced lithium is subject to weather conditions. The Department of Jobs, Tourism, Science and Innovation (JTSI) said that "[i]f you get heavy rain and heavy fresh water encroachment into the brine fields, you need more processing to" produce lithium.<sup>152</sup> Bad weather and equipment problems in 2017 meant production at the Olaroz facility in northern Argentina was 21% below the company's initial target.<sup>153</sup>

The Latin American countries have also placed caveats on lithium exports, as they see them as a strategic mineral. Chile has imposed processing requirements on companies wishing to develop lithium projects. Additionally, would-be Chilean producers need authorization from the Nuclear Energy Commission and operating conditions are set directly by the government on a case-by-case basis. One company estimates it could take up to 7 years to set up a new operation in Chile, while "most lithium projects in Argentina fail because they can't close financing."<sup>154</sup>

#### Finding 7

Western Australia has a distinct global competitive advantage in lithium production on account of its hard rock reserves, mature mining industry and stable political environment.

#### Other mineral inputs to batteries

WA has another significant advantage in that many of the other primary commodities required for lithium-ion battery production are also available here:

If you stack up all the materials ... it is not just lithium, but also copper, cobalt, nickel and graphite – they are all available in Australia. If you coordinated Africa into a single economic unit and a single governance unit and tied all the African countries together, Africa would probably be superior to Australia but it is not. In a single jurisdiction, there is no

<sup>151</sup> Future Smart Strategies, A lithium industry in Australia, February 2018, p3. Available at: <u>www.amec.org.au/Public/Advocacy/AMEC Submissions/A lithium Industry in Australia.aspx</u>. Accessed on 25 July 2018.

<sup>152</sup> Mr Joe Ostojich, Deputy Director General, Department of Jobs, Tourism, Science and Innovation (JTSI), *Transcript of Evidence*, 16 May 2018, pp2–3.

<sup>153</sup> Laura Lombrana and Jonathan Gilbert, *Bloomberg*, 'It's Hard to Keep Up With All That Lithium Demand', 22 August 2017. Available at: <u>www.bloomberg.com/news/articles/2017-08-21/supplying-lithium-gets-trickier-as-electric-revolution-quickens</u>. Accessed on 25 July 2018.

<sup>154</sup> Ibid.

other jurisdiction on the planet that has all the resources that we have."<sup>155</sup>

AMEC also noted that, much as the battery opportunity was heavily focussed on lithium mining and processing, a range of other commodities produced here in WA were also seeing an upturn in demand:

I think lithium's the headline mineral, but over 12 or 25 other minerals have all seen commodity price increases, greater demand rising, whether it be graphite, nickel – lots of minerals that perhaps have not been in the lithium story, we are actually starting to see a big boost and a significant increase in interest in exploring for those products and also opening mines.<sup>156</sup>

WA is the second largest global producer of rare earths; third for cobalt; and fourth for nickel – all essential inputs into batteries.<sup>157</sup> The location for these mineral deposits is shown in Figure 4.6.

Increased demand for a range of commodities is obviously a boon for the WA economy. There was, however, some contention about the availability of graphite:

We have got cobalt, nickel, we have certainly got lithium, and we have got copper. The thing we do not have is graphite. Ninety per cent of the world's graphite is in China and they are not going to sell it to you, because they see it as a strategic asset and they will not give it to you.<sup>158</sup>

The extent of WA's graphite reserves will be one of the issues explored by a proposed Cooperative Research Centre (CRC) (see below). However, JTSI provided information on local research that might fill this gap. It said WA is leading in the development of synthetic graphite:

...with University of WA technology being commercialised by ASX listed Hazer Group Ltd. This company has developed technology where natural gas is passed over a catalyst that is largely iron ore, producing

<sup>155</sup> Professor Ray Wills, Managing Director, Future Smart Strategies, *Transcript of Evidence*, 16 May 2018, p8.

<sup>156</sup> Mr Warren Pearce, CEO, Association of Mining and Exploration Companies, *Transcript of Evidence*, 16 May 2018, p6.

<sup>157</sup> Government of Western Australia, *Future Battery Industry Strategy*, 31 January 2019, p6. Available at: <u>www.jtsi.wa.gov.au/docs/default-source/default-document-library/future-battery-industry-strategy-wa-0119.pdf?sfvrsn=ccc7731c\_6</u>. Accessed on 14 February 2019.

<sup>158</sup> Mr Joe Ostojich, Deputy Director General, JTSI, Transcript of Evidence, 16 May 2018, p5.

hydrogen gas and graphite as a waste product created from the carbon removed from the methane.<sup>159</sup>



#### Figure 4.6- Distribution of WA's battery metals<sup>160</sup>

<sup>159</sup> Mr Joe Ostojich, Deputy Director General, JTSI, *Answers to Questions on Notice*, 13 June 2018.

<sup>160</sup> Government of Western Australia, *Future Battery Industry Strategy*, 31 January 2019, p9. Available at: <u>www.itsi.wa.gov.au/docs/default-source/default-document-library/future-battery-industry-strategy-wa-0119.pdf?sfvrsn=ccc7731c\_6</u>. Accessed on 14 February 2019.

In a recent statement to the Australian Stock Exchange, Hazer said that its graphite had shown no loss of capacity after 150 discharge cycles in a lithium-ion battery, and it:

...requires less stages of post-processing in comparison to the commercial alternatives because of the ability to tailor the 'raw' graphite to better suit the end application...less graphite post-processing stages can potentially result in better economics and a smaller carbon footprint.<sup>161</sup>

Mineral Resources Limited is building a pilot company at Kwinana to produce ultrahigh-purity graphite using Hazer technology, and has agreed to fund a large-scale plant if the pilot is successful.<sup>162</sup> The construction of the new plant is financially supported by the large battery company Albermarle.<sup>163</sup>

#### 4.4 Mineral processing

WA's resources sector has traditionally struggled to move along the value chain to more complex precursor element processing, component manufacture and goods assembly. However, as battery demand lifts and WA industry acquires scale, companies are signalling an intent to bring additional opportunities to the local economy.

#### **Private sector developments**

Chinese companies have been particularly proactive in investing in the lithium-ion battery production supply chain. Unlike their involvement in the Australian iron ore industry, where the raw commodity is simply exported, Chinese investors are becoming involved in developing the value-added lithium supply chain here in WA.<sup>164</sup>

Chinese company Tianqi Lithium Australia has been an early mover to processing lithium in WA, converting spodumene lithium from its Greenbushes mine to lithium carbonate and lithium hydroxide. In September 2017 Tianqi announced contracts to build a lithium hydroxide processing plant in Kwinana. The new \$400 million first-stage

<sup>161</sup> HazerGroup, Hazer's High Purity Graphite Shows Strong Performance in Lithium-ion Batteries, 10 May 2018, p4. Available at: <u>www.asx.com.au/asxpdf/20180510/pdf/43txmnhjzgrfl4.pdf</u>. Accessed on 27 July 2018.

<sup>162</sup> Peter Milne, *The West Australian*, 'Hazer plots 'cracking' hydrogen revolution in Kwinana', 19 September 2018. Available at: <u>https://thewest.com.au/business/hazer-plots-crackinghydrogen-revolution-in-kwinana-ng-b88958562z</u>. Accessed on 10 December 2018.

<sup>163</sup> Angela Macdonald-Smith, Australian Financial Review, 'Lithium-rich Australia seeks to lure battery cell manufacturers', 11 December 2018. Available at: www.afr.com/business/mining/lithiumrich-australia-seeks-to-lure-battery-cell-manufacturers-20181210-h18xma. Accessed on 11 December 2018.

<sup>164</sup> Lachlan Colquhoun, *Asia Times*, 'China charges Australia's lithium boom', 23 January 2018. Available at: <u>www.atimes.com/article/china-charges-australias-lithium-boom/</u>. Accessed on 26 July 2018.

plant entered its commissioning phase in early 2019 and expects to start exports later this year.<sup>165</sup> The company swiftly moved to announce the \$300 million Stage Two of its project and expects to commission it in late 2019.<sup>166</sup>

Tianqi is one of the world's four largest producers of lithium. Two others, Albemarle (a US company) and SQM (a Chilean company), have also signalled their intent to establish projects in WA.<sup>167</sup>

SQM has announced plans to develop a lithium refinery at Kwinana in conjunction with Kidman Resources (also known as WA Lithium), which operates a mine near Southern Cross. Kwinana was chosen due to its proximity port facilities and other chemical companies. The refinery will cost about \$700 million.<sup>168</sup>

Albemarle received conditional approval from the Environmental Protection Authority in mid-June 2018 for a 100,000 tonnes per annum (tpa) lithium hydroxide processing plant at Kemerton, near Bunbury. The proposed plant will comprise five 20,000 tpa process trains.<sup>169</sup> The plant will become the State's largest lithium plant and the initial earthworks contract was awarded in February 2019.<sup>170</sup>

AMEC confirmed that it has 19 member companies currently active in either the exploration for, or extraction of, lithium, and the wider battery minerals chain. It estimated that the WA Lithium/SQM processing facility at Kwinana would have a construction workforce of 200 and a final operating workforce of 180 workers. AMEC stated that there are already seven proposals to develop lithium processing or refining facilities in WA and there are emerging new proposals to "develop processing or refining for other battery minerals such as graphite (Mineral Commodities) and nickel (Nickel West)."<sup>171</sup>

<sup>165</sup> Sean Smith, The West Australian, 'Tianqi fires up \$700m lithium game changer in Kwinana', 18 January 2019, p1. Available at: <u>https://thewest.com.au/business/mining/tianqi-fires-up-700m-lithium-game-changer-in-kwinana-ng-b881076970z</u>. Accessed 25 March 2019.

<sup>166</sup> MSP Engineering, MSP News, 2019. Available at: www.mspengineering.com.au/news/article/13122017-93/tianqi-lithium-hydroxide-processingplant-stage-2-commences.aspx. Accessed 3 April 2019.

<sup>167</sup> Mr Joe Ostojich, Deputy Director General, JTSI, Transcript of Evidence, 16 May 2018, p3.

<sup>168</sup> Stuart McKinnon, The West Australian, 'Lithium jobs boom as Kidman picks Kwinana for refinery', 4 May 2018. Available at: <u>https://thewest.com.au/business/mining/lithium-jobs-boom-as-kidman-picks-kwinana-for-refinery-ng-b88825814z</u>. Accessed on 26 July 2018.

<sup>169</sup> Stuart McKinnon, *The West Australian*, 'Albemarle wins EPA tick for Kemerton lithium plant', 15 June 2018. Available at: <u>https://thewest.com.au/business/mining/albemarle-wins-epa-tick-for-kemerton-lithium-plant-ng-b88867624z</u>. Accessed on 26 July 2018.

<sup>170</sup> Australian Mining, 'Albemarle awards Kemerton lithium work to BGC Contracting', 21 February 2019. Available at: <a href="http://www.australianmining.com.au/news/albemarle-awards-kemerton-lithium-work-to-bgc-contracting/">www.australianmining.com.au/news/albemarle-awards-kemerton-lithium-work-to-bgc-contracting/</a>. Accessed on 3 April 2019.

<sup>171</sup> Mr Warren Pearce, CEO, Association of Mining and Exploration Companies, *Answers to Questions* on Notice, 28 May 2018.

AMEC anticipates that thousands of WA jobs could be developed by a larger lithium industry and many could be located in regional WA. An expanded lithium industry could also assist the development of regional ports in Bunbury, Esperance and the Pilbara.<sup>172</sup>

Since AMEC provided this information about its members' activities in the lithium sector in early 2018, the following announcements have been made:

- Tianqi Lithium and US-based Albemarle are proceeding with a third stage of expansion at their Greenbushes lithium mine, approving an additional \$516 million investment. This will increase its spodumene concentrate production capacity to 1.8 million tpa by 2021.<sup>173</sup>
- Shipments of spodumene concentrate from the Bald Hill lithium-tantalum mine in the Eastern Goldfields began in March 2018. The mine is operated by Alliance Mineral Assets after it merged with its joint venture partner Tawana Resources. Alliance is currently working on the plant's Stage Two upgrade, which will be commissioned by September 2019.<sup>174</sup>
- Mineral Resources has announced it will spend \$610 million building its lithium concentrate processing plant at its Wodgina hard rock lithium project in the Pilbara. It will also spend about \$1.6 billion on its rail system. The processing plant will have a capacity of 750,000 tpa of 6% spodumene concentrate. In late 2018 Mineral Resources sold half of its share in this mine to Albermarle.<sup>175</sup>
- Neometals has signed an option agreement with the City of Kalgoorlie-Boulder over a site for the company's proposed 10,000 tpa lithium hydroxide plant which would be fed by lithium concentrate from the company's Mt Marion project 40km south-west of Kalgoorlie.<sup>176</sup>

<sup>172</sup> Mr Warren Pearce, CEO, Association of Mining and Exploration Companies, *Answers to Questions* on Notice, 28 May 2018.

<sup>173</sup> Australia China Business Review, 'Tianqi joint venture to invest further \$516m on WA lithium mine', 25 July 2018. Available at: <a href="http://www.acbr.com.au/tianqi-joint-venture-invest-further-516m-wa-lithium-mine">www.acbr.com.au/tianqi-joint-venture-invest-further-516m-wa-lithium-mine</a>. Accessed on 26 July 2018.

<sup>174</sup> Lauren Barrett, *Small Caps*, 'Alliance Mineral Assets posts lithium production record from Bald Hill mine', 7 February 2019. Available at: <u>https://smallcaps.com.au/alliance-mineral-assetslithium-production-record-bald-hill-mine/</u>. Accessed on 3 April 2019.

<sup>175</sup> Imelda Cotton, *Small Caps*, 'Mineral Resources and Albemarle formalise \$1.6b partnership for Wodgina lithium project', 17 December 2018. Available at: <u>https://smallcaps.com.au/mineralresources-albemarle-partnership-wodgina-lithium-project/</u>. Accessed on 3 April 2019.

<sup>176</sup> Stuart McKinnon, *The West Australian*, 'Neometals finds West Kalgoorlie site for lithium hydroxide plant', 6 June 2018. Available at: <u>https://thewest.com.au/business/mining/neometals-finds-west-kalgoorlie-site-for-lithium-hydroxide-plant-ng-b88857915z</u>. Accessed on 26 July 2018.

 Wesfarmers is one of three companies considering building a battery manufacturing plant in Kwinana, with one unnamed South Korean business also considering a potential battery facility there.<sup>177</sup>

#### Recent reports on the State's lithium industry

AMEC's interest in this new sector led to its 2018 report, A Lithium Industry in Australia: A Value Chain Analysis for Downstreaming Australia's Lithium Resources. The report called the current situation a "once-in-a-generation confluence of local advantages to value-add" and estimated that the currently \$165 billion global lithium value chain will grow to an estimated \$2 trillion by 2025 (see Figure 4.7).<sup>178</sup>

AMEC later published a second report, *The Path Forward: Supporting the Development of a Lithium and Battery Minerals Industry in Western Australia*. The report warned that without close Government and industry collaboration, Australia will only capture \$10 billion of the total \$2 trillion value in the next 8 years. AMEC estimated that there is roughly a two year window before the global value chain is 'solidified'. However, if just "one more step was taken down the value chain into electro-chemical processing, by 2025 Australia would have a share of a further \$297 billion."<sup>179</sup>





177 Matt Mckenzie, *Business News*, 'Battery plant rumoured for Wesfarmers', 23 May 2018. Available at: <u>www.businessnews.com.au/article/Battery-plant-rumoured-for-Wesfarmers</u>. Accessed on 26 July 2018.

<sup>178</sup> Future Smart Strategies, A Lithium Industry in Australia, February 2018, p1. Available at: <u>www.amec.org.au/Public/Advocacy/AMEC\_Submissions/A\_lithium\_Industry\_in\_Australia.aspx</u>. Accessed on 25 July 2018.

 <sup>179</sup> Association of Mining and Exploration Companies, *The Path Forward: Supporting the* Development of a Lithium and Battery Minerals Industry in Western Australia, 16 May 2018, p2.
Available at: <u>https://amec.org.au/Public/Advocacy/AMEC\_Submissions/The\_Path\_Forward.aspx</u>.
Accessed on 26 July 2018.

<sup>180</sup> Ibid, p11.

In 2018 Regional Development Australia published a report, *Lithium Valley: Establishing the Case for Energy Metals and Battery Manufacturing in Western Australia,* which was prepared by Future Smart Strategies and Professor Peter Newman from Curtin University. It provides evidence as to why a 'Lithium Valley' could be established in WA, similar to Silicon Valley in California. Its rationale is that "the science and engineering realities that show WA has all the basic raw materials, environment and expertise to make it happen."<sup>181</sup>

The report proposes that WA will gain 93,000 jobs and a \$56 billion economic boost by 2025 if it expands its lithium and new energy metals sector beyond exporting just the spodumene concentrate. It also confirmed that WA has substantial reserves of all of the critical battery materials (see Figure 4.8).



# Figure 4.8- Country reserves of key battery materials as a percentage of known global reserves<sup>182</sup>

#### Advanced manufacturing and battery assembly

WA does not currently possess the capability to undertake more complex component manufacturing or battery assembly and there are open questions regarding whether the State is well-positioned to move further along the value chain.

WA's Chamber of Commerce and Industry (CCIWA) partnered with the Chamber of Minerals and Energy, BHP, Neometals, Synergy and the City of Kwinana on an industry-

 <sup>181</sup> Regional Development Australia (Perth), *Lithium Valley: Establishing the Case for Energy Metals and Battery Manufacturing in Western Australia*, 13 July 2018, p8. Available at: <a href="http://www.rdaperth.org/rda-projects/lithium-valley/">www.rdaperth.org/rda-projects/lithium-valley/</a>. Accessed on 26 July 2018.
182 Ibid, p13.

led report on the economic viability a battery supply chain in WA.<sup>183</sup> Its final report, *WA's Future in the Lithium Battery Value Chain*, was published in November 2018. While acknowledging that WA is well positioned to benefit from the rapid growth in global demand for lithium-ion batteries, it cautioned:

...almost all mid-stream and the vast majority of downstream lithiumion battery supply chain is concentrated in East Asia (Japan, Republic of Korea and particularly the PRC [People's Republic of China]). Current trends in investment strongly indicate that this will continue to be the case for the foreseeable future.<sup>184</sup>

The CCIWA notes that WA's minerals production is deeply and increasingly integrated within South East Asian supply chains, with most existing and future production of concentrate and chemicals underpinned by offtake agreements in these supply chains. However, CCIWA questions the likelihood of WA being competitive in sectors other than the technical and battery grade precursor manufacturing sectors.

Over time, WA's industry may reach a scale such that it is able to develop the capacity to undertake further processing steps (and be globally competitive in doing so). The WA Government's *Future Battery Industry Strategy* (discussed further below) identifies these opportunities and they will also be considered by the Future Battery Industry CRC (discussed below), if it is approved.

#### 4.5 State Government planning and support

The State Government has moved quickly to support the growth in the lithium industry, and to support the efforts of mining companies. JTSI advised that it had established a task force to "inform the Government about what kind of strategy ought to be pursued relating to … new energy and battery storage facilities."<sup>185</sup> JTSI confirmed there were no current Government incentives in place to encourage the establishment of further steps in the lithium processing production process, but that this was a key question for the taskforce.<sup>186</sup>

The taskforce is chaired by the Minister for Mines and Petroleum and includes other key State agencies such as, Mines, Industry Regulation and Safety, Primary Industries and Regional Development and Treasury. The taskforce also includes broad representation from industry and other stakeholder groups. The taskforce will divide

<sup>183</sup> Stephen Bell, Chamber of Commerce and Industry WA, 'Industry-Govt join for lithium strategy', 19 July 2018. Available at: <u>https://cciwa.com/about-us/news-and-media-statements/industry-govt-join-for-lithium-strategy</u>. Accessed on 26 July 2018.

<sup>184</sup> Chamber of Commerce and Industry WA, WA's Future in the Lithium Battery Value Chain, November 2018, p7. Available at: <u>http://cciwa.com/getmedia/9070c931-962f-4fd2-a7d9-1204afd03606/CCIWA WALithiumBatteryValueChainReport Full</u>. Accessed on 6 December 2018.

<sup>185</sup> Mr Joe Ostojich, Deputy Director General, JTSI, *Transcript of Evidence*, 16 May 2018, p2.

<sup>186</sup> Ibid, p4.
into work streams "where various parties are going to be responsible for a number of things, including economic activity, market failure, incentivisation and all those sorts of things."<sup>187</sup>

One of the first public events of the lithium taskforce was holding a 'Lithium and Energy Materials Industry Consortium' in July 2018 to assist the Government consult with industry and research organisations over its 'Lithium and Energy Materials Strategy'.<sup>188</sup>

The development of a lithium processing industry in WA faces competition from other Australian jurisdictions. A feasibility study is under way for a 15-gigawatt-hour 'Gigafactory' for battery production in Townsville.<sup>189</sup> German company Sonnen has begun assembling batteries in Adelaide and will manufacture 50,000 batteries for home installations over the next five years, creating around 430 manufacturing and installation jobs. Sonnen will use the plant as its production base for batteries sold into the Australian, Asian and South Pacific markets.<sup>190</sup>

JTSI has not yet reviewed the potential employment prospects from the State's lithium mining sector due to difficulties in accurately forecasting future production. It gave as an example AMEC's estimate for annual lithium demand in 2025, which ranged from 75,000 to 590,000 tonnes.<sup>191</sup> Unknown factors that also make the forecasting task difficult included:

- various models on the rate of uptake of EVs around the world;
- the impact of automated vehicles on the emerging EV market;
- the take-up rate, and size, of home battery storage systems; and
- the ability of battery manufacturers to increase battery capacity whilst using the same quantity of lithium.<sup>192</sup>

<sup>187</sup> Mr Joe Ostojich, Deputy Director General, JTSI, *Transcript of Evidence*, 16 May 2018, p4.

<sup>188</sup> Hon Bill Johnston MLA, Minister for Mines and Petroleum, Media Statement, 'Lithium taskforce announces first industry consortium', 28 June 2018. Available at: www.mediastatements.wa.gov.au/Pages/McGowan/2018/06/Lithium-taskforce-announces-firstindustry-consortium.aspx. Accessed on 26 July 2018.

<sup>189</sup> Angela Macdonald-Smith, Australian Financial Review, 'Lithium-rich Australia seeks to lure battery cell manufacturers', 11 December 2018. Available at: www.afr.com/business/mining/lithiumrich-australia-seeks-to-lure-battery-cell-manufacturers-20181210-h18xma. Accessed on 11 December 2018.

<sup>190</sup> AAP, The West Australian, 'Battery maker begins production in SA', 27 November 2018. Available at: <u>https://thewest.com.au/technology/battery-maker-begins-production-in-sa-ng-s-1908553</u>. Accessed on 11 December 2018.

<sup>191</sup> Mr Joe Ostojich, Deputy Director General, JTSI, Answers to Questions on Notice, 13 June 2018.

<sup>192</sup> Ibid.

Horizon Power agreed it would be "electric vehicle legislation in China, as well as European and American policies on renewables, that will drive the level of [lithium] activity in WA", but an increase in Australian sales of batteries and EVs would have a marginal impact on the output of WA's lithium mines.<sup>193</sup>

#### The WA Government's Future Battery Industry Strategy

In January 2019, Hon Bill Johnston, Minister for Mines and Petroleum, released the WA Government's *Future Battery Industry Strategy*, aimed squarely at capturing the range of value chain benefits presented by burgeoning global demand for battery technologies.

The Strategy discusses WA's comparative advantages to attract global capital, including its reserves of battery minerals, industry-leading value-adding expertise, best practice environmental and ethical standards, globally recognised mining and mineral processing expertise and research capacity, and world-class industrial and export infrastructure.

The four themes upon which the Strategy is based are: investment attraction; project facilitation; research and technology sector development; and adoption of battery technologies. A series of objectives and pathways are linked to these themes, as outlined in Figure 4.9.

In the Strategy's foreword, WA's Chief Scientist, Professor Peter Klinken, notes WA's many competitive advantages and the State's proud tradition in the mining and resource sector. He urges the State to build on this foundation and investigate further opportunities in further processing the lithium.

He also notes that action must be taken now:

This is not a time to be timid or risk averse. The world is moving ahead at a rapid rate, and other nations not blessed with our natural resources are pushing ahead strongly.

This is a highly competitive field, and time is of the essence. The risk to Western Australia is not if we explore downstream opportunities, the risk is if we do NOT examine these prospects assiduously. Future generations could look back and rightfully ask "What were you doing when you had all the elements necessary for battery production, and you chose to ignore them?<sup>194</sup>

<sup>193</sup> Submission No. 30 from Horizon Power, 19 April 2018, p30.

<sup>194</sup> Government of Western Australia, *Future Battery Industry Strategy*, 31 January 2019, p2. Available at: <u>www.jtsi.wa.gov.au/docs/default-source/default-document-library/future-battery-industry-strategy-wa-0119.pdf?sfvrsn=ccc7731c\_6</u>. Accessed on 14 February 2019.

Figure 4.9- Overview: WA's Future Battery Industry Strategy<sup>195</sup>

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<sup>195</sup> Government of Western Australia, *Future Battery Industry Strategy*, 31 January 2019, p11. Available at: <u>www.jtsi.wa.gov.au/docs/default-source/default-document-library/future-battery-industry-strategy-wa-0119.pdf?sfvrsn=ccc7731c\_6</u>. Accessed on 14 February 2019.

#### The development of a new Cooperative Research Centre

Echoing the Chief Scientist's comments, evidence to this Inquiry consistently emphasised the need for timely action and collaborative effort between industry, government and the research community to develop WA's battery industry value chain. The Committee was told that a significant amount of collaborative effort is currently underway on a proposal to establish a new CRC in WA to focus on the opportunities offered by the lithium industry.

The CRC Program supports industry-led collaborations between industry, researchers and the community. It's a proven model for linking researchers with industry to focus on research and development towards use and commercialisation. It aims to:

- improve the competitiveness, productivity and sustainability of Australian industries, especially where Australia has a competitive strength and in line with government priorities;
- foster high quality research to solve industry-identified problems through industry-led and outcome-focused collaborative research partnerships between industry entities and research organisations; and
- encourage and facilitate small and medium enterprise participation in collaborative research.

JTSI has worked with the Department of Mines, Industry Regulation and Safety, Curtin University and the Minerals Research Institute of Western Australia (MRIWA) in support of an application under the CRC scheme to establish the Future Battery Industries CRC. JTSI has provided \$500,000 and the WA Government provided another \$5.5 million to the MRIWA in its 2018 Budget. All funding is subject to the CRC proposal being agreed to in early 2019.<sup>196</sup> The CRC was short-listed to the next round of the CRC process and a comprehensive business case was being developed for it.<sup>197</sup>

WA's businesses have also committed over \$20 million to support the CRC, and if the bid is successful, the Federal Government will provide another \$25 million.<sup>198</sup>

One role of the CRC will be to analyse the areas in the lithium transformation 'value chain' that can be completed here in WA (see Figure 4.10).

<sup>196</sup> Mr Joe Ostojich, Deputy Director General, JTSI, Answers to Questions on Notice, 13 June 2018.

<sup>197</sup> Hon Bill Johnston MLA, Minister for Mines and Petroleum, Media Statement, 'Success in first stage of bid for CRC', 8 October 2018. Available at: www.mediastatements.wa.gov.au/Pages/McGowan/2018/10/Success-in-first-stage-of-bid-for-

 <sup>&</sup>lt;u>CRC.aspx</u>. Accessed on 10 December 2018.
Michael Bloch, *Solarquotes*, 'WA Government Boosts Backing For Battery Industry Research Centre Bid', 19 July 2018. Available at: <u>www.solarquotes.com.au/blog/future-batteries-crc-mb0673/</u>. Accessed on 26 July 2018.



Figure 4.10- The lithium transformation chain – from rock to batteries<sup>199</sup>

#### Finding 8

The rapid development of lithium exports from Western Australia over the past five years places it in a position to supply about 60% of the world's annual consumption. The development of projects to refine the lithium and move along the lithium-ion battery value chain could provide the State with tens of thousands of new jobs, placed close to residential areas in the South West.

#### Finding 9

Collaborative effort between the Government, industry and the research community is essential to successfully develop the battery supply chain in Western Australia.

<sup>199</sup> Future Smart Strategies, A lithium industry in Australia, February 2018, p3. Available at: <u>www.amec.org.au/Public/Advocacy/AMEC\_Submissions/A\_lithium\_Industry\_in\_Australia.aspx</u>. Accessed on 25 July 2018.

# **The Coming Wave of Electric Vehicles**

...this thing that has kind of been three to five years away, for about 10 years.<sup>200</sup>

# 5.1 An uncertain future

EVs, or 'electric drive vehicles', feature prominently in any discussion about the future of electricity networks. EVs have the potential to radically affect electricity consumption and production patterns. The potential growth in demand for EVs is also material to this Inquiry insofar as many of the raw commodities and components used to power EVs (i.e. batteries) are (or could be) sourced or produced here in Western Australia (WA). There are clear synergies with the development of the battery-oriented distributed energy resources (DER) value chain. Depending on the take-up and utilisation patterns of EVs, they may help, hinder, complement or constrain Microgrids and associated technologies.

This chapter explores different scenarios for the introduction of EVs into the State's fleet, as well as their likely impact on the State's electricity resources.

The Toyota Prius was the world's first commercially produced hybrid electric car and has been manufactured since 1997. Initially it had a small petrol engine which charged a nickel metal hydride battery system. In 2015, Toyota switched to a lithium-ion battery for its larger plug-in models. These batteries are more expensive but are lighter and can hold a larger charge.<sup>201</sup> By 2018 Toyota had sold over 6 million Prius worldwide.<sup>202</sup>

The introduction of the Prius was the first time that EV technology became price competitive with petrol engines<sup>203</sup> and spurred projections that EVs would soon overtake the sales of internal combustion, fossil-fuelled, vehicles. However, currently, EVs make up fewer than 2% of the world's car fleet. A recent projection for the rapid introduction of fully electric vehicles from around 2022-23 was made by Professor Ray Wills, as shown in Figure 5.1.

<sup>200</sup> Mr Jason Waters, Chief Executive Officer (CEO), Synergy, *Transcript of Evidence*, 9 May 2018, p11.

<sup>201</sup> Quora, What kind of battery does the Toyota Prius have?, nd. Available at: www.quora.com/What-kind-of-battery-does-the-Toyota-prius-have. Accessed on 21 June 2018.

<sup>202</sup> Toyota, Worldwide sales of Toyota hybrids surpass 10 million units, 14 February 2017. Available at: <u>https://newsroom.toyota.eu/global-sales-of-toyota-hybrids-reach-10-million/</u>. Accessed on 29 March 2019.

<sup>203</sup> Dr Christopher Jones, National Secretary, Australian Electric Vehicle Association Inc, *Transcript of Evidence*, 18 June 2018, p1.



Figure 5.1- Proposed global transition to electric vehicles – vehicle sales 2017-30<sup>204</sup>

## 5.2 Electric vehicles in the Australian market

EVs utilise one or more electric motors for propulsion and are powered by an external electricity system, or a self-contained system comprised of a battery, solar panels or an electric generator which converts fuel to electricity. EVs may include road and rail vehicles, surface and underwater vessels, electric aircraft and electric spacecraft. The use of the term 'electric vehicle' in the context of this Inquiry refers to road-based vehicles – essentially, passenger and commercial cars, buses and larger road freight motor vehicles (trucks).

More than one type of EV is currently available on the Australian market.

**Battery Electric Vehicles** (BEVs) (such as the Tesla Model S) are powered entirely by electric batteries and its operation does not produce any emissions. It can recharge with electricity and through 'regenerative braking'. When a vehicle's breaks operate while driving, heat and energy is produced and is diverted to recharge the battery.<sup>205</sup>

**Hybrid Electric Vehicles** (HEVs) (such as the Toyota Prius) are powered by a combination of petrol and battery power. HEVs have both an electric motor and a small petrol engine and the power output is controlled by an on-board computer. When the HEV commences forward motion the electric motor operates; the petrol engine then takes over as the vehicle speed increases. The petrol engine also recharges the car's battery and allows for a longer driving range and fuel economy.<sup>206</sup>

<sup>204</sup> Prof Ray Wills, 5 June 2018. Available at:

https://twitter.com/ProfRayWills/status/1004179945499779078. Accessed on 8 June 2018. 205 Synergy, *Learn about electric vehicles*, 2018. Available at: <u>www.synergy.net.au/Your-</u>

home/Electric-Vehicles/Learn-about-electric-vehicles. Accessed on 11 June 2018. 206 Ibid.

**Plug-in Hybrid Electric Vehicles** (PHEVs) (such as the Holden Volt) are similar to HEVs, having both a petrol engine and an electric motor. PHEVs recharge by plugging in to an external charging outlet and can drive a certain distance using battery power alone. Only when the battery power drops to a critical level will the petrol engine operate until the batteries are recharged.<sup>207</sup>

# 5.3 The rapid decline in battery prices

The cost of installed lithium-ion batteries has declined over the past decade by about 80%: from around US\$1,000 per kWh in 2010 to an estimated US\$200 per kWh in 2018.<sup>208</sup> However, total battery costs for EVs are falling more slowly, as consumers demand EVs with a longer range and thus larger batteries. A recent report has compared the lifetime cost of batteries and found that the PHEV is more expensive than internal combustion-engined vehicles in almost all scenarios, while the BEV is very cost-competitive once installed battery prices reach US\$200-\$250 per kWh.<sup>209</sup>

# 5.4 International initiatives to develop electric vehicles

EVs do not currently constitute a large percentage of the global road transportation fleet. EV sales currently make up only 1-2% of vehicles sold in developed nations, such as Australia, the US, the UK, Germany and France. However, many governments support a rapid move to EVs, primarily motivated by the impacts of climate change. For example, Australia is one of 24 members of the Clean Energy Ministerial (CEM), a global forum to promote policies and programs that advance clean energy technology and to encourage a transition to a global clean energy economy. The CEM members account for about 90% of global clean energy investments and 75% of global greenhouse gas emissions.<sup>210</sup>

The CEM's electric vehicle initiative (EVI) is led by China and the US and seeks to facilitate the global deployment of 20 million EVs by 2020. The International Energy Agency has estimated that EVs must represent 35% of new vehicle sales by 2035 to limit climate change to less than 2°C. This translates to a global EV fleet of around 150

<sup>207</sup> Synergy, *Learn about electric vehicles*, 2018. Available at: <u>www.synergy.net.au/Your-home/Electric-Vehicles/Learn-about-electric-vehicles</u>. Accessed on 11 June 2018.

<sup>208</sup> The Senate, Select Committee on Electric Vehicles, submission 127, Bloomberg NEF, pp3-4. 209 Henry Lee and Alex Clark, *Belfer Centre*, 'Charging the Future', September 2018. Available at:

www.belfercenter.org/publication/charging-future. Accessed on 6 December 2018.
Clean Energy Ministerial, About The Clean Energy Ministerial, nd. Available at: <a href="http://www.cleanenergyministerial.org/about-clean-energy-ministerial">http://www.cleanenergyministerial.org/about-clean-energy-ministerial.</a>. Accessed on 8 June 2018.

million by 2030, or a 150-fold increase over the present fleet. In 2015 the millionth EV was sold since they were introduced to market in 2010.<sup>211</sup>

In 2017, the CEM launched its *EV30@30* campaign by setting an aspirational goal for all EVI members to have a 30% market share for electric vehicles of their total of all vehicles by 2030.<sup>212</sup> As shown in Figure 5.2, many European countries participate in this CEM program, but as yet Australia does not.



Figure 5.2- Participation by country in Clean Energy Ministerial initiatives and campaigns<sup>213</sup>

While it took 5 years for the first million EVs to be sold, over 1 million were sold during 2017; with more than half of these sales in China. The total number of EVs on the road surpassed 3 million worldwide in 2017, an expansion of over 50% from 2016.<sup>214</sup>

<sup>211</sup> Clean Energy Ministerial, *Electric Vehicle Initiative (EVI)*, June 2016, p1. Available at: <u>www.cleanenergyministerial.org/sites/default/files/2018-03/EVI-CEM7-FS.pdf</u>. Accessed on 8 June 2018.

<sup>212</sup> International Energy Agency, *Global EV Outlook 2018*, 2018, p16. Available at: <u>www.iea.org/publications/freepublications/publication/GlobalEVOutlook2017.pdf</u>. Accessed on 8 June 2018.

<sup>213</sup> Clean Energy Ministerial, Participation in CEM Initiatives and Campaigns, 30 June 2017. Available at: <u>www.cleanenergyministerial.org/sites/default/files/2018-</u>03/CEM%20Matrix%20of%20Participation%20and%20Leadership.pdf. Accessed on 8 June 2018.

 <sup>214</sup> Clean Energy Ministerial, *The IEA Global Electric Vehicle (EV) Outlook 2018*, 30 May 2018.
Available at: www.cleanenergyministerial.org/publications.clean.energyministerial/ioa.global

Available at: <u>www.cleanenergyministerial.org/publications-clean-energy-ministerial/iea-global-</u> <u>electric-vehicle-ev-outlook-2018</u>. Accessed on 8 June 2018.

In 2017, the global sale of BEVs grew by 61% to 734,000 while HEVs grew by just 36% to 386,000.  $^{\rm 215}$ 

Many countries are using government policies that mandate the phasing out of vehicles fuelled by fossil fuels as a method of overcoming impediments to EV ownership (see Table 5.1). China, which produces about one-third of vehicles sold globally each year, plans to announce a ban on the sale of diesel and petrol cars in the near future.<sup>216</sup>

Country	Commencement	
	year of ban	
South Korea	2020	
Costa Rica	2021	
Norway	2025	
Denmark	2030	
Germany	2030	
India	2030	
Ireland	2030	
Israel	2030	
Netherlands	2030	
Britain	2040	
France	2040	
Spain	2040	
Taiwan	2040	

Table 5.1- Countries with mandated withdrawal of cars fuelled by fossil fuels<sup>217</sup>

In California, much of the development of EV technology can be traced to specific government policies, especially the 'Zero Emission Vehicle Program' or 'ZEV Mandate'.<sup>218</sup> Introduced in 1990, the ZEV Mandate was designed to assist California achieve its emissions goals by requiring that a certain percentage of the State's fleet used the cleanest available technologies. The policy has been amended several times since 1990 and its long-term goal is to have 1.5 million EVs in California by 2025.<sup>219</sup>

<sup>215</sup> David Scutt, *Business Insider*, 'Global electric vehicle sales are booming', 22 January 2018. Available at: <u>www.businessinsider.com.au/the-rapid-growth-in-global-electric-vehicle-sales-in-4-charts-2018-1</u>. Accessed on 21 June 2018.

<sup>216</sup> *BBC News*, 'China looks at plans to ban petrol and diesel cars', 10 September 2017. Available at: <u>www.bbc.com/news/business-41218243</u>. Accessed on 8 June 2018.

<sup>217</sup> Wikipedia, *List of countries banning fossil fuel vehicles*, 6 December 2018. Available at: <a href="https://en.wikipedia.org/wiki/List\_of\_countries\_banning\_fossil\_fuel\_vehicles">https://en.wikipedia.org/wiki/List\_of\_countries\_banning\_fossil\_fuel\_vehicles</a>. Accessed on 10 December 2018.

<sup>218</sup> Jonn Axsen, *The Conversation*, 'How to get more electric vehicles on the road', 13 December 2017. Available at: <u>https://theconversation.com/how-to-get-more-electric-vehicles-on-the-road-88755</u>. Accessed on 8 June 2018.

<sup>219</sup> TransportPolicy.net, *California: ZEV*, 2018. Available at: <u>www.transportpolicy.net/standard/california-zev/</u>. Accessed on 8 June 2018.

Norway has an aggressive policy to increase its EV fleet and it currently has the highest total of EVs per capita in the world. In 2013 there were just four plug-in EVs per 1,000 cars. In 2017, over 52% of all new Norwegian car sales were EVs. Norway exempts new EVs from almost all taxes. This can be worth thousands of dollars a year to a driver in terms of free or subsidized parking, re-charging and use of toll roads, ferries and tunnels.<sup>220</sup>

More than half of the global sales of EVs in 2017 were in China, where they had a total market share of 2.2%. EVs sold in the Chinese market in 2017 more than doubled the amount delivered in the United States, the second-largest market.<sup>221</sup>

Individual companies have also made pledges to move their fleets to EVs. Ikea has announced that by 2020 it will shift to a zero-emissions delivery truck fleet in five of the large cities it operates in. By 2025, the company aims to complete this transition to all of its stores worldwide.<sup>222</sup>

## 5.5 Response from the car industry

Major car makers including General Motors, Ford, Toyota Motor Corp and Volkswagen AG have all outlined plans to expand their EV offerings. The Ford Motor Company announced in 2018 that it would invest USD\$11 billion with the aim to have 40 EV models in their fleet by 2022. Of these, 16 models will be fully electric and the remaining will be PHEVs. Similarly, General Motors has stated that it will add 20 new battery electric and fuel cell vehicles to its fleet by 2023.

In 2017 Volkswagen said it would spend USD\$40 billion on electric cars, autonomous driving and new mobility services by the end of 2022.<sup>223</sup> In its most recent announcement, VW said that all of its models post-2026 would be EVs.<sup>224</sup>

<sup>220</sup> Camilla Knudsen and Alister Doyle, *Reuters*, 'Norway powers ahead (electrically): over half new car sales now electric or hybrid', 3 January 2018. Available at: <u>www.reuters.com/article/us-environment-norway-autos/norway-powers-ahead-over-half-new-car-sales-now-electric-or-hybrid-idUSKBN1ESOWC</u>. Accessed on 8 June 2018.

<sup>221</sup> International Energy Agency, Global EV Outlook 2018, 2018, p9. Available at: www.iea.org/publications/freepublications/publication/GlobalEVOutlook2017.pdf. Accessed on 8 June 2018.

<sup>222</sup> Yale Climate Connections, 'Electric vehicles: Ikea wants a zero-emissions delivery fleet', November 21, 2018. Available at: <u>www.yaleclimateconnections.org/2018/11/ikea-wants-a-zero-emissions-delivery-fleet/</u>. Accessed on 11 December 2018.

<sup>223</sup> The Guardian, 'Ford to invest \$11bn and have 40 hybrid and fully electric vehicles by 2022', 15 January 2018. Available at: www.theguardian.com/environment/2018/jan/15/ford-to-invest-11bn-and-have-40-hybrid-and-fully-electric-vehicles-by-2022?CMP=Share\_iOSApp\_Other. Accessed on 8 June 2018.

<sup>224</sup> Christoph Rauwald, *Bloomberg*, 'VW Says the Next Generation of Combustion Cars Will Be Its Last', 5 December 2018. Available at: <u>www.bloomberg.com/news/articles/2018-12-04/vw-says-</u><u>the-next-generation-of-combustion-cars-will-be-its-last</u>. Accessed on 5 December 2018.



Figure 5.3- Car manufacturers' announcements on new electric vehicle models<sup>225</sup>

The most recent announcement of the construction of new EVs has been from Sir James Dyson, UK inventor of the bagless vacuum cleaner, who intends to begin constructing EVs in Singapore.<sup>226</sup>

The success which EV manufacturer Tesla has had in the global market has made other manufacturers review their future strategies for fossil-fuelled vehicles. Tesla aim was to increase its production Model 3 cars to 6,000 per week by the end of June 2018.<sup>227</sup> In May 2018, nearly 40% of EVs sold in the US were Tesla models, mainly the Model 3. Consumers had a choice of 42 different EV models, with only 8 selling more than 1,000 vehicles in that month.<sup>228</sup> In August 2018, the Tesla Model 3 became the best-selling

<sup>225</sup> International Energy Agency, *Global EV Outlook 2018*, 2018, p38. Available at: https://webstore.iea.org/global-ev-outlook-2018. Accessed on 8 June 2018.

<sup>226</sup> Simon Jack, *BBC News*, 'Dyson chooses Singapore for new electric car plant', 23 October 2018. Available at: <u>www.bbc.com/news/business-45950377</u>. Accessed on 5 December 2018.

<sup>227</sup> *Reuters*, 'Tesla aiming to build 6,000 Model 3 cars per week by end-June: report', 18 April 2018. Available at: <u>www.reuters.com/article/us-tesla-stocks/tesla-aiming-to-build-6000-model-3-cars-per-week-by-end-june-report-idUSKBN1H038Y</u>. Accessed on 8 June 2018.

<sup>228</sup> Inside EVs, *Monthly Plug-In Sales Scorecard*, June 2018. Available at: <u>https://insideevs.com/monthly-plug-in-sales-scorecard/</u>. Accessed on 8 June 2018.

car in the US by value, with sales totalling USD\$992 million.<sup>229</sup> Figure 5.3 outlines the announcements made by 20 car makers about their intentions to manufacture EVs.

The dramatic increase in US EV sales, by month, since 2010 can be seen in Figure 5.4.



Figure 5.4- US monthly electric car sales – 2010-18<sup>230</sup>

## 5.6 E-buses to lead the revolution?

Electrification of non-car transport modes is also developing quickly, especially public transport electric buses (e-buses) and two-wheelers. In 2017, global sales of e-buses were about 100,000 and sales of two-wheelers were estimated at 30 million. The vast majority of these sales were in China.<sup>231</sup>

The large Chinese city of Shenzhen (population 12 million) has converted its total bus fleet of 16,000 to e-buses. By the end of 2018, all of its 22,000 taxis were also required to have been converted to EVs.<sup>232</sup>

China had about 99% of the world's 385,000 e-buses in 2017. This accounted for approximately 17% percent of China's entire transport fleet. Bloomberg reported that every five weeks, Chinese cities added about 9,500 e-buses to their fleets—the equivalent of London's entire bus fleet. This growth in the number of e-buses has

 <sup>229</sup> Michael Grinshpun, *Clean Technica*, 'Tesla Model 3 = #1 Best Selling Car In The US (In Revenue)', 9 September 2018. Available at: <u>https://cleantechnica.com/2018/09/09/tesla-model-3-becomes-1-best-selling-car-in-the-us/</u>. Accessed on 10 December 2018.

<sup>230</sup> Inside EVs, *Monthly Plug-In Sales Scorecard*, June 2018. Available at: <u>https://insideevs.com/monthly-plug-in-sales-scorecard/</u>. Accessed on 8 June 2018.

<sup>231</sup> International Energy Agency, Global EV Outlook 2018, 2018, p9.

<sup>232</sup> Matthew Keegan, *The Guardian*, 'Shenzhen's silent revolution: world's first fully electric bus fleet quietens Chinese megacity', 12 December 2018. Available at: <u>www.theguardian.com/cities/2018/dec/12/silence-shenzhen-world-first-electric-bus-fleet</u>. Accessed on 17 December 2018.

started to make an observable reduction in fuel demand as each bus consumes 30 times more fuel than average sized passenger sedans.<sup>233</sup>

In November 2018, Chinese bus manufacturer Yutong secured an order for 100 e-buses for Chilean bus companies wanting to replace their diesel buses. This followed an earlier order in 2017 for 50 e-buses for Argentina from another Chinese company, BYD.<sup>234</sup>

Bloomberg New Energy Finance's latest EV outlook projects that the e-bus market will grow faster than electric cars. Bloomberg expects the electrification of road transport to start rapidly increasing in the second half of the 2020s, and e-buses to make up 84% of all bus sales globally by 2030.<sup>235</sup>

The City of San Francisco and its Municipal Transportation Agency (SFMTA) announced in May 2018 that all public buses operating in the city will be electric after 2035. To achieve this goal, all new buses purchased after 2024 will be e-buses. A significant expansion of SFMTA's charging infrastructure will be required to meet this goal. Many of its newer buses are diesel-electric hybrids while its existing diesel powered vehicles use biodiesel fuel exclusively. About 50% of the electricity needed to power its electric public transport system comes from hydro power.<sup>236</sup>

# 5.7 Why are there so few electric vehicles in Australia, especially WA?

In early 2017 there were only 270 battery or PHEVs in WA.<sup>237</sup> The Australian Energy Market Operator (AEMO) has developed three scenarios for EV ownership in WA through until 2028 in its most recent Wholesale Electricity Market *Electricity Statement of Opportunities*. There is a substantial difference between the high and low scenarios of 18% of the vehicle market in 2028 or about 450,000 vehicles, as shown in Figure 5.5.

<sup>233</sup> Jeremy Hodges, *Bloomberg*, 'Electric Buses Are Hurting the Oil Industry', 24 April 2018. Available at: <u>www.bloomberg.com/news/articles/2018-04-23/electric-buses-are-hurting-the-oil-industry</u>. Accessed on 8 June 2018.

<sup>234</sup> *Climate Action*, 'Argentina to secure 50 new electric buses', 12 January 2017. Available at: <u>www.climateaction.org/news/argentina to secure 50 new electric buses/</u>. Accessed on 20 March 2019.

<sup>235</sup> Rachel Williamson, *Stockhead*, 'E-buses will be the fastest electric vehicles on the road, says Bloomberg', 23 May 2018. Available at: <u>https://stockhead.com.au/resources/e-buses-will-be-the-fastest-electric-vehicles-on-the-road-says-bloomberg/</u>. Accessed on 8 June 2018.

<sup>236</sup> Steve Hanley, Clean Technica, 'San Francisco Moving To All-Electric Bus Fleet By 2035', 18 May 2018. Available at: <u>https://cleantechnica.com/2018/05/18/san-francisco-moving-to-all-electric-bus-fleet-by-2035/</u>. Accessed on 8 June 2018.

<sup>237</sup> Western Power, *Electric vehicles plug in to the network's future*, 2018. Available at: <u>https://westernpower.com.au/energy-solutions/projects-and-trials/electric-vehicles-plug-in-to-the-network-s-future?gclid=EAIaIQobChMIvf630KzR2AIVIBO9Ch166wS9EAAYAyAAEgKraPD\_BwE.</u> Accessed on 11 June 2018.



Figure 5.5- Projected number and market share of electric vehicles in WA – 2018-28<sup>238</sup>

The Australian Electric Vehicle Council's 2017 report, *The State of Electric Vehicles in Australia*, found that Australia has fallen behind in regard to the uptake of EVs. While two million EVs were sold globally in 2016, only 1,369 EVs were sold in Australia, representing 0.1% of the Australian new car market.<sup>239</sup>

It is anticipated that an improvement in the number of lower-cost EV models in Australia will produce greater sales. In 2016 there were 16 battery and hybrid EV models available in Australia. The majority of growth has been in higher end models, with 13 of the 16 models costing in excess of \$60,000. In 2016, Australian businesses remained the largest buyer of EVs with 64% percent of total sales while government fleets comprised only 2% of total sales.<sup>240</sup> In Australia, EV sales fell dramatically by 23% between 2015 and 2016 to just 1,369 vehicles, but recovered to 2,284 vehicles sold in 2017.<sup>241</sup>

The Australian Electric Vehicle Association (AEVA) said that the main barrier to greater EV ownership in Australia was availability:

Right now, if you want to buy an electric vehicle, you have the choice of three vehicles and two of them are over \$80,000. We know that there are cheaper makes and models of electric vehicle out there in the world,

<sup>238</sup> Australian Energy Market Operator, *Electricity Statement of Opportunities*, Perth, 15 June 2018, p31.

<sup>239</sup> Electric Vehicle Council in Australia, *The state of electric vehicles in Australia*, June 2017, p3. Available at: <u>http://electricvehiclecouncil.com.au/wp-content/uploads/2015/05/State-of-EVs-in-Australia-2017.compressed.pdf</u>. Accessed on 12 June 2018.

<sup>240</sup> Ibid, p6.

<sup>241</sup> Sophie Vorrath, *Renew Economy*, 'Electric vehicle policy support "urgent", as sales inch up in 2017', 15 June 2018. Available at: <u>https://reneweconomy.com.au/electric-vehicle-policy-supporturgent-sales-inch-2017/</u>. Accessed on 21 June 2018.

they are just not available in Australia. There were some recent changes to the Commonwealth's Motor Vehicle Standards Act 1989 and the idea is to make parallel imports of energy-efficient vehicles a little easier. That is ongoing, from what I understand. Basically, right now, if you want to buy an electric car, you have very limited options.<sup>242</sup>

Data comparing EV models currently available in Australia to other right-hand drive countries in Figure 5.6 supports this claim.



Figure 5.6- Current electric vehicle models available in right-drive countries<sup>243</sup>

Another nine new PHEV and BEV models are expected to be introduced in the Australian market in the near future– five of which should be priced below \$60,000.<sup>244</sup>

The AEVA also identified that Australia's small market size and dealership model were also barriers to greater EV ownership:

...the dealerships have a lot more autonomy in what vehicles they put on their showroom floors. That is not the case elsewhere in the world. Basically, the manufacturers are looking for some kind of sign that our appetite is whet for EVs. That is code language for some kind of support over and above what they can offer, and other nations around the world have implemented incentives to get electric vehicles on the roads and they work extraordinarily well.<sup>245</sup>

<sup>242</sup> Dr Christopher Jones, National Secretary, Australian Electric Vehicle Association Inc, *Transcript of Evidence*, 18 June 2018, p1.

<sup>243</sup> Energeia, Australian Electric Vehicle Market Study, Melbourne, May 2018, p24.

<sup>244</sup> Sophie Vorrath, *Renew Economy*, 'Electric vehicle policy support "urgent", as sales inch up in 2017', 15 June 2018. Available at: <u>https://reneweconomy.com.au/electric-vehicle-policy-supporturgent-sales-inch-2017/</u>. Accessed on 21 June 2018.

<sup>245</sup> Dr Christopher Jones, National Secretary, Australian Electric Vehicle Association Inc, *Transcript of Evidence*, 18 June 2018, p2.

Another issue facing current motor vehicle dealerships is that EVs are problematic because they have so few mechanical parts. The AEVA said that dealers today obtain about 60% of their revenue from servicing cars but this will reduce dramatically with the wide introduction of EVs, and dealerships will need new business models when retailing them.<sup>246</sup> The Perth Electric Vehicle Hire and Sales Company has spent 3 years installing EV charging stations but has now opened WA's first dedicated EV dealership. It will offer buyers the opportunity to lease and hire a range of EV brands, as well as to purchase them.<sup>247</sup>

The low uptake of EVs in Australia does not necessarily equate to poor consumer attitudes. Surveys conducted in Victoria indicated that over 50% of respondents would be willing to purchase an EV and that 19% had already conducted their own research for purchasing one. Concerns raised included:

- a lack of supply of vehicles with sufficient range;
- limited availability at a price that competes with non-EV cars; and
- the limitation of charging infrastructure.<sup>248</sup>

#### Government support to lower electric vehicle ownership costs

Price is a major impediment to the purchase of EVs. Australians have to drive further before the cost of owning an EV breaks even with internal combustion engine vehicles. It is estimated that at current prices, Australians would need to drive over 40,000kms a year for it to be cheaper to own an EV.<sup>249</sup>

The AEVA told the Committee that countries with a higher ownership rate for EVs offered support to owners, such as luxury tax breaks, and "reductions in stamp duties or equivalent stamp duties and even reduced registration fees. It is a very small chunk of the cost but it is a sign that says, "We take [EVs] seriously."<sup>250</sup> The AEVA offered the South Australian and the ACT governments as examples of local jurisdictions that have

<sup>246</sup> Dr Christopher Jones, National Secretary, Australian Electric Vehicle Association Inc, *Transcript of Evidence*, 18 June 2018, p2.

<sup>247</sup> The West Australian, 'Electric cars are coming fast', 5 March 2019. Available at: <u>https://thewest.com.au/lifestyle/motoring/electric-cars-are-coming-fast-ng-b881125207z</u>. Accessed on 20 March 2019.

<sup>248</sup> Electric Vehicle Council in Australia, *The state of electric vehicles in Australia*, June 2017, p10. Available at: <u>http://electricvehiclecouncil.com.au/wp-content/uploads/2015/05/State-of-EVs-in-Australia-2017.compressed.pdf</u>. Accessed on 12 June 2018.

<sup>249</sup> Bridie Schmidt, *Renew Economy*, 'Australia EV uptake hindered by long road to price parity', 8 June 2018. Available at: <u>https://reneweconomy.com.au/australia-ev-uptake-hindered-long-road-price-parity-43708/</u>. Accessed on 12 June 2018.

<sup>250</sup> Dr Christopher Jones, National Secretary, Australian Electric Vehicle Association Inc, *Transcript of Evidence*, 18 June 2018, p2.

offered small incentives, including reductions in registration fees, that coincided with them having the greatest market share of EVs in Australia.<sup>251</sup>

While non-financial incentives such as priority access lanes and free parking have been successful in other countries, the best incentive for drivers to switch to EVs remains the introduction of financial incentives. The experience in Denmark strongly supports this argument. EV sales jumped strongly between 2013 and 2015 due to import tax exemption. However, when Denmark phased out the tax exempt status of EVs, sales of new EVs dropped by 84% over the next two years despite a doubling in the number of charging stations. A similar reaction to the removal of subsidies occurred in Estonia in 2014.<sup>252</sup>

In Australia, the then-Federal Treasurer, Hon Scott Morrison, was reported in 2018 as saying that EV buyers "would get no further handouts from the Federal Government as the cars already enjoyed a number of concessions, including a free ride on the 40c per litre fuel excise."<sup>253</sup>

In WA, in 2007 the State Government offered a \$15,000 grant and a 20% reduction in taxis leases for taxis owners to purchase up to 10 'green' taxis that matched the fuel efficiency and emission standards of petrol-electric hybrid cars.<sup>254</sup>

A recent report on the future of EVs sales in Australia prepared for the Australian Renewable Energy Agency (ARENA) confirmed the most important incentives that were used to encourage Norwegian drivers to purchase EVs were financial ones, as shown in Figure 5.7.

<sup>251</sup> Dr Christopher Jones, National Secretary, Australian Electric Vehicle Association Inc, *Transcript of Evidence*, 18 June 2018, p2.

<sup>252</sup> Bridie Schmidt, *Renew Economy*, 'Australia EV uptake hindered by long road to price parity', 8 June 2018. Available at: <u>https://reneweconomy.com.au/australia-ev-uptake-hindered-long-road-price-parity-43708/</u>. Accessed on 21 June 2018.

<sup>253</sup> Ben Packham, The Australian, 'Electric vehicles already receiving enough subsidies: Scott Morrison', 24 January 2018. Available at: www.theaustralian.com.au/national-affairs/electricvehicles-already-receiving-enough-subsidies-scott-morrison/newsstory/cf715a1fd38376cc34ead00bb17527a9. Accessed on 21 June 2018.

<sup>254</sup> Hon Alannah MacTiernan MLA, Minister for Planning and Infrastructure, *Media Statement*, 'Perth's taxi fleet to go green', 6 June 2007. Available at: <u>www.mediastatements.wa.gov.au/Pages/Carpenter/2007/06/Perth%27s-taxi-fleet-to-go-green.aspx</u>. Accessed on 11 June 2018.



Figure 5.7- Norwegian car-buyer ranking of incentives<sup>255</sup>

The ARENA study modelled the impact of EV sales in Australia based on levels of government assistance. The modelling in Figure 5.8 projects that accelerated assistance would bring forward increased PHEV sales rates by approximately 8 years.



Figure 5.8- Forecast of annual Australian plug-in electric vehicle sales<sup>256</sup>

The Australian Senate conducted a Select Committee inquiry into EVs and included measures to support the acceleration of EV uptake in its terms of reference.<sup>257</sup>

<sup>255</sup> Energeia, *Australian Electric Vehicle Market Study*, May 2018, p2. Available at: <u>https://arena.gov.au/assets/2018/06/australian-ev-market-study-report.pdf</u>. Accessed on 28 November 2018.

<sup>256</sup> Ibid, p7.

<sup>257</sup> The Senate, Select Committee on Electric Vehicles, *Terms of Reference*, nd. Available at: <u>www.aph.gov.au/Parliamentary\_Business/Committees/Senate/Electric\_Vehicles/ElectricVehicles</u> <u>/Terms\_of\_Reference</u>. Accessed on 10 December 2018.

#### Finding 10

In other jurisdictions, government assistance, such as priority access lanes, free parking, reductions in import and stamp duties and registration fees, have encouraged electric vehicle ownership.

#### **Development of charging infrastructure**

Driver perceptions about the range are one of the major psychological barriers to EV uptake. Drivers are often concerned about the likelihood of 'running out' of electricity and of EVs generally having too short a range. This is particularly pertinent in a State like WA, where the distances between some regional centres are vast. After vehicle availability and price, ready access to charging infrastructure was seen by the AEVA as the third barrier to EV ownership in WA:

You do not need a charging network to have a viable electric vehicle. Most people will charge at home, probably overnight, at a low rate when the rates are cheap, and they can go about their day with all of the range that the battery has stored in it. For people who want to, or need to, do longer trips, then charging infrastructure is certainly valuable...<sup>258</sup>

Charging infrastructure comes in a variety of forms. The majority of chargers available in Australia are AC chargers. AC charging is used primarily for locations where an EV will be parked for more than an hour. AC charging levels range from 2.4kW to 22kW, with an average 11kW installation charging a vehicle at approximately 50km of range per hour.<sup>259</sup>

DC chargers provide much faster charging rates and are more useful for travelling longer distances between major cities. Australia currently has 40 DC charging stations. The AEVA stated that a 50kW DC fast charger installation costs approximately \$30,000 in charger hardware, with grid connection costing up to a further \$50,000.<sup>260</sup>

A recent report found that at the current level of use in the US (about 10%), commercial EV chargers are not economically profitable. A sustained increase to about 40% utilisation is required to make them competitive, compared to residential charging and internal combustion engines.<sup>261</sup> Different EVs can have vastly different battery

<sup>258</sup> Dr Christopher Jones, National Secretary, Australian Electric Vehicle Association Inc, *Transcript of Evidence*, 18 June 2018, p3.

<sup>259</sup> Electric Vehicle Council in Australia, *The state of electric vehicles in Australia*, June 2017, p9. Available at: <u>http://electricvehiclecouncil.com.au/wp-content/uploads/2015/05/State-of-EVs-in-Australia-2017.compressed.pdf</u>. Accessed on 12 June 2018.

<sup>260</sup> Dr Christopher Jones, National Secretary, Australian Electric Vehicle Association Inc, *Transcript of Evidence*, 18 June 2018, p10.

<sup>261</sup> Henry Lee and Alex Clark, *Belfer Centre*, 'Charging the Future', September 2018. Available at: <u>www.belfercenter.org/publication/charging-future</u>. Accessed on 6 December 2018.

ranges. For example, in Australia the Hyundai *Ioniq* has a 28kWh battery which gives it a range of about 150 to 200-kilometres and is priced at under \$40,000. However, a Tesla *Model S* has a 100kWh battery that gives it a range of over 500 kilometres, but at a cost of over \$200,000.<sup>262</sup>

Horizon Power considered the range issue to be particularly pertinent in regional WA and agreed that Australia is one of the developed countries with the lowest rate of take-up of EVs. It thought that the "lack of financial incentives, long distances, low number of cars available and lack of infrastructures are the main reasons for this low take-up", and that:

These hurdles are even more prominent in regional WA, where the take up of electric vehicle is expected to remain low for residential customers in the foreseeable future, unless specific strategic initiatives are undertaken.<sup>263</sup>

Battery size is a major component of EV cost. As consumers demand greater range (and therefore increasingly more expensive, larger batteries), EV prices are not declining at the same rate as the cost of DER batteries (grid or building-scale). A recent report has compared the lifetime cost of batteries and found that the PHEV is more expensive than internal combustion-engined vehicles in almost all scenarios, while the BEV is very cost-competitive once installed battery prices reach US\$200-\$250 per kWh.<sup>264</sup>

In 2017, to overcome similar disincentives to those faced in WA, the Queensland Government launched its 'Electric Super Highway' (ESH). The ESH is expected to be the world's longest EV superhighway of fast-charging stations, extending from the Gold Coast to the Far North, and is part of an effort to facilitate the increased uptake of EVs in Queensland.<sup>265</sup>

Tesla has installed 18 120kW 'Superchargers' on Australian highways permitting travel between Adelaide to Melbourne and Brisbane. These chargers are able to charge an EV's battery in about 30 minutes. It has also installed 384 'Destination Chargers' which take about four times longer.<sup>266</sup> Tesla also announced it would install Superchargers to

<sup>262</sup> Henry Lee and Alex Clark, *Belfer Centre*, 'Charging the Future', September 2018. Available at: <u>www.belfercenter.org/publication/charging-future</u>. Accessed on 6 December 2018.

<sup>263</sup> Mr Frank Tudor, Managing Director, Horizon Power, *Questions on Notice*, 4 May 2018, p2.

<sup>264</sup> Henry Lee and Alex Clark, *Belfer Centre*, 'Charging the Future', September 2018. Available at: <u>www.belfercenter.org/publication/charging-future</u>. Accessed on 6 December 2018.

<sup>265</sup> Sophie Vorrath, *Renew Economy*, 'Electric vehicle charging networks rolled out across WA, Qld', 30 June 2017. Available at: <u>https://reneweconomy.com.au/electric-vehicle-charging-networks-rolled-across-wa-qld-86346/</u>. Accessed on 11 June 2018.

<sup>266</sup> The Advertiser, 'Tesla installs SA country recharging stations for electric cars, completes link from Adelaide to Brisbane', 18 October 2017. Available at: www.adelaidenow.com.au/technology/tesla-installs-sa-country-recharging-stations-for-electric-

WA's EV charging network. The first one opened in Bunbury in October 2017.<sup>267</sup> The AEVA has worked with Tesla to have a three-phase, 32-amp socket charging network around WA, including in the Pilbara, Kimberley and at the Mundrabilla Roadhouse on the Nullarbor (which has a large solar array).<sup>268</sup>

A new project, *Fast Cities*, has commenced building an ultrafast EV charging network on highways across Australia, commencing with the Cairns to Adelaide route in 2018-19. Each charging site will include two state-of-the-art locally manufactured ultrafast 350kW chargers.<sup>269</sup> *Fast Cities* has secured a \$7 million investment from St Baker's Energy Innovation Fund allowing work to begin on the \$100 million project. The first step of the plan is to have the first 16 sites – which will span between Brisbane and Melbourne – installed by the end of 2019, with the balance of the 42 to be completed by the end of 2021.<sup>270</sup>

Australian company, Chargefox, has raised \$15 million to commence building a network of 21 'ultra rapid' charging stations on highways in the Eastern States, and is planning sites in WA.<sup>271</sup> In a move to speed up the installation of EV chargers in NSW, the Department of Planning has removed the need for planning approvals for the installation of new charges in carparks and depots.<sup>272</sup>

The Clean Energy Finance Corporation (CEFC) has projected that charging networks will require \$1.7 billion in investment by 2040, with around 28,500 service station-style charge points required around the country by 2040.<sup>273</sup>

cars-completes-link-from-adelaide-to-brisbane/news-

story/a051d1e4b567de0ed8ea599ac1683fbf. Accessed on 11 June 2018.

<sup>267</sup> Thomas Munday, Bunbury Mail, 'Eaton Fair Shopping Centre opens Western Australia's first Tesla supercharging hub', 8 October 2017. Available at: <a href="https://www.bunburymail.com.au/story/4973422/tesla-supercharging-hub-powers-up-in-eaton/">www.bunburymail.com.au/story/4973422/tesla-supercharging-hub-powers-up-in-eaton/</a>. Accessed on 11 June 2018.

<sup>268</sup> Dr Christopher Jones, National Secretary, Australian Electric Vehicle Association Inc, *Transcript of Evidence*, 18 June 2018, p4.

<sup>269</sup> St Baker's Energy Innovation Fund, *Fast Cities*, 2016. Available at: <u>www.stbenergy.com.au/project/fast-cities/</u>. Accessed on 30 July 2018.

<sup>270</sup> Sophie Vorrath, *Reneweconomy*, 'EV fast-charging network to roll out in Australia after funding boost', 30 July 2018. Available at: <u>https://reneweconomy.com.au/ev-fast-charging-network-to-roll-out-in-australia-after-funding-boost-13345/</u>. Accessed on 30 July 2018.

<sup>271</sup> AAP, *The Guardian*, 'Ultra rapid' electric car charging network coming to Australia', 22 October 2018. Available at: <a href="https://www.theguardian.com/environment/2018/oct/22/ultra-rapid-electric-car-charging-network-coming-to-australia">www.theguardian.com/environment/2018/oct/22/ultra-rapid-electric-car-charging-network-coming-to-australia</a>. Accessed on 10 December 2018.

<sup>272</sup> Cole Latimer, Sydney Morning Herald, 'NSW to give electric vehicle infrastructure a supercharge', 5 September 2018. Available at: <u>https://www.smh.com.au/business/the-economy/nsw-to-give-electric-vehicle-infrastructure-a-supercharge-20180905-p501v2.htm</u>. Accessed on 10 December 2018.

<sup>273</sup> Energeia, Australian Electric Vehicle Market Study, May 2018. Available at: <u>https://arena.gov.au/assets/2018/06/australian-ev-market-study-report.pdf</u>. Accessed on 28 November 2018.

#### A more positive view?

A number of recent reports have produced a more bullish view regarding the future for EVs in Australia. The CEFC (in conjunction with ARENA) released a report in mid-2018, *Australian Electric Vehicle Market Study*, in which it finds that EVs could represent 90% of all cars and light commercial vehicles on Australian roads by 2050.<sup>274</sup> It projects that with accelerated forms of policy intervention (such as financial incentives, government fleet purchases and changes to the regulation of vehicle emissions, fuel efficiency and vehicle import regulations), EV sales could reach up to 50% of new car sales by 2030. Even with no intervention, the CEFC projects that sales will still accelerate rapidly post-2027.

The CEFC has invested in a number of projects aimed at promoting the uptake of EV, including discounted financing options for individual and fleet buyers, funding a project repurposing car battery systems for second-life storage supply and is working with charging network developers to finance new charging infrastructure.<sup>275</sup>

The Electric Vehicle Council noted in late 2018 that a number of Australian jurisdictions have either announced or are developing EV policy frameworks and strategies. The ACT Government has released their *Transition to Zero Emissions Vehicles Action Plan 2018-21*; the Queensland Government has released their strategy titled *The Future is Electric*; the Tasmanian Government proposes a range of EV actions in *Climate Action 21*: *Tasmania's Climate Change Action Plan 2017-2021*; and the NSW Government's *Future Transport Strategy* has been released for public consultation.<sup>276</sup>

The Senate's Select Committee on Electric Vehicles made 17 recommendations to the Federal Government in its report tabled on 30 January 2019. These recommendations included the development of a national strategy and specific targets to accelerate EV uptake and ensure Australia takes advantage of the opportunities offered by the transition to EVs. It also recommended that the Federal Government establish an intergovernmental taskforce with the states to develop and implement the national strategy.<sup>277</sup>

<sup>274</sup> Energeia, *Australian Electric Vehicle Market Study*, May 2018, p7. Available at: <u>https://arena.gov.au/assets/2018/06/australian-ev-market-study-report.pdf</u>. Accessed on 28 November 2018.

<sup>275</sup> Ibid, p15.

<sup>276</sup> ClimateWorks Australia, The state of electric vehicles in Australia: driving momentum in electric mobility, June 2018, p25. Available at: <u>https://electricvehiclecouncil.com.au/wp-content/uploads/2018/11/The-state-of-electric-vehicles-in-Australia-2018 compressed.pdf</u>. Accessed on 2 April 2019.

<sup>277</sup> The Senate, Select Committee on Electric Vehicles, Report, Canberra, January 2019, pxi. Available at:

www.aph.gov.au/Parliamentary\_Business/Committees/Senate/Electric\_Vehicles/ElectricVehicles /~/media/Committees/electricvehicles\_ctte/report.pdf. Accessed on 2 April 2019.

# 5.8 Initiatives to encourage greater electric vehicle use in WA

CEFC's modelling of future EV ownership in Australia shows that, relative to other states, WA has fewer government initiatives encouraging EV ownership and the lowest ownership rates, as shown in Figure 5.9.

Policy Type	AUS	ACT	SA	VIC	NSW	QLD	WA
Sales per 10,000 vehicles (2016)	7	18	9	8	7	5	3
Regulation	×	1	×	×	×	*	×
Up-front Financial Incentives *	~	\$2,110	\$5,000	\$100	<b>&lt;\$</b> 250	\$660	×
Subsidised Charging / Discounted Parking		×	~	~	~	1	~
Non-Financial Incentives	~	~	1	×	~	~	~

Figure 5.9- Electric vehicle policy support in Australian jurisdictions<sup>278</sup>

Despite the low level of ownership in WA, companies such as Synergy and the RAC are establishing the infrastructure to assist the rapid growth of use of EVs. The RAC has developed an 'Electric Highway' project that has placed 50kW fast-charging stations at 11 locations in Perth and the South West. A fee applies to use the chargers on the Electric Highway, which are owned by different local governments.<sup>279</sup> Both AC and DC charging are available at the charging stations, with the RAC claiming that they "will fast charge an electric vehicle to 80% charge in twenty minutes."<sup>280</sup>

A partnership between Synergy and the AEVA is expected to see more than 70 charge points installed at rest areas on all major roads in the State's south and east, and select locations in the north.<sup>281</sup> Local governments have also installed EV charging stations. For example, the City of Swan has an EV charge station that is used both to charge its EV fleet and is also available to the public for EV recharge at a rate of \$0.40/kWh.<sup>282</sup>

<sup>278</sup> Energeia, Australian Electric Vehicle Market Study, May 2018, p4. Available at: https://arena.gov.au/assets/2018/06/australian-ev-market-study-report.pdf. Accessed on 28 November 2018.

<sup>279</sup> The Royal Automobile Club of WA, RAC Electric Highway, 2016. Available at: <u>https://rac.com.au/about-rac/advocating-change/sustainability/electric-highway</u>. Accessed on 11 June 2018.

<sup>280</sup> ChargeStar, About ChargeStar, 2015. Available at: <u>https://www.chargestar.com.au/about-faqs/</u>. Accessed on 1 April 2019.

<sup>281</sup> Sam Jeremic, *The West Australian*, 'WA's electric car-charging network to expand', 10 July 2017. Available at: <u>https://thewest.com.au/lifestyle/motoring/fresh-charge-towards-electric-ng-b88528489z</u>. Accessed on 11 June 2018.

<sup>282</sup> City of Swan, 'City of Swan charging ahead', 27 July 2017. Available at: <u>https://www.swan.wa.gov.au/News-Media/Focus-stories/2016/City-of-Swan-charging-ahead</u>. Accessed 1 March 2019.

Synergy has also developed a unique EV tariff for its customers. The EV Home Plan tariff is lower than the standard residential A1 tariff during the off-peak period and the same during the Standard home period. A 'time of use' meter records the amount of energy and the time of day the electricity was used to charge the EV.<sup>283</sup>

The AEVA suggested that a simple change to the State's planning codes to require new house garages to include a 32-amp single-phase connection would save costs later on, and would be a cost effective way to encourage further EV ownership. Approximately 95% of AEVA members charge their EV at home at a low cost and very rarely do it on the open road, as they know "that it will take between 40 minutes to an hour to put another 150 to 200-kilometre range on your vehicle."<sup>284</sup>

# 5.9 Likely impact of electric vehicles on WA's grid

The State Government has acknowledged that EVs have the capacity to affect the State's electricity networks. There are two main ways that EVs can affect WA's electricity grids: by *increasing the volume* of total electricity consumed and *changing the pattern* of electricity consumption.

#### Electric vehicles' impact on total electricity consumption

The large uncertainty over the future take-up of EVs in WA makes it difficult to estimate the impact of their use on the State's networks, especially the South West Interconnected System (SWIS), to which most West Australians are connected. AEMO's latest modelling reveals a large difference between its low scenario of an additional 0.4% consumption (72GWh) due to EV use to its high scenario of an additional 2.8% (571GWh). Its expected forecast will be an additional consumption of about 1.5% or 293GWh, as shown in Figure 5.10.<sup>285</sup>

Sustainable Energy Now has projected significantly larger increases in consumption, triggered by more ambitious growth in EV sales. It estimates that, if all cars sold in WA were EVs by 2026, this would mean an estimated 1,500GWh increase in annual electricity consumption, or around 30% higher than current demand.<sup>286</sup> This estimate is three times higher than the highest projected take-up rate by 2027 provided by AEMO, as shown in Figure 5.10.

<sup>283</sup> Synergy, *Electric Vehicle Home Plan*, 2018. Available at: <u>www.synergy.net.au/Your-home/Energy-plans/Electric-Vehicle-Home-Plan</u>. Accessed on 11 June 2018.

<sup>284</sup> Dr Christopher Jones, National Secretary, Australian Electric Vehicle Association Inc, Transcript of Evidence, 18 June 2018, pp8–9.

<sup>285</sup> Australian Energy Market Operator, *Electricity Statement of Opportunities*, Perth, 15 June 2018, p31.

<sup>286</sup> Submission No. 32 from Professor Ray Wills, Future Smart Strategies, 27 April 2018, p15.



Figure 5.10- Electric vehicle contribution to SWIS's operational consumption – 2018-28<sup>287</sup>

#### Electric vehicles' impact on peak demand and electricity load profiles

The timing of vehicle charging also has the potential to significantly affect electricity networks. Under a large EV fleet scenario, peak demand issues could be compounded if a significant proportion of vehicles charge at the same time. As people come home from work, switch on air conditioners and other appliances, as the sun begins to set (and photovoltaic (PV) output declines), networks could be placed under greater strain were a large EV fleet to simultaneously plug in and recharge. Peak demand could increase markedly and the amplitude between peak and off-peak could become greater.

Conversely, if cars were incentivised to recharge during the middle of the day, when the solar PV cell output is high and household consumption is low, demand across the day would level out and the 'duck curve' phenomenon identified by AEMO could be considerably alleviated (see section 3.5 for a discussion of the duck curve). Equally, car recharging late into the night and early morning would again flatten demand profiles across the 24-hour period.

AEMO has considered the impact of EVs across the network. It assumes that EV use will have "a negligible impact on peak demand over the forecast period" on account of a small EV fleet but expects that new tariff structures will discourage the charging of EVs during peak demand times. It gives as an example the new Synergy EV home tariff plan that encourages EV charging between 11pm and 4am.<sup>288</sup>

<sup>287</sup> Australian Energy Market Operator, *Electricity Statement of Opportunities*, Perth, 15 June 2018, p31.

<sup>288</sup> Submission No. 32 from Professor Ray Wills, Future Smart Strategies, 27 April 2018, p32.

Western Power told the Committee:

Technical work has begun, and will continue into the future, to model the demands of charging EVs via the grid in multiple charging profiles and scenarios. ... Western Power engineers are also modelling various predicted rates of uptake of EVs and what impact this will have on the grid to ensure that we are ready when EV sales start to rise. Western Power is also working closely with the Electric Vehicle Council and Synergy to ensure that we are ready when EV sales start to rise.<sup>289</sup>

In its submission to this Inquiry, Synergy said "[u]nder large-scale uptake, electric vehicles will result in substantial additional load for the network."<sup>290</sup> It told the Committee that its preliminary modelling shows that the impacts of EV uptake will not be substantial for the SWIS and its business until between 2025 and 2030. It considers these timeframes to be broadly consistent with the results of the modelling undertaken by AEMO in its *2017 WEM Electricity Statement of Opportunities*.<sup>291</sup>

The Sustainable Energy Now Inc. submitted that "EV's will comprise a major part of the grid load along regional 'electric highways'" and they may "ultimately increase total grid load by over 20%."<sup>292</sup>

The challenge will be to manage the timing and location of EV charging load. AEMO stated that they may also have a role in easing the SWIS's 'duck curve' if they are charged when the rooftop solar output is at its highest:

...we have hours during the day on very hot sunny days when there is low demand where we worry about the voltage of the system. If we can send the right signals, those would be great hours, for example, if we have storage, to be able to charge batteries; as we are adding in electric vehicles, to be able to charge cars; because we need demand essentially in the afternoons.<sup>293</sup>

The Public Utilities Office also believes there will be a benefit from greater EV use in WA. It said that the SWIS is the 'peakiest' electricity system in Australia, meaning that there is the greatest difference between the daily peak load and low load. Additionally, WA does not have a large amount of network-connected industry and manufacturing that operates overnight which could boost power use. The Public Utilities Office said

<sup>289</sup> Ms Claire Smith, Senior Government Relations Specialist, Western Power, *Questions on Notice*, 4 May 2018, p4.

<sup>290</sup> Submission No. 22 from Synergy, 13 April 2018, p8.

<sup>291</sup> Mr Jason Waters, CEO, Synergy, Questions Taken on Notice, 6 June 2018, p3.

<sup>292</sup> Submission No. 27 from Sustainable Energy Now Inc, 18 April 2018, p16.

<sup>293</sup> Ms Audrey Zibelman, CEO, Australian Energy Market Operator, *Transcript of Evidence*, 21 November 2018, p2.

that using that unused network infrastructure to help charge EVs overnight was a way of minimising network costs, and evening the difference between the peak loads.<sup>294</sup>

There is a potential for Synergy to contribute to the management of network load issues via their contractual arrangements with customers, so as to time the EV charging or have it charge in a particular way. The customer could also choose to charge their EV from their own solar-powered home batteries, which could then be recharged during the low-load daylight hours.

#### Finding 11

Electric vehicles have the potential to lift electricity consumption and flatten network load profiles, improving the security and stability of the power system.

#### The development of autonomous vehicles

Following rapidly on the heels of the development of EVs is the break-through in computing power that has led to the development of autonomous or 'self-drive' vehicles. Professor Ray Wills told the Committee that in 2017, 70% of cars sold had some level of driver-assist functionality, ranging from level 1 to 3. These levels still require drivers to keep their hands on the steering wheel:

That level 1 to 3 is stuff that you will be familiar with. It is emergency braking, it is driver assist, it is lane following and it is active cruise control. That fits into that category. Only 30% of cars were sold with it, but 70% had the option of buying it if you wanted the option.<sup>295</sup>

As the State's internal combustion fleet is replaced over time and transitions to vehicles that are 100% electric, demand for electricity will increase but the marketing of fully-autonomous EVs associated with car sharing and ridesharing (such as with Uber Share currently) might reduce car dependency and likely erode the size of the fleet.<sup>296</sup>

Fully-autonomous self-driving vehicles, with level 5 functionality, are the models that will not have a steering wheel. Professor Wills believes that this higher level of driverassist will start to emerge in many vehicle markets in 2023–24.<sup>297</sup> Tony Seba from Stanford University expects that once level 5 autonomous cars are available, 80% of cars will be retired as car ownership is largely replaced by 'transport as a service', in which fleets of cars offer rides on demand. Part of this preference change will be due to

<sup>294</sup> Mr Aden Barker, Acting Director, Retail and Consumer Policy, Public Utilities Office, Department of Treasury, *Transcript of Evidence*, 14 February 2018, p17.

<sup>295</sup> Professor Ray Wills, Managing Director, Future Smart Strategies, *Transcript of Evidence*, 16 May 2018, p5.

<sup>296</sup> Submission No. 32 from Professor Ray Wills, Managing Director, Future Smart Strategies, 27 April 2018, p16.

<sup>297</sup> Professor Ray Wills, Managing Director, Future Smart Strategies, *Transcript of Evidence*, 16 May 2018, p5.

the rise of 'millenials'. Sheba gives as an early example of this shift in preferences in that 10% of American drivers who traded in their cars in 2017 did not buy a new one.<sup>298</sup>

Recent well-publicised accidents involving autonomous vehicles (such as in California<sup>299</sup> and Arizona<sup>300</sup>) are likely to erode driver confidence in this functionality and could delay its take-up, and make future projections of the number of vehicles with these features more difficult.

<sup>298</sup> Tony Seba, Zero emission miles not zero emission vehicles: Why leaders are driving climate policy in the wrong direction, 21 March 2018. Available at: <a href="https://tonyseba.com/tag/self-driving-cars/">https://tonyseba.com/tag/self-driving-cars/</a>. Accessed on 11 June 2018.

<sup>299</sup> Nicole Karlis, *Salon*, 'A Tesla in Autopilot mode just crashed into a police car', 30 May 2018. Available at: <u>www.salon.com/2018/05/29/a-tesla-in-autopilot-mode-just-crashed-into-a-police-car/</u>. Accessed on 11 June 2018.

<sup>300</sup> Sam Levin and Julia Carrie Wong, *The Guardian*, 'Self-driving Uber kills Arizona woman in first fatal crash involving pedestrian', 20 March 2018. Available at: <a href="https://www.theguardian.com/technology/2018/mar/19/uber-self-driving-car-kills-woman-arizona-tempe">www.theguardian.com/technology/2018/mar/19/uber-self-driving-car-kills-woman-arizona-tempe</a>. Accessed on 11 June 2018.

# Conclusion

With DER, the energy system is moving from a system that is dominated by central large-scale, synchronous power plants with passive consumption, to one that includes a multitude of resources and technologies of various sizes. At the same time, consumers are engaging with their electricity services in new ways, and with this we are seeing a significant proportion of energy being generated at the consumer premises – facilitating a move from a centralised to a decentralised system.<sup>301</sup>

# 6.1 Microgrids already demonstrating their value in WA

Significant change is underway in Western Australia's energy industry and the pace of change is extraordinary. Since the initiation of this inquiry in February 2018, a raft of initiatives in distributed energy resources (DER) have been announced, both in Western Australia (WA) and across the country. In a remarkably short period of time, Microgrids and DER have moved from being marginal technologies to now being a key part of our energy mix, fundamentally changing the way we produce and consume electricity.

This Interim Report has sought to provide a snap shot of the situation in WA as at early 2019. It aims to provide a context for the Final Report's subsequent consideration of the complex challenges, opportunities, enablers and barriers for Microgrids.

This Report identifies a growing international consensus on the meaning and application of the term 'Microgrid'. A lexicon is also emerging to provide shorthand definitions on the physical characteristics, technical configurations and operational environments for an array of Microgrid and DER applications. Consistent terminology assists technical experts, commercial entities and policy makers to constructively engage on technology and standards, business models, policy and regulation.

This Report finds that WA is home to world-leading innovation in Microgrid technologies, much of which is being led by the State-owned electricity Government Trading Enterprises. Multiple projects across the State also demonstrate that the public and private sectors can partner effectively to trial a range of new technologies and commercial models. As the results of these trials are evaluated, it is becoming increasingly clear that Microgrids and DER offer a broad range of potential benefits.

<sup>301</sup> Ms Audrey Zibelman, Managing Director and Chief Executive Officer, Australian Energy Market Operator, *Supplementary Information*, 21 November 2018, p1.

Beyond the immediate application of Microgrid technologies, there are also significant opportunities for WA along the DER asset value chain. The State has a distinct set of global competitive advantages: it is replete with the raw material inputs for battery manufacture; has a mature and sophisticated mining industry; well established transport links; and a politically stable environment in which to do business. Pursuit of the value chain opportunities in DER could generate employment opportunities throughout the State and deliver significant economic growth.

WA's most obvious prospects lie in commodities production, but there are chemicals processing, component manufacturing and assembly opportunities as well. WA is arguably yet to acquire the scale required to move into the later stages of battery production, but a number of global battery industry participants are currently deploying capital into WA and considering further investment along the value chain.

The State Government has also sent bold signals into the market through the announcement of its *Future Battery Industry Strategy* and its support for the Future Battery Industries Cooperative Research Centre, in close collaboration with industry and the research community.

Much of the demand for the commodities required for battery production is also driven by rising global demand for Electric Vehicles (EVs), and this report has found that they also have the potential to fundamentally shape electricity network dynamics. Any consideration of the evolution of power systems must have an eye to the potential impact of an electrified car fleet, given that they can influence both the volume and profile of electricity demand. However, whilst Microgrid and associated technologies are clearly on the march in WA, it is less clear what impact EVs will have, given uncertainty around the rate of EV uptake.

Microgrid applications throughout WA demonstrate the potential value that these technologies offer the State's economy. In both regional and metropolitan contexts, DER trials show that these new technologies can contribute to the provision of affordable, reliable, secure and sustainable energy supply.

The question becomes whether WA is positioned to fully realise the benefits.

The implications of increased DER penetration are significant. There are a range of commercial and operational challenges, particularly associated with a higher proportion of unscheduled generation on WA's power systems. WA's ability to capture the benefits offered by Microgrids is contingent on the complex interplay between physics, technology, markets and regulatory structures.

Having provided an overview of Microgrids and associated technologies in WA, the Final Report for this inquiry will examine the implications of a distributed energy future. It will outline the major operational considerations, discuss regulatory, policy

and market frameworks that affect Microgrid technologies and consider key enablers and barriers to their further expansion.

MS J.J. SHAW, MLA CHAIR

# **Appendix One**

# Committee's Functions and Powers

The functions of the Committee are to review and report to the Assembly on:

- a) the outcomes and administration of the departments within the Committee's portfolio responsibilities;
- b) annual reports of government departments laid on the Table of the House;
- c) the adequacy of legislation and regulations within its jurisdiction; and
- d) any matters referred to it by the Assembly including a bill, motion, petition, vote or expenditure, other financial matter, report or paper.

At the commencement of each Parliament and as often thereafter as the Speaker considers necessary, the Speaker will determine and table a schedule showing the portfolio responsibilities for each committee. Annual reports of government departments and authorities tabled in the Assembly will stand referred to the relevant committee for any inquiry the committee may make.

Whenever a committee receives or determines for itself fresh or amended terms of reference, the committee will forward them to each standing and select committee of the Assembly and Joint Committee of the Assembly and Council. The Speaker will announce them to the Assembly at the next opportunity and arrange for them to be placed on the notice boards of the Assembly.
## **Appendix Two**

### Inquiry's Terms of Reference

The Economics and Industry Standing Committee will investigate and report on the emergence and impact of electricity Microgrids and associated technologies in Western Australia, including:

- a) The potential for Microgrids and associated technologies to contribute to the provision of affordable, secure, reliable and sustainable energy supply, in both metropolitan and regional WA;
- b) Opportunities to maximise economic and employment opportunities associated with the development of Microgrids and associated technologies, including (but not limited to):
  - i. Development of raw material resources/primary commodities
  - ii. Research and development
  - iii. Design, engineering and construction
  - iv. Advanced manufacturing
  - v. ICT
  - vi. Ongoing asset operations;
  - c) Key enablers, barriers and other factors affecting Microgrid development and electricity network operations, including:
    - i. Regulatory barriers
    - ii. Technical factors
    - iii. Workforce planning and development
    - iv. Social factors
    - v. Electric Vehicles; and

d) Initiatives in other jurisdictions to facilitate the development, and maximise the value of, Microgrids and associated technologies.

# Appendix Three

## Submissions Received

	1		1
No.	Name	Position	Organisation
1	Mr Chris Pattas	General Manager,	Australian Energy
		Network Pricing,	Regulator
		Policy and	
	Mc Camantha McCahan	Compliance	
2		Development	VSUN Ellergy
		Manager	
3	Mr Ken Bowron	Executive	Department of
		Director, Building	, Mines, Industry
		and Energy	Regulation and
			Safety
4/4A	Mr Guy Chalkley	Chief Executive	Western Power
		Officer	
5	Mr Shaun Gregory	Executive Vice	Woodside
		President,	
		Exploration and	
C	Mr Donald Vatas	Chief Executive	Columbus Crown
D	wir Donaid Yales	Officer	Columbus Group
7	Mr Chris Rodwell		Chamber of
,	Wir einis Rouweil	Officer	Commerce and
		Childen	Industry (WA)
8	Mr David Karr	Principal/Chief	Interspacial
		Executive Officer	Systems
9	Mr Darren Gladman	Director – Smart	Clean Energy
		Energy	Council
10	Mr Craig de Laine	General Manager,	Australian Gas
		People and	Infrastructure
		Strategy	Group
11	Mr Mark Twidell	APAC Director –	Tesla
12	Mr. Androw Dickoring	Energy Products	Infractivity
12	WIT Andrew Pickering	Chief Investment	Capital
		Officer	Capital
13/13A	Mr J.D. Patrick Creaghan	Managing Director	ATCO Australia
_0, 10, 1		and Chief	
		Operating Officer	
14	Mr Greg Locke	General Manager,	Lendlease
		Services and	
		Engineering, WA	

## Appendix Three

	Mr Greg Allen	Executive General Manager	Energy Made Clean
15	Mr Graeme Hamilton	General Manager, Government and Regulatory Affairs	Alinta Energy
16	Mr Duncan MacKinnon	Wholesale Policy Manager	Australian Energy Council
17/17A/17B	Mr Rod Littlejohn	Managing Director	Tersum Energy
18	Ms Shahana McKenzie	Chief Executive Officer	Bioenergy Australia
19	Mr Cameron Parrotte	Executive General Manager, WA	Australian Energy Market Operator
20/20A/20B	Ms Elizabeth Aitken	General Manager Operations	Perth Energy
21	Mr Noel Schubert		
22/22A/22B	Mr Jason Waters	Chief Executive Officer	Synergy
23	Mr Alan Bansemer	Chair	WA Technology and Industry Advisory Council
24	Mr Neil Canby	Executive Director	Sunrise Energy Group Pty Ltd
25	Dr Farhad Shahnia	Senior Lecturer, School of Engineering and IT	Murdoch University
26	Dr Jill Cainey	Global Applications Director	S&C Electric Company
27	Dr Rob Phillips, Mr Ben Rose, Mr Ian Porter		Sustainable Energy Now Inc.
28	Professor Chris Moran	Deputy Vice- Chancellor, Research	Curtin University
29/29A	Mr David Martin	Managing Director and Co-founder	Power Ledger
30	Mr Frank Tudor	Managing Director/ Chief Executive Officer	Horizon Power
31	Mr Lex Hardie	President	Oil Mallee
	Mr Simon Dawkins	Director	Association of Australia Inc.
32	Professor Ray Wills	Managing Director	Future Smart Strategies

Appendix Three

33	Mr Wayne Wood	Branch Secretary	Australian Municipal, Administrative, Clerical and Services Union (ASU) WA Branch
34	Mr Warren Pearce	Chief Executive Officer	Association of Mining and Exploration Companies
35	Mr Jon Sibley	Principal Policy Advisor	Australian Renewable Energy Agency
36	Ms Anne Pearson	Chief Executive	Australian Energy Market Commission
37	Mr Darren Klemm AFSM	Fire and Emergency Services Commissioner	Department of Fire and Emergency Services
38	Ms Louise Giolitto	Chief Executive Officer	Western Australian Council of Social Service
39	Cr Quentin Davies	Chair	North Eastern Regional Organisation of Councils
40	Ms Suzanne Toumbourou	Executive Director	Australian Sustainable Built Environment Council
41	Mr Karl Raszyk	Chairman	Esperance Community Power Project

# Briefings

Date	Name	Position	Organisation
14 February 2018	Mr Aden Barker	Acting Director,	Public Utilities
		Retail and	Office, Department
		Consumer Policy	of Treasury
	Ms Brooke	Acting Project	
	Eddington	Leader, Energy	
		Industry	
		Development	
		Division	
1 March 2018	Ms Audrey	Chief Executive	Australian Energy
	Zibelman	Officer	Market Operator
	Mr Cameron	Executive General	
	Parrotte	Manager western	
16 March 2019	Dr Michael	Australia CEO and Managing	Carnagia Claan
10 March 2010	Ottaviano	Director	Energy/Energy
	Ottaviano	Director	Made Clean
	Mr Greg Locke	General Manager	Lendlease
	Win Greg Locke	Energy and	Lenaicuse
		Technology	
		Services	
29 March 2018	Mr Guy Chalkley	Chief Executive	Western Power
		Officer	
	Mr Seán	Executive Manager	
	McGoldrick	Asset	
		Management	
	Ms Fiona Bishop	Executive Manager	
		of Change and	
4.4 12040		Innovation	
4 April 2018	Mr Frank Tudor	Chief Executive	Horizon Power
	N/r N/atthow	Dartner	Jackson McDonald
20 Julie 2018	Bowen	Partner	
	Ms Chloe D'Souza	Solicitor	
19 September	Mr Matthew	Partner	lackson McDonald
2018	Bowen		
	Ms Chloe D'Souza	Solicitor	
24 September	Mr Matt Lecar	Principal, FERC and	Pacific Gas and
2018		ISO Relations	Electric Company

San Francisco, USA	Mr Mark Esguerra	Director, Integrated Grid Planning, Grid Integration and Innovation	
	Mr Dean Weng	Senior Project Engineer, Integration of Distributed Energy Resources Power Delivery and Utilization	Electric Power Research Institute
	Mr Haresh Kamath	Senior Program Manager, Distributed Energy Resources Power Delivery and Utilization	
	Dr Tanguy F. Hubert	Senior Project Engineer, Integration of Distributed Energy Resources Power Delivery and Utilization	
	Mr Nicholas Tumilocwicz	Principal Manager, Integration of Distributed Energy Resources Power Delivery and Utilization	
	Mr Rajan Mutialu	Senior Analyst, Policy and Planning Division	California Public Utilities Commission
	Mr Andrew Schwartz	Director, Policy and Electricity Markets	SolarCity (Tesla Energy Operations Inc)
	Mr Andrew Klinkman	Business Development Energy Products	Tesla
25 September 2018 Sacramento, USA	Mr David Hochschild Ms Laurie ten	Commissioner Deputy Director,	California Energy Commission
	Норе	Research and Development Division	

		1	
	Ms Rachel Huang	Director, Energy	Sacramento
		Strategy, Research	Municipal Utility
		and Development	District
	Mr David Brown	Principal	
		Distribution	
		System Engineer,	
		Grid Planning and	
		Operations	
	Mr Timothy Tutt	Program Manager,	
		Legislative and	
		Regulatory Affairs	- HC
	Dr Keith E. Casey	Vice President,	California
		Market	Independent
		Infrastructure	System Operator
		Development	Corporation
	Mr John Goodin	Manager,	
		Infrastructure and	
		Regulatory Policy	
	Mr Keoni Almeida	Manager,	
		Stakeholder and	
		Industry Affairs	
	Mr Clyde Loutan	Principle,	
		Renewable Energy	
		Integration	
27 September	Dr Babak Enayati	Lead R&D	Institute of
2018		Engineer, National	Electrical and
New York, USA		Grid	Electronics
	Dr Aleksi Paaso	Manager,	Engineers (IEEE)
		Emerging	Power and Energy
		Technology,	Society
	Ma Canada d		New Yester
	IVIs Sangeeta	Vice President,	New York Power
	Ranade	Clean Energy	Authority
		Business and	
		Market	
	Ma Densiniala Luce	Development	
		vice President,	
	IVIT BEIL CUOZZO	Auvanced	
		Renewables	
	Mr Domice Colors	Program Analyst	Con Edicor
	ivir Damian Sciano	Director of	Con Ealson
		Bosourco	
		Integration	
	Mr Mark Tarray	Director Decearch	Now York State
	wir wark Torpey	Director, Research	
		and Development	Energy Research

	Mr David Crudele	Program Manager, Smart Grid	and Development Authority
	Mr Ted Kelly	Assistant Counsel	New York State
	Mr Andrew Owens	Electric Power System Platform Technology Manager, New York Power Authority	Public Service Commission
	Ms Nicola Jones	Utility Engineer	
28 September 2018 New York, USA	Ms Sarah McKinley	Manager of State Outreach, Office of External Affairs	Federal Energy Regulatory Commission
	Dr David Kathan	Senior Economist, Office of Energy Policy and Innovation	
	Ms Christy Walsh	Director, Division of Policy Development	
	Ms Valerie Teeter	Manager, Division of Policy Development	
	Mr Ben Foster	Senior Energy Industry Analyst	
	Mr Richard L. Kauffman	Chairman of Energy and Finance for New York	Office of Governor Cuomo
	Ms Victoria Harmon	Senior Advisor to the Chairman of Energy and Finance	
	Ms Marlene Motyka	US and Global Renewable Energy Leader	Deloittes
	Ms Suzanna Sanborn	Senior Manager, Market Insights, Energy and Resources	
	Mr Michael Cusick	Chair, Energy Committee	New York State Assembly

# Public Hearings

Date	Name	Position	Organisation
4 April 2018	Mr Luke	Vice President	Carnarvon Chamber of
Carnarvon	Vandeleur		Commerce and Industry
	Mr Kristan	Committee	
	Pinner	Member	
	Mr Karl	President	Shire of Carnarvon
	Brandenburg		
	Mr Mark	Acting Chief	
	Dacombe	Executive Officer	
	Mr Laurie Curro	General Manager,	Horizon Power
		Power System	
		Services	
	Mr Terry Mohn	General Manager,	
		Advanced	
		Microgrid	
		Development	
	Mr David	Technical	
	Edwards	Visionary,	
		Advanced	
		Microgrid	
		Development	
11 April 2018	Mr Frank Tudor	Chief Executive	Horizon Power
		Officer	
	Mr Laurie Curro	General Manager,	
		Power Systems	
		Services	
	Mr Terry Mohn	General Manager,	
		Advanced	
		Microgrid	
		Developments	
	Mr Mike	General Manager,	
	Houlahan	Commercial	
		Services and	
		Finance	
	Mr Mark	General Manager,	
	Peterson	Consumer Energy	
	Mr Guy Chalkley	Chief Executive	Western Power
		Officer	
	Mr Ben Bristow	Acting Head of	
		Grid	
		Transformation	

Mr Seán McGoldrick         Executive Manager, Asset Management         Synergy           9 May 2018         Mr Jason Waters         Chief Executive Officer         Synergy           Mr Allen Gerber         Manager, Energy Solutions         Australian Energy Market Operator         Australian Energy Market Operator           Mr Cameron Parrotte         Executive General Australia         Australian Energy Market Operator         Australian Energy Market Operator           Mr Martin Mr Dean Sharafi         General Manager, System Management         Future Smart Strategies           Dr Natalia         Principal Policy and Market Development Analyst         Future Smart Strategies           16 May 2018         Professor Ray Wills         Managing Director         Future Smart Strategies           Mr Neil van Drunen         Policy Officer         Association of Mining and Exploration           Mr Robert Klug         Chief Commercial Officer         Sandfire Resources           Mr Joe Ostojich         Deputy Director General, Policy, Planning and Science         Sandfire Resources           Professor Lyn Beazley, AO         Manager Secretariat         Sustralian Services Union (WA)           13 June 2018         Mr Wayne Wood Britheli         Manager Secretary         Australian Services Union (WA)           13 June 2018         Mr Wayne Wood Britheli         Assistant Branch Secretary         Australian S	1				
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Secretary     Energy Made Clean       Ms Tristy     Microgrid Policy     Energy Made Clean       Fairfield     and Project     Expert (New       Projects and     Stakeholder     Engagement)			Ms Jill Hugo	Assistant Branch	Union (WA)
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Engagement)				Stakeholder	
				Engagement)	

	Mr Paul Azzalini	Manager, Strategy and Development	Lendlease
18 June 2018	Dr Christopher	National	Australian Electric
	Jones	Secretary	Vehicle Association Inc
	Dr Farhad	Senior Lecturer	School of Engineering
	Shahnia		and Information
	Dr Tania Urmee	Senior Lecturer	Technology, Murdoch
	Dr GM Shafiullah	Lecturer	University
	Mr Ian	Chief Executive	Clean Energy Finance
	Learmonth	Officer	Corporation
	Ms Samantha	Non-Executive	
	Tough	Director	
	Mr Simon	Executive	
	Brooker	Director,	
		Corporate and	
		Project Finance	
	Professor Peter	Professor,	Curtin University
	Newman, AO	Sustainability	
	Professor Greg	Professor,	
	Morrison	Sustainable Cities	
	Mr Tim Walton	Director Energy	
		Research	
		Initiatives	
	Mr Dermot	Regional Advisor	Clean Energy Council
	Costello	WA	
	Mr Greg Szozda	Principal	Jacobs Group (Aust) Pty
		Consultant,	Ltd
		Power	
		Generation	
		Engineering	
	Mr Jason Greeff	Lawyer	Australia
20 June 2018	Dr Ray Challen	Governing Body Member	Economic Regulation Authority
	Mr Paul Kelly	Executive	
		Director,	
		Regulation and	
		Inquiries	
22 August 2018	Dr Brian Spak	Leader, Grids and	Commonwealth
		Renewable	Scientific and Industrial
		Energy	Research Organisation
		Integration	
10 October	Mr Patrick	Managing	ATCO Australia
2018	Creaghan	Director and Chief	
		Operating Officer	

	Mr Stevan Green	President, Gas	
		Division	
	Mr Steven Lewis	General Manager,	
		Business	
		Development	
	Ms Elizabeth	General Manager,	Perth Energy
	Aitken	Operations	
	Mr Patrick Peake	General Manager,	
		EMR, Regulation	
	Ms Nicole	Manager,	
	SanGregory	Wholesale Risk	
		and New	
17.0.1		Products	
17 October	Mr Rod	Managing	Tersum Energy
2018	Littlejohn	Director	
	Miss Erin Stone	Energy Economist	
	Mr Murray	Chair	Geraldton Community
	настеу		Energy Steering
	Mr David Martin	Managing	Committee
	IVIT David Iviartin	Director	Power Ledger
	Mc Sarah	Director Dolicy Applyst	
	Graham	Policy Analyst	
31 October	Mr Laurie Curro	General Manager	Horizon Power
2018	IVIT Laurie Curro	Power Systems	TIONZON FOWER
2010	Mr Terry Mohn	General Manager	
	in reny monit	Advanced	
		Microgrid	
		Development	
	Mr Mark	General Manager,	
	Paterson	Consumer Energy	
21 November	Mr Chris Pattas	General Manager,	Australian Energy
2018		Distribution	Regulator
	Mr Andrew	Chief Executive	Energy Networks
	Dillon	Officer	Australia
	Mr Stuart	General Manager,	
	Johnston	Network	
		Transformation	
	Ms Audrey	Chief Executive	Australian Energy
	Zibelman	Officer	Market Operator
	Mr Cameron	Executive General	
	Parrotte	ivianager WA	
	Mr Martin	Group Manager,	
	IVIATICKA	WA Market	
22 November	Ma Cunz Challelan	Operations	Mastern Dourse
23 November	wir Guy Chaikley	Officer	western Power
2010		Unicer	

	Mr Michael Crevola	Chief Financial Officer	
	Mr Seán McGoldrick	Executive Manager, Asset	
		Management	
	Mr Ben Bristow	Manager,	
		Distribution Grid	
		Strategy	
	Mr David	Manager, DER	Australian Energy
	Markham	and Networks	Council
	Mr Scott Davis	Policy Delicy Advisor M/A	
		Commissioner	Australian Enorgy
	Shepherd	Commissioner	Market Commission
	Ms Anne	Chief Executive	
	Pearson		
	Mr Andrew	Director,	
	Truswell	Transmission and	
		Distribution	
		Networks	
28 November	Mr Will	General Manager,	Synergy
2018	Bargmann	Corporate	
		Services	
	Mr Jason Froud	Manager, Policy	
	Mr Zaeen Khan	Executive	Public Utilities Office,
		Director	Department of Treasury
	Mr Aden Barker	Program Director,	
		Wholesale Energy	
		Markets	

# Appendix Six

# Closed Hearing

Date	Name	Position	Organisation
18 June 2018	Mr Tony Stocken	Senior Business	Tesla Motors
		Development	Australia Pty Ltd
		Manager	
	Ms Emma Fagan	Energy Policy	

## **Appendix Seven**

Scheduled and Semi-scheduled (Large-scale Renewable) Generators in the SWIS



Scheduled generators and their capacity credits<sup>302</sup>

 <sup>302</sup> Australian Energy Market Operator, *Electricity Statement of Opportunities*, 15 June 2018, p14. Available at: <u>www.aemo.com.au/-</u> /media/Files/Electricity/WEM/Planning\_and\_Forecasting/ESOO/2018/2018-WEM-ESOO-<u>Report.pdf</u>. Accessed on 12 December 2018.

#### Appendix Seven

# Semi-scheduled (large-scale renewable) generators and their capacity credits<sup>303</sup>



 <sup>303</sup> Australian Energy Market Operator, *Electricity Statement of Opportunities*, 15 June 2018, p14. Available at: <u>www.aemo.com.au/-</u> /media/Files/Electricity/WEM/Planning\_and\_Forecasting/ESOO/2018/2018-WEM-ESOO-<u>Report.pdf</u>. Accessed on 12 December 2018.

### Rapid Growth of Microgrids in Other Jurisdictions

### Introduction

The development of Microgrid projects in other jurisdictions is proceeding rapidly, especially in locations such as Antarctica and other remote communities. Navigant Research estimated in 2017 that there were approximately 1,870 active Microgrid projects in 123 countries providing nearly 21GW of generation capacity. About 320MW of this capacity was from solar panels<sup>304</sup> and a third (8.4GW) is provided in the Asia-Pacific region.<sup>305</sup>

### **Australian Jurisdictions**

#### ACT

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) has called for expressions of interest for companies to build a 850kW ground-mounted solar array at its Canberra Deep Space Communication Complex in Tidbinbilla, ACT. The CSIRO intends to buy all of the output of the proposed solar farm and associated battery through a power purchase agreement and expects to save significant costs compared to its current tariff for electricity from the main grid.<sup>306</sup>

#### **Northern Territory**

The \$59 million Solar Energy Transformation Program (SETuP) is jointly funded by the Australian Renewable Energy Agency (ARENA) and the Northern Territory Government. 10MW of solar generation capacity will be installed across 15 remotes sites in the second round. This will replace expensive diesel-generated power in 28 off-grid Indigenous communities. SETuP began in 2017 with the integration of 3.3MW of solar photovoltaic (PV) panels across 10 remote communities. The Daly River Nauiyu project is the only one to have installed a 2MWhr lithium-ion battery and is now providing solar power during the day for its 450 residents. The second round of projects includes

<sup>304</sup> Navigant Research, Microgrid Deployment Tracker 4Q17, 19 February 2018. Available at: www.navigantresearch.com/research/microgrid-deployment-tracker-4q17. Accessed on 6 June 2018.

<sup>305</sup> Power, *Microgrid Deployment Continues to Grow Worldwide*, 7 February 2018. Available at: <u>www.powermag.com/microgrid-deployment-continues-to-grow-worldwide/</u>. Accessed on 6 June 2018.

<sup>306</sup> Sophie Vorrath, *One Step Off the Grid*, 'Canberra Deep Space complex to go solar, as CSIRO launches tender', 4 December 2018. Available at: <u>https://onestepoffthegrid.com.au/canberra-deep-space-complex-go-solar-csiro-launches-tender/</u>. Accessed on 4 December 2018.

a 1MW solar array at the Tiwi Island community of Wurrumiyanga, which will ultimately supply power to three communities on Bathurst and Melville Islands.<sup>307</sup>

#### Tasmania

#### Bruny Island

A three-year solar and battery trial carried out with 40 households on Bruny Island off Tasmania was designed to create a 'microcosm of a future Australian electricity grid'. The CONSORT trial is led by Australian National University's Network Aware Coordination platform which utilises a series of smart algorithms that control multiple solar and battery installations to provide power to the grid when it is needed. With just 3.5% of homes on Bruny Island participating in the trial it has already reduced the Island's diesel usage by 30%.<sup>308</sup>

The software used in the trial and placed at each participant's house monitors their installation and uses their battery power in the most efficient way by 'talking to' all the installations to decide when it needs to provide electricty 'at the best price'.

The project is a joint venture between:

- the University of Tasmania, which examined the social acceptance of the technology;
- the University of Sydney, which calculated the battery payment structures;
- the Australian National University, which deployed the network aware coordinating algorithms to bring together the battery network;
- TasNetworks, which controlled the distribution of energy;
- Reposit Power, which ran the energy trading and control system, and
- ARENA which provided around \$2.9 million in funding.<sup>309</sup>

#### Fraser Island

Following on the success of the installation of a similar renewable energy system on King Island (see below), Hydro Tasmania in December 2017 switched on the Flinders Island Hybrid Energy Hub which combines 900kW of wind, 200kW solar, and a mix of

<sup>307</sup> One Step Off The Grid, 'Another 28 off-grid communities to go solar in Northern Territory', 31 May 2018. Available at: <u>https://onestepoffthegrid.com.au/another-28-off-grid-nt-</u> communities-go-solar-arena-backed-scheme/. Accessed on 6 June 2018.

<sup>308</sup> CONSORT, CONSORT Bruny Island Battery Trial, 2019. Available at: <u>http://brunybatterytrial.org/</u>. Accessed on 2 April 2019.

<sup>309</sup> WAToday, 'Bruny Island solar trial a microcosm for future energy system', 22 April 2018. Available at: <u>www.watoday.com.au/business/the-economy/bruny-island-solar-trial-a-microcosm-for-future-energy-system-20180417-p4za5f.html</u>. Accessed on 6 June 2018.

enabling technologies including 300kWh of battery storage, a 850kVA flywheel, and a 1.5MW dynamic resistor. This Hub is already providing levels of about 80% renewables and significantly reducing the use of its 3MW diesel power station at a cost of just \$13 million.<sup>310</sup>

#### King Island

Over the past 20 years, Hydro Tasmania has been installing renewable energy systems on King Island in the Bass Strait, along with enabling technology such as energy storage. The Island now relies on renewables for 65% of its annual electricity needs. It's Advanced Hybrid Power Station has about 2.4MW of wind generation and 0.4kW of solar. Hydro Tasmania incorporated a 1.5MW dynamic resistor to regulate the system's frequency. Additional technologies, work in concert with the dynamic resistor to allow the system to run with the diesel generators shut down.<sup>311</sup> The development of the King

### Figure A8.1- Different power outputs from King Island's Advanced Hybrid Power Station



Island Renewable Energy Integration Project has seen the annual consumption of diesel nearly halve: from 4.5 million litres to 2.6 million litres. Hydro Tasmania plans to lower this further to just 1.6 million litres per annum.<sup>312</sup>

As illustrated in Figure A8.1,<sup>313</sup> on a day in July 2018, these sources were meeting the Island's power needs of 1.56MW while also recharging its battery, and discharging 470kW of excess power to a resistor.

#### Victoria

The Victorian Government will provide up to \$10 million in grant funding to support innovative, market driven commercially ready Microgrid demonstration projects in Victoria as part of its Microgrid Demonstration Initiative. Grants of between \$100,000

<sup>310</sup> Sophie Vorrath, *Renew Economy*, 'Flinders Island makes switch to renewables, with solar, wind and energy storage Hub', 8 November 2017. Available at: <u>https://reneweconomy.com.au/flinders-island-makes-switch-to-renewables-with-solar-windand-energy-storage-hub-60610/</u>. Accessed on 25 March 2019.

<sup>311</sup> Rocky Mountain Institute, King Island, November 2015, p18. Available at: <u>https://d231jw5ce53gcq.cloudfront.net/wp-</u> <u>content/uploads/2017/04/Islands\_Microgrid\_Profiles\_Islands\_Global\_Remote\_Communities\_Ca</u> <u>seStudy\_2015.pdf</u>. Accessed on 7 June 2018.

<sup>312</sup> Submission No. 32 from Future Smart Technologies, 27 April 2018, p13.

<sup>313</sup> Hydro Tasmania, King Island Renewable Energy Integration Project, 2014. Available at: <u>www.kingislandrenewableenergy.com.au</u>. Accessed on 16 July 2018.

and \$5 million will be available to facilitate and implement state-wide Microgrid demonstration projects.<sup>314</sup> As an example, \$4.5 million is being provided to Origin Energy to develop a \$20 million cloud-based virtual power plant project that will distribute power during peak periods from up to 650 customers with solar PV and batteries. These investments are in addition to the \$1.3 billion Solar Homes program which will deliver half-priced solar panels to 650,000 Victorian households and solar hot water systems to 60,000 homes, with no upfront cost.<sup>315</sup>

#### International projects

Australia is a member of the International Smart Grid Action Network (ISGAN) which was launched in July 2010 at the first Clean Energy Ministerial meeting, a forum for energy and environment ministers and stakeholders from 23 countries and the European Union. In April 2011, ISGAN was established as the International Energy Agency Implementing Agreement for a Co-operative Programme on Smart Grids.<sup>316</sup>

#### Antarctica

#### Mawson Station

The Australian Antarctic Division's (AAD) Mawson Station is located at the edge of the Antarctic plateau and is the longest continuously operating station south of the Antarctic Circle. In early 2003, AAD installed two Enercon 300kW wind turbines to add to its 550kW of diesel generator capacity, becoming the first nation to install wind generators in Antarctica. In 2014, the wind turbines generated enough electricity to reduce Mawson's diesel consumption by 288,000 litres.<sup>317</sup> The wind farm, together with the power-house control and storage system, provide 95% of the station's load for long periods of time.<sup>318</sup>

#### Ross Island

In 2009, engineering company ABB installed a wind and diesel Microgrid at New Zealand's Scott Base and America's McMurdo Station in Antarctica, which are home to about 1,200 people. The system consists of a 500kW PowerStore grid stability system,

<sup>314</sup> Department of Environment, Land, Water and Planning, *Microgrids*, December 2017, p1. Available at: <u>www.energy.vic.gov.au/\_\_data/assets/pdf\_file/0027/92394/Microgrids-Fact-Sheet.pdf</u>. Accessed on 7 June 2018.

<sup>315</sup> Hon Daniel Andrews MP, Premier, Building Victoria's Largest Virtual Power Plant, 5 September 2018. Available at: www.premier.vic.gov.au/building-victorias-largest-virtual-power-plant/. Accessed on 11 December 2018.

<sup>316</sup> International Smart Grid Action Network (ISGAN), *About Us*, nd. Available at: <u>www.iea-isgan.org/about-us/</u>. Accessed on 7 June 2018.

<sup>317</sup> Kaitlyn Bunker, *Renew Economy*, 'Renewables at the South Pole', 12 November 2015. Available at: <u>https://reneweconomy.com.au/renewables-at-the-south-pole-49298/</u>. Accessed on 6 June 2018.

<sup>318</sup> Australian Antarctic Division, Wind power, 8 July 2016. Available at: www.antarctica.gov.au/living-and-working/station-life-and-activities/renewable-energy/windpower. Accessed on 6 June 2018.

the Microgrids Control distributed control system for the integration of all the power station equipment and three 300kW wind turbines. The system saves approximately 460,000 litres of fuel annually.<sup>319</sup>

#### Canada

The Nemiah Valley of British Columbia is home to the Xeni Gwet'in First Nation and is separated by about 100km of road from the nearest electricity grid. In 2007 Canada's first PV-diesel Microgrid was installed there. Like most of Canada's 300 remote communities, it had relied primarily on diesel-powered generators for its electricity. The 27.4kW of PV represent about 36% of peak load and supplies roughly 11% of the electricity used in the community annually. These measures save approximately 26,000 litres of fuel annually - a 25% reduction.<sup>320</sup>

#### Caribbean

The Rocky Mountain Institute's *Islands Energy Program* will transition 13 Caribbean islands to Microgrids. The project has already installed 140MW of renewable energy and batteries and will install a further 95MW by 2020 at a cost of \$300 million. The residents of these island nations pay some of the highest electricity prices in the world due to their near-total dependence on imported diesel fuel. The program uses advanced techniques to protect the Microgrids from hurricanes.<sup>321</sup>

#### China

The Chinese National Energy Administration is planning 30 Microgrid demonstrations as part of its renewable energy development plan. The first sites were chosen in 2017. A team at the Berkeley Lab in the US is collaborating with the Institute of Electrical Engineering of the Chinese Academy of Sciences, which will oversee the demonstration projects.<sup>322</sup>

#### India

The Smart Power India energy service company and its partners are operating 106 Microgrids across the states of Bihar, Jharkhand and Uttar Pradesh. The plant sizes

<sup>319</sup> ABB, Ross Island research station, 2018. Available at: <u>https://new.abb.com/distributed-energy-microgrids/references/ross-island</u>. Accessed on 6 June 2018.

<sup>320</sup> Sophie Pelland et. al, IEEE Transactions on Sustainable Energy, 'Nemiah Valley Photovoltaic-Diesel Mini-Grid: System Performance and Fuel Saving Based on One Year of Monitored Data', vol. 3, no. 1, 2011, p1. Available at: <u>www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/canmetenergy/files/pubs/2011-075.pdf</u>. Accessed on 7 June 2018.

<sup>321</sup> Rocky Mountain Institute, *Islands Energy Program*, nd. Available at: <u>https://rmi.org/our-work/global-energy-transitions/islands-energy-program/</u>. Accessed on 6 June 2018.

<sup>322</sup> Berkeley Lab, Collaboration with China Energy Group on Energy System Planning and Grid Integration, 2018. Available at: <u>https://building-microgrid.lbl.gov/projects/collaboration-chinaenergy-group-energy</u>. Accessed on 6 June 2018.

range from 10kW to 70kW, and total 3.6MW. The Microgrids serve over 42,500 residents.<sup>323</sup> Smart Power India was established by The Rockefeller Foundation to implement the Smart Power for Rural Development Program. The Program aims to electrify 1,000 Indian villages, housing more than a million people.<sup>324</sup>

#### Japan

A committed effort is underway in Japan to make dozens of its towns and communities partly self-sufficient from the power grid using a \$33.3 billion Government-funded *National Resilience Program*. The Program focuses on building back-up capabilities for Japan's cities and towns in the event of a disaster, such as the tsunami that caused a meltdown at the Fukushima nuclear power plant in 2011.<sup>325</sup>

#### Korea

A number of Korea's islands are moving to greater use of renewable energy as a way of becoming carbon-free. For example, Jeju Island, home to 600,000 people, hopes to become carbon-free by 2030 with a project worth USD\$5.4 billion. It is spending USD\$100 million to help nearby Gapado Island, home to 177 people, to become carbon-free. Two wind power generators totalling 500kW in capacity have been installed on Gapado and half of the 97 houses on the island have solar generators installed, with excess energy stored in batteries.<sup>326</sup>

#### **Puerto Rico**

In June 2018, in discussing his *Energy 2.0* plan and a future that would allow his citizens to choose whether they want to stay on the grid or leave, Puerto Rico Governor Ricardo Rosselló said, "We want Microgrids everywhere." Currently 98% of the island's energy comes from fossil fuels and the Governor wants to rapidly transition to 40-45% renewable energy.<sup>327</sup> Rosselló's Government later issued five requests for tender for the development of Microgrids that can operate independently from the grid. This

<sup>323</sup> Smart Power India, *Smart Power Mini-Grids*, March 2017. Available at: <u>www.smartpowerindia.org/our-mini-grids/</u>. Accessed on 6 June 2018.

<sup>324</sup> Smart Power India, *About Us*, 2017. Available at: <u>www.smartpowerindia.org/about-us/</u>. Accessed on 6 June 2018.

 <sup>325</sup> Reuters, 'Quiet energy revolution underway in Japan as dozens of towns go off the grid', 19 September 2017. Available at: <u>www.reuters.com/article/us-japan-energy-revolution/quiet-energy-revolution-underway-in-japan-as-dozens-of-towns-go-off-the-grid-idUSKCN1BU0UT</u>. Accessed on 6 June 2018.

<sup>326</sup> EcoWatch, South Korea's Plan to Have World's First Carbon-Free Island, 7 June 2016. Available at: www.ecowatch.com/south-koreas-plan-to-have-worlds-first-carbon-free-island-1891165990.html. Accessed on 6 June 2018.

<sup>327</sup> Microgrid Knowledge, "We Want Microgrids Everywhere," says Puerto Rico's Gov. Rosselló, 6 July 2018. Available at: <u>https://microgridknowledge.com/microgrids-puerto-rico-rossello/</u>. Accessed on 6 June 2018.

follows the near total collapse of Puerto Rico's electricity transmission grid following Hurricane Maria in September 2017.<sup>328</sup>

#### Singapore

The Renewable Energy Integration Demonstrator is based on Semakau Island (located south of the main island) and is a research and development project testing solutions for "sustainable multi-activity off-grid communities in Southeast Asia." It was established in 2014 and is supported by the Nanyang Technological University and the Singapore Economic Development Board and the National Environment Agency.<sup>329</sup>

#### Sweden

In the Swedish rural town of Simris a large European utility company has been testing the islanding of a 100% renewable-powered Microgrid. Once every five weeks, the 150 E.ON customers become part of an islanded Microgrid which relies on the privatelyowned 500kW of wind and 442kW of solar generation capacity, as well as a 800kW battery installed by E.ON, and a back-up renewable fuel generator.

The trial in Simris now forms a part of the \$26 million European Union's biggest research and innovation program, the InterFlex project. The project will run until the end of 2019, and aims to provide data into six innovation streams: islanding, demand response, energy storage, cross energy carrier synergies, electric vehicles, and grid automation. Having successfully demonstrated the islanding capabilities, the Simris project will now integrate demand-response technologies into its Microgrid. The Simris system operates with zero inertia when islanded from the grid.<sup>330</sup>

#### Thailand

The Thai-Government-backed renewable energy developer BCPG and Western Australian company Power Ledger announced in December 2017 an agreement to bring peer-to-peer renewable energy trading to Thailand while collaborating on the formation of a Microgrid development in Bangkok. This project will develop 6–10 multi-storey apartment buildings trading between 1–2MW of embedded solar generation.<sup>331</sup>

<sup>328</sup> Microgrid Knowledge, *Puerto Rico Seeks Developers for Five Industrial Microgrids*, 10 July 2018. Available at: <u>https://microgridknowledge.com/industrial-microgrids-puerto-rico/</u>. Accessed on 6 June 2018.

<sup>329</sup> Nanyang Technological University, *About REIDS*, 2012. Available at: <u>http://erian.ntu.edu.sg/REIDS/Pages/AboutREIDS.aspx</u>. Accessed on 6 June 2018.

<sup>330</sup> Yasmin Ali, One Step Off The Grid, '100% renewable microgrid for Sweden's rural community of Simris', 23 May 2018. Available at: <u>https://onestepoffthegrid.com.au/100-renewable-microgrid-swedens-rural-community-simris/</u>. Accessed on 6 June 2018.

<sup>331</sup> Power Ledger, *Power Ledger Signs Agreement With BCPG To Bring Distributed Renewable Energy Trading To Thailand!*, 17 December 2017. Available at: <u>https://medium.com/power-</u>

#### **United Kingdom**

#### **Orkney**

Orkney is an archipelago of more than 70 islands off the northeastern coast of Scotland. Only approximately 20 islands are inhabited by a population of over 21,000 people.<sup>332</sup> Work on Orkney's Microgrid began in 2004 and was completed in 2009, becoming the UK's first smart grid. Almost 20MW of renewable generation was connected to the system and an Active Network Management controller manages their output, in real time, to match network capacity.<sup>333</sup>

#### Falkland Islands

Beginning in 2007, several wind farms were installed in the Falkland Island archipelago, totalling approximately 2MW. This increased annual electricity generation from wind to about one-third of annual demand, and saves over 1.4 million litres of fuel annually.<sup>334</sup>

#### Shetland Islands

The Northern Isles New Energy Solutions (NINES) project ran between 2011 and 2016 and aimed to deliver an affordable and reliable energy system for the Shetland Islands, which is not connected to the UK's national electricity network. The £18 million project was led by Scottish Hydro Electric Power Distribution, which is the owner and operator of Shetland's network. NINES trialled a 1MW battery to manage fluctuations in supply and demand for the 234 customers participating in the trial.<sup>335</sup>

The project demonstrated that an islanded-electricity distribution system "can operate securely with a high penetration of local renewable generation." It trialled domestic demand side management combined with new monitoring and control systems to manage the electricity network. More than 8.5MW of renewable energy was connected on Shetland during the project. The daily average of renewable generation has now reached 30% of its total energy requirements.<sup>336</sup>

ledger/power-ledger-signs-agreement-with-bcpg-to-bring-distributed-renewable-energy-tradingto-thailand-cd68d09c23ac. Accessed on 7 June 2018.

<sup>332</sup> The Editors of Encyclopaedia Britannica, *Orkney Islands*, 20 February 2019. Available at: <u>www.britannica.com/place/Orkney-Islands</u>. Accessed on 29 March 2019.

<sup>333</sup> Scottish and Southern Electricity Networks, Orkney Smart Grid, nd. Available at: www.ssepd.co.uk/OrkneySmartGrid/. Accessed on 7 June 2018.

<sup>334</sup> Rocky Mountain Institute, Falkland Islands, November 2015, p17. Available at: <u>https://d231jw5ce53gcq.cloudfront.net/wp-</u> <u>content/uploads/2017/04/Islands Microgrid Profiles Islands Global Remote Communities Ca</u> <u>seStudy 2015.pdf</u>. Accessed on 7 June 2018.

<sup>335</sup> NINES, *Our project*, 23 May 2018. Available at: <u>www.ninessmartgrid.co.uk/our-project/</u>. Accessed on 7 June 2018.

<sup>336</sup> Scottish and Southern Electricity Networks, Smart grid and energy storage on Shetland demonstrates the power of renewable energy, 7 June 2017. Available at: <u>http://news.ssen.co.uk/news/all-articles/2017/06/northern-isles-new-energy-solutions-project/</u>. Accessed on 7 June 2018.

#### **United States of America**

#### <u>Alaska</u>

Wind-powered community Microgrids in Lower Koskokwin, Alaska, provide electricity and heat to four rural communities, reducing residents' fuel bills and their dependence upon diesel fuel. The Microgrids combine diesel, wind energy and battery storage. Additionally, the energy creates heat by sending excess wind power to thermal heating storage units in homes. Each of the communities have a diesel power plant and the project permits the local utility to sell power for heating at half the cost of what residents were paying for diesel-based power.<sup>337</sup>

#### **California**

The Clean Coalition is working with several utilities on developing community-scale Microgrid demonstration projects in San Francisco and Sonoma County, California, and Long Island, New York.<sup>338</sup> More than 100 Microgrids are operating or under development in California and the California Energy Commission is developing a road map to further commercialize Microgrids. Many of these developments are aimed at reducing the impact of disasters, such as wild fires and storms, on the electricity grid.<sup>339</sup>

#### <u>Hawaii</u>

Hawaii's State Government gave a direction in 2015 to state utilities to generate 100% of their electricity from renewable energy sources by 2045. The Hawaiian Electric Company announced in 2018 that it would add seven large-scale solar and battery storage projects which would bring a total of 1,055MWh of storage and 260MW of solar capacity to the islands of Oahu, Maui, and Hawaii. This adds to the existing 500MW of renewable energy capacity and will ensure that the 100% target is met by 2040.<sup>340</sup>

#### <u>Illinois</u>

In March 2018 ComEd was authorized to establish a 10-year Microgrid demonstration project in southern Chicago. The Bronzeville Community Microgrid Project will connect with a Microgrid at the Illinois Institute of Technology, creating one of the first utility-scale Microgrid clusters in the US. ComEd stated it was committed to working with the Environmental Defense Fund and the consumer group Citizens Utility Board, to develop

<sup>337</sup> Lisa Cohn, *One Step Off The Grid*, 'Wind-powered microgrids heat "boxes of bricks" in Alaska homes', 13 December 2017. Available at: <u>https://onestepoffthegrid.com.au/wind-powered-microgrids-heat-boxes-bricks-alaska-homes</u>. Accessed on 6 June 2018.

<sup>338</sup> Clean Coalition, *Community Microgrids*, 2018. Available at: <u>www.clean-coalition.org/our-work/community-microgrids/</u>. Accessed on 6 June 2018.

<sup>339</sup> Peter Asmus, San Francisco Chronicle, 'S.F. blackout underscores need for microgrids', 27 April 2017. Available at: <u>www.sfchronicle.com/opinion/openforum/article/S-F-blackout-underscoresneed-for-microgrids-11104815.php</u>. Accessed on 6 June 2018.

<sup>340</sup> Joshua Hill, Renew Economy, 'Hawaii to add more than 1GWh of storage as it heads to 100% renewables', 12 October 2018. Available at: <u>https://reneweconomy.com.au/hawaii-to-add-more-than-1gwh-of-storage-as-it-heads-to-100-renewables-24508/</u>. Accessed on 11 December 2018.

a pilot tariff that would allow organisations other than utilities to develop and operate Microgrids.<sup>341</sup>

#### New York University

New York University is one of the largest universities in the US. It has produced its own power since the 1960's, transitioning away from oil-fired technology towards a natural gas-fired combined heat and power facility, with Microgrid capability. The system has a generation capacity of 13.4MW and supplies electricity to 22 buildings and heat to 37 buildings across the university campus. The University's Microgrid consists of two 5.5MW gas turbines for producing electricity, coupled with heat-recovery steam generators and a 2.4MW steam turbine. The Microgrid is connected to the external grid and purchases electricity when demand is higher than that generated on-site.<sup>342</sup>

#### Vermont

In May 2017 Green Mountain Power (GMP) announced a new program to work with Tesla and utilise their Powerwall 2 batteries and GridLogic software platform to use stored energy to help drive down costs for their customers. GMP estimated that, paired with the installation of PV panels on their own land, the program would be the equivalent of a reduction of up to 10MW of their peak load. GMP plans to deploy up to 2,000 Powerwall batteries to homeowners for a \$15 monthly fee or a \$1,300 one-off cost. This would eliminate the need for their customers to rely on manually-controlled fossil fuel backup generators.<sup>343</sup>

<sup>341</sup> Daily Energy Insider, *Illinois regulators approve microgrid project on South Side of Chicago*, 1 March 2018. Available at: <u>https://dailyenergyinsider.com/featured/11003-illinois-regulators-approve-microgrid-project-south-side-chicago/</u>. Accessed on 7 June 2018.

<sup>342</sup> Microgrids at Berkley Lab, New York University, 2018. Available at: <u>https://building-microgrid.lbl.gov/new-york-university</u>. Accessed on 6 June 2018.

<sup>343</sup> Green Mountain Power, GMP Launches New Comprehensive Energy Home Solution from Tesla to Lower Costs for Customers, 12 May 2017. Available at: <u>https://greenmountainpower.com/press/gmp-launches-new-comprehensive-energy-home-solution-tesla-lower-costs-customers/</u>. Accessed on 7 June 2018.

# Appendix Nine

# Glossary

TERM	DESCRIPTION	
AAD	Australian Antarctic Division	
AEMO	Australian Energy Market Operator	
AEVA	Australian Electric Vehicle Association	
AMEC	Association of Mining and Exploration Companies	
ARENA	Australian Renewable Energy Agency	
BEV	Battery Electric Vehicle	
CCIWA	Chamber of Commerce and Industry (WA)	
CEFC	Clean Energy Finance Corporation	
CEM	Clean Energy Ministerial	
CEO	Chief Executive Officer	
СРТ	Cloud Predictive Technology	
CRC	Cooperative Research Centre	
CSIRO	Commonwealth Scientific and Industrial Research Organisation	
DCEP	Dunsborough Community Energy Project	
DER	Distributed Energy Resource(s) (e.g. solar PV panel)	
DERMS	Distributed Energy Resources Management System	
DPIRD	Department of Primary Industries and Regional Development	
EN	Embedded Networks	
ENAC	Electricity Networks Access Code 2004 (WA)	
ESH	Electric Super Highway	
EV	Electric drive vehicle/electric vehicle	
EVI	Electric Vehicle Initiative	
GCE	Geraldton Community Energy	
GMP	Green Mountain Power	
HEV	Hybrid Electric Vehicle	
IEEE	Institute of Electrical and Electronics Engineers	
ISGAN	International Smart Grid Action Network	
JTSI	Department of Jobs, Tourism, Science and Innovation	
MRIWA	Minerals Research Institute of Western Australia	
NINES	Northern Isles New Energy Solutions	
NIS	Non-Interconnected Systems	
NWIS	North West Interconnected System	
PHEV	Plug-in Hybrid Electric Vehicle	
РРА	Power Purchase Agreement	
PRC	People's Republic of China	
prosumer	individual electricity consumer who also produces power back	
	into the network	
PV	photovoltaic	
SCADA	Supervisory Control and Data Acquisition	

Appendix Nine

SETuP	Solar Energy Transformation Program
SFMTA	City of San Francisco and its Municipal Transportation Agency
SPS	Stand-Alone Power System(s)
SWIS	South West Interconnected System
tpa	tonnes per annum
VPP	Virtual Power Plant
VRFB	Vanadium Redox Flow Batteries
WA	Western Australia
WEM	Wholesale Electricity Market
ZEV Mandate	Californian Zero Emission Vehicle Program



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