Chapter 4

Manufacturing and value-chain activities—opportunities and challenges

Introduction

4.1 This chapter focuses on the opportunities and challenges associated with electric vehicle (EV) manufacturing and value-chain activities including:

- EV and EV component manufacturing;
- Battery manufacturing and commodity value-adding; and
- Charging infrastructure.

EV and EV component manufacturing

4.2 The Committee has heard about the future opportunities for manufacturing in the industries related to EVs. A number of companies the Committee has spoken to and visited are already on the front foot seeking to take advantage of the commercial opportunities presented by the rising consumer demand for EVs.

4.3 In its submission, Deakin University shared its positive outlook for manufacturing in this area:

> No component, nor assembly of a complete electric vehicle, is beyond the capability of Australian industry.
>
> The opportunities for local manufacture will, therefore, be determined on price, production volumes and access to requisite designs, which may otherwise be constrained by intellectual property protections.
>
> Volume can be enhanced by exports and intellectual property issues addressed through partnerships. A comprehensive analysis of supply chain requirements and opportunities should be undertaken by an industry capability network or similar agency.[1]

4.4 One of the inherent benefits to EVs is that they are less complex than internal combustion engine vehicles and hence have 'thousands of fewer components per vehicle'.[2] Not only does this lead to potentially lower costs per vehicle (excluding the batteries) for the consumer (and cheaper servicing), but it also reduces the capital cost and complexity of manufacturing including logistics.[3]

4.5 There will also be changes to how motor vehicles are made and how much they cost to build. Uniti Australia has stated that 'new advanced manufacturing processes, light-weight materials and new vehicle designs have led to a dramatic

---

1 Deakin University, *Submission 35*, p. 3.

2 Association of Mining and Exploration Companies (AMEC), *Submission 20.2*, p. 4.

3 See, for example: University of Adelaide, *Submission 91*, p. [3]; Uniti Australia, *Submission 2*, p. [3].

reduction in the costs of assembling vehicles'.[4] Dr Brett Dale, Chief Executive Officer of the Motor Trades Association of Queensland (MTAQ) made his views clear on the future of manufacturing, including custom order motor vehicles:

> I [spoke about] the concept of 3D printing. With the way in which that's developing and the rate at which it's developing, there's a real possibility that, in the next five to 10 years, you'll custom print the car that you want. When you look at the components associated with electric vehicles, there are way fewer than the existing fleets on the road. Printing a fully electric vehicle, which will be autonomous by then, could be done custom; you would get a product comparative to an architecturally designed home or a spec home. So, manufacturing is the key, and governments need to support the investment into that, because it will be the technology that determines whether we are a competitive nation.[5]

4.6 The advent of automated vehicles will also likely present changes to structural and material requirements, and vehicle design, 'which might create further opportunities to utilise Australian resources'.[6]

4.7 Although the majority of submitters and witnesses expressed support for local manufacturing associated with EVs, others, such as Mr Tony Weber, Chief Executive Officer of the Federal Chamber of Automotive Industries were more circumspect:

> On the question of manufacturing in the future, obviously we ceased [vehicle] manufacturing late last year [2017]. In the future, if we were to look at manufacturing being realistic, we'd have to examine the fact that, despite Australia having a market of 1.2 million vehicles a year, no vehicle sells at 50,000 units per year in Australia. Fifty thousand units is not considered to be the scale required for a factory anywhere in the world, and therefore you would need extensive export markets, in conjunction with a very successful product in the domestic market, before it was viable. One of the substantial issues with manufacturing in Australia is lack of real access to markets outside of Australia, especially in the Asian region, because of tariffs and non-tariff barriers.[7]

Residual car-making skills and experience

4.8 In October 2017, the General Motors (GM) Holden automotive manufacturing facility in Elizabeth, South Australia was closed. As the last car making plant in Australia at the time, it also signified the end of passenger vehicle manufacturing in

4 Uniti Australia, *Submission 2*, p. [3].

5 Dr Brett Dale, Chief Executive Officer, Motor Trades Association of Queensland, *Committee Hansard*, 27 September 2018, p. 39.

6 University of Adelaide, *Submission 91*, p. [3].

7 Mr Tony Weber, Chief Executive Officer, Federal Chamber of Automotive Industries, *Committee Hansard*, 18 October 2018, p. 15.

Australia at that time.[8] This left not only hundreds of highly skilled automotive workers unemployed, but many thousands more who worked in businesses supplying components to GM Holden. This effect has been mirrored across the country in the wake of other high profile car plant closures in recent years with estimates suggesting that up to 50 000 workers could have been impacted as a result.[9] The Committee notes that Iveco manufactures trucks at its Dandenong plant.[10]

4.9 Notwithstanding the closure of Toyota's Altona plant in western Melbourne, the Hobsons Bay Council observed that 'there remains capacity and expertise in the areas of vehicle design, heavy vehicle manufacturing, conversions, component manufacturing and servicing'. This capacity stands ready to take advantage of the growth in EVs.[11] The South Australian Government put forward a similar view:

> The state also retains an automotive sector following the closure of Holden with many component suppliers, a strong research base and a remnant pool of skilled workers.[12]

4.10 The Victorian Automobile Chamber of Commerce (VACC) expressed its view that opportunities exist for Australian industry stemming from a ready skilled workforce and the introduction of automated manufacturing techniques:

> Whilst passenger car manufacturing has now ceased, it is not beyond possibility that the assembly of EVs may become a viable business option. EVs have fewer components than traditional ICE vehicles, thus eliminating the need for many costly manufacturing processes such as engine casting, tooling and the creation of component parts. Given the inherent residual engineering capacity that is available in Victoria and other states, business models involving the importation of electric motors and the assembly of EVs from Completely Knocked Down packs (CKDs) using robotics and other automated processes may be viable.[13]

4.11 The Australian Council of Trade Unions (ACTU) has argued that it would make sense to take advantage of such a large skilled workforce and existing supplier capacity, and situate any new industry in areas where skilled automotive workers and associated businesses are located:

> EV manufacturing could be centred in precisely the communities and area, such as Elizabeth in SA and Geelong in Victoria, that have been most

---

8 Mike Ladd, 'Holden closure: Australia's history of car manufacturing comes to an end', *ABC News Online*, 8 October 2017, https://www.abc.net.au/news/2017-10-08/holden-closure-australia-history-car-manufacturing/9015562 (accessed 25 October 2018).

9 Australian Council of Trade Unions, *Submission 107*, p. 4.

10 Iveco, *Manufacturing*, https://www.iveco.com.au/manufacturing (accessed 26 November 2018).

11 Hobsons Bay Council, *Submission 52*, p. 4.

12 South Australian Government, *Submission 130*, p. 4. See also: AEVA—SA, *Submission 69*, p. 4.

13 Victorian Automobile Chamber of Commerce, *Submission 26*, p. 12.

> affected by the destruction of the Australian car industry. The return of vehicle production to these areas would revitalise these communities, bringing jobs, allowing families to escape and poverty and would encourage the engagement of young people with education and training.[14]

4.12 The Australian Manufacturers Workers Union (AMWU) echoed these sentiments:

> Australia is uniquely placed as a country with a ready supply of skilled workers capable of building a world-class EV manufacturing facility. As a result of the closure of Australia's conventional automotive manufacturing industry, there are many workers capable of supporting the development of an electric vehicle industry in Australia.
>
> In addition, there is also a significant infrastructure to support the development of such an industry in Australia, particularly in the former regions that hosted automotive manufacturing facilities until recently. These areas have vocational education providers that specialise in the skills required, they have connections for import and export and are close to established supply chains.[15]

Automotive Transformation Scheme

4.13 As car manufacturers signalled their intention to close Australian manufacturing facilities, the Australian Government established a $2 billion industry adjustment scheme called the Automotive Transformation Scheme (ATS). The ATS, started in 2011 will run until the end of 2020, and provides:

> businesses involved in the Australian automotive industry with cash payments to cover up to 15% of the cost of investing in plant and equipment, and 50% of the cost of investing in research and development, to encourage investment and innovation in the Australian automotive industry.[16]

4.14 The ATS has been taken up by firms such as Precision Components to reshape their businesses for the opportunities of the future. Mr Christian Reynolds, Director of Precision Buses, a South Australian bus manufacturer, explained his company's journey from 'metal stamping component manufacturer' to an 'advanced manufacturing group'.[17]

> Precision Buses is a genesis from Precision Components. Precision Components was a component manufacturer at tier 1 level to Holden and Ford, which, through the Automotive Transformation Scheme, took the opportunity to transition into vehicle manufacturing. We've set up an

---

14 ACTU, *Submission 107*, p. 2.

15 Australian Manufacturers Workers Union, *Submission 116*, p. [4].

16 Australian Government Business Website, Automotive Transformation Scheme (ATS), https://www.business.gov.au/assistance/automotive-transformation-scheme (accessed 25 October 2018).

17 Mr Christian Reynolds, Director, Precision Buses, *Committee Hansard*, 10 August 2018, p. 21.

> advanced manufacturing facility in Edinburgh Parks [South Australia], where we have a level of collaboration between four business entities. We're looking at co-locating to advance the knowledge share and the engineering detail around how we progress autonomous and electric vehicles.[18]

4.15 The Committee heard that there were a number of limitations with the ATS and its eligibility requirements. For example, many companies do not meet the minimum throughput of 30 000 vehicles per annum. However, there is an exemption in the form of a national interest test. The Department of Industry, Innovation and Science's (DIIS) submission explained how the ATS was being expanded:

> Businesses that have made a financial commitment to carry on business in Australia as a motor vehicle producer or supplier to the automotive industry, for the first time can also participate in the scheme. Businesses that do not satisfy certain registration requirements may seek the Minister's permission to apply for registration on national interest grounds.[19]

4.16 Prospective EV manufacturer, Australian Clean Energy Electric Vehicle Group (ACE-EV) suggested that this test was difficult to meet for start-up manufacturers.[20] Ms Claire Johnson, Chief Executive Officer from Hydrogen Mobility Australia suggested that the ATS should be reframed 'around zero- and ultra-low emission vehicles'.[21] Ms Johnson continued:

> When [the ATS] is set to cease with, at this point, no future assistance available in the form of an automotive scheme, we think that can send a strong signal to international companies who are looking to invest in Australia.[22]

4.17 Hyundai's submission said that funding is available for research and development (R&D) under the ATS and that this should be further prioritised.[23] Tritium suggested that the ATS be extended to component manufacturing, noting that 'grant programs are vital in supporting entrepreneurs who may be building or seeking to build a business in the EV industry'.[24]

---

18 Mr Christian Reynolds, Director, Precision Buses, *Committee Hansard*, 10 August 2018, p. 20.

19 Department of Industry, Innovation and Science, *Submission 112*, p. 13.

20 Mr Gregory McGarvie, Managing Director, Australian Clean Energy Electric Vehicle Group, *Committee Hansard*, 27 September 2018, p. 55.

21 Ms Claire Johnson, Chief Executive Officer from Hydrogen Mobility Australia, *Committee Hansard*, 10 August 2018, pp. 28–29. See also: Toyota, *Submission 77*, p. 11.

22 Ms Claire Johnson, Chief Executive Officer from Hydrogen Mobility Australia, *Committee Hansard*, 10 August 2018, pp. 28–29.

23 Hyundai, *Submission 103*, pp. [12–13].

24 Tritium, *Submission 58*, p. [5].

Assembly of imported parts

4.18 Some submitters and witnesses have expressed their support for EV manufacturing based on the local assembly of imported pre-built parts. Volvo confirmed that it is currently contemplating such an approach in relation to buses:

> Volvo Bus also sees a future where we will be able to provide local manufacturers in Australia with a chassis product that can be bodied locally here in Australia. This will allow the same high standards of body building to deliver safe, reliable and [Australian Design Rules] compliant vehicles manufactured here in Australia, sustaining a vibrant and specialised body manufacturing industry.[25]

4.19 In its submission, Uniti Australia said that it 'is designing a vehicle to be assembled in Australia by Australians and for Australians' from imported parts.[26] Dr Michael Molitor, Chairman of Uniti Sweden AB (parent company of Uniti Australia) explained that his company expected to be manufacturing 'up to 100 000 units within three to five years' in Australia.[27] Mr Greg McGarvie, Managing Director of the ACE-EV provided details about his company's two-stage approach for its Australian EV manufacturing plant:

> We're taking a low-risk approach. Initially we were looking at $5 million to get the assembly plant. We've got an assembly facility available to get that set up and get their components in CKD and then, as soon as it looked like there was interest and appetite for more vehicles, to the second stage, which is full manufacturing here. In other words, we'd be doing carbon fibre structures here, their panels here, supply chain—we've been contacted by various lithium suppliers. We've got quite a few different supply chains wanting to link in with us. We've got research facilities wanting to link in with us. As you know, the carbon fibre research in Australia is quite advanced.[28]

Retrofitting electric drive trains

4.20 As part of this inquiry, the Committee visited the SEA Electric manufacturing facility in Dandenong, Victoria (see Appendix 3). SEA Electric is an Australian-based company that initially retrofitted electric powertrains and batteries to a wide range of commercial buses and trucks. SEA Electric now supports the importation of gliders—a manufactured vehicle without a powertrain—to which SEA Electric fits a powertrain and batteries providing a fully electric vehicle to their clients. The Group Managing Director of SEA Electric, Mr Tony Fairweather, described a future scenario where local manufacturing may form part of the light truck manufacturing process:

---

25 Volvo, *Submission 70*, p. 3.

26 Uniti, *Submission 2*, p. [3].

27 Dr Michael Molitor, Chairman, Uniti Sweden AB, *Committee Hansard*, 10 August 2018, p. 56.

28 Mr Greg McGarvie, Managing Director, Australian Clean Energy Electric Vehicle Group, *Committee Hansard*, 27 September 2018, p. 56.

> The chief engineer from Isuzu Australia visited yesterday. He explained how the pilot process at the moment in their particular case involves substantial testing and evaluation of half a dozen vehicles, which are going into service with some of Australia's largest operators of trucks later this year. Their hope and intention is to potentially be producing their glider vehicles, assembled in Australia with our driveline technology in them, early next year or sometime next year. At the moment, everything they do right now, which is up to 10,000 units a year, is 100 per cent imported internal combustion engine product. Isuzu is an example of a company that is very progressive and working towards an electrification option with, hopefully, some local content. That opportunity for others is there. Our intention is in licensing our technology but also very much in having a local assembly element for our products and for end users. It's kind of a hybrid approach.[29]

4.21 Mr Fairweather noted that it was not only the new segment of the truck market that is looking to convert to fully-electric, there are also those who may seek to retrofit existing trucks with end of life conventional powertrains.[30] Mr Fairweather asserted that SEA's all-electric commercial trucks now 'had payback periods of three or four years based on the total-cost-of-ownership model'.[31]

4.22 In October 2018, the Victorian Government announced it had signed an agreement that would result in SEA Electric establishing an additional factory in the regional town of Morwell in Victoria's Latrobe Valley. Mr Fairweather estimated that the Morwell plant could build 2 400 four-tonne vans and commuter buses, and employ up to 500 workers over the next five years. The plant is expected to be up and running in less than a year and generate about $200 million in economic activity.[32]

4.23 The Australian Productivity Council put forward its views on a more cost-competitive manufacturing approach that would be better suited to a lower volume producer such as Australia:

> The business concept had three main features.
>
> Firstly, it proposed a way of building cars on a common flexible platform (CFP) to substantially reduce initial development and tooling cost per model at the expense of a higher base unit cost. Trading up-front costs against unit costs in this way would provide better production economies,

---

29 Mr Tony Fairweather, Group Managing Director, SEA Electric, *Committee Hansard*, 31 August 2018, p. 5.

30 Mr Tony Fairweather, Group Managing Director, SEA Electric, *Committee Hansard*, 31 August 2018, p. 4.

31 Mr Tony Fairweather, Group Managing Director, SEA Electric, *Committee Hansard*, 31 August 2018, p. 2.

32 Ben Potter, 'SEA Electric eyes $200 million-plus annual van sales with Vic Labor backing', *Australian Financial Review*, 30 October 2018, https://www.afr.com/news/sea-electric-eyes-200mplus-annual-van-sales-with-vic-labor-backing-20181030-h17ajk (accessed 31 October 2018).

> more variety and shorter model cycle times at all volumes below 40,000 annual units than the conventional manufacturing methods.
>
> Secondly, the business proposed a different plant format, similar to production concepts developed by Volvo at Uddevalla in Sweden, as an alternative to the Toyota Production System (TPS). The proposed plant design had fixed assembly stations as distinct from a moving assembly line with part sets delivered sequentially to the workspace for assembly by a skilled two-person team completing one vehicle per shift. Such a plant is much less expensive to build, is more flexible, offers higher worker morale and a flatter, less expensive, management structure than a conventional plant.
>
> Thirdly, the business proposed a direct-selling model from a digital platform supported by company-owned sites in shopping centres, a model subsequently demonstrated by Tesla in Australia. This would collapse the dealer margin into the producing business and enable solid profit margins, budgeted at 30%, providing rapid growth through retained earnings while offering customers an ultra high quality product at a reasonable price.[33]

4.24 Mr Reynolds described how Precision Buses has used existing local Australian engineering and design capability, previously harnessed for car manufacturing to reimagine how buses are built. Instead of importing chassis and fitting a coach body and other fittings as has been done in the past, Precision Buses is looking at how it can bring together bus components from a range of local and imported suppliers to build a product that meets their client's requirements:

> We've manufactured two electric buses to date that are being prepared to go into trial. The aim of those buses is to look at how electric drive line is affected by mass transport patronage, topography, traffic structure in terms of time and delay, and also weather conditions. We also manufacture an architecture which [has] moved away from the traditional chassis and coach into an integrated model which allows us to become an [Original Equipment Manufacturer (OEM)] in the bus manufacturing space. This allows us to integrate various technologies from partners, whether that be drive line from other OEMs or autonomous technologies from other companies, which allows us to try and connect mass transport artery with last mile solution so that we have an integrated solution. By setting that up in a local condition, we're able to bring economic benefit to suppliers and manufacturers locally. We use the existing capability that was available with OEM manufacturers in the passenger car space to engineer for us today.[34]

4.25 One of the benefits to manufacturing locally are the synergies that could be generated by having collaborators co-located, particularly in regard to emerging technologies such as automation. Two companies, EasyMile and Transit Australia Group, have announced plans to manufacture autonomous vehicles in South

---

33 Australian Productivity Council, *Submission 7*, pp. [5–6].

34 Mr Christian Reynolds, Director, Precision Buses, *Committee Hansard*, 10 August 2018, p. 20.

Australia.[35] Mr Simon Pearce, Head of EasyMile Asia-Pacific described EasyMile's relationship with Precision Buses as 'seamless' when integrating their technology. Mr Pearce suggested that automated vehicles are a parallel technology that would develop side by side with electric and that it made sense to co-locate where synergies might be gained for both parties.[36]

EV component manufacturing

4.26 The Committee heard that 'Australia has the skills needed to manufacture EVs and components like battery cells, motors and power electronics'.[37] The MTAQ noted that 'Australia has always been an effective supplier of components'.[38]

4.27 Monash University submitted that Australia would need to be 'selective' in deciding where to focus in regards to manufacturing EVs or components. The submission suggested that:

> Areas of strength lie in development of [Intellectual Property], protection and nurturing of emerging energy storage technologies and integrated systems for electric vehicles developed in our innovation system so that we are better prepared for the next-generation of technologies required for the EV market.[39]

4.28 Associate Professor Nesimi Ertugrul from the School of Electrical and Electronic Engineering at the University of Adelaide put forward a similar view:

> My view is: why don't we focus on some value-added part of these electronics—from the battery level, motor control level, similar topology, similar developers. If this continues happening, we can become an electronic nation. We can compete, with electronics all produced in automated manner without touching a single hand. That's how I see it.[40]

4.29 During the inquiry, the Committee visited the Nissan Casting Plant Australia (NCAP) in Dandenong, Victoria (see Appendix 3). The plant casts, machines and assembles components for motor vehicles in the Nissan range with parts exported to Japan, Thailand, Mexico and the United States. The plant employs nearly 150 people and operates six days per week.[41] NCAP's submission stated:

---

35 Hon David Ridgway MLC, South Australian Minister for Trade, Tourism and Investment, *South Australia, EasyMile and Transit Australia Group sign a MOU to advance AV manufacturing and technology in South Australia*, Media Release, 24 July 2018, https://premier.sa.gov.au/news/south-australia-easymile-and-transit-australia-group-sign-a-mou-to-advance-av-manufacturing-and (accessed 26 November 2018).

36 Mr Simon Pearce, Head of EasyMile Asia-Pacific, *Committee Hansard*, 10 August 2018, p. 18.

37 See, for example: AEVA—ACT, *Submission 6*, p. 13; VACC, *Submission 26*, p. 12.

38 MTA of Queensland, *Submission 41*, p. [4].

39 Monash University, *Submission 128*, p. 2. See also: HMA, *Submission 73*, p. [17].

40 Associate Professor Nesimi Ertugrul, School of Electrical and Electronic Engineering, University of Adelaide, *Committee Hansard*, 10 August 2018, p. 47.

41 Nissan, *Submission 40*, p. 1.

> NCAP produces six key components for Nissan EV and hybrid vehicles that are sold globally. The growth of EVs globally is allowing us to not only expand our workforce, but also develop talents in areas such as engineering, manufacturing, logistics and more.[42]

4.30 Pilbara Metals Group (PMG) commented that Australia's large reserves of raw materials required for battery manufacturing 'has allowed companies to [proceed] with planning and engineering studies to produce various components of batteries in Australia'. PMG suggested that production of battery cathodes could be a logical starting point.[43]

4.31 MTAQ submitted that the manufacture of a key component such as a battery pack in Australia could lead to other parts of the EV manufacturing chain also being based in Australia:

> The economics of vehicle manufacture tends to indicate the most important component is the battery pack. The geographic sourcing of these items can be expected in large part to determine the architecture of the future electric vehicle manufacturing. Tesla has demonstrated the economic power that battery manufacturing confers on an OEM electric vehicle producer.[44]

4.32 The Committee has also heard that Australia has significant, high-quality deposits of rare earth elements (REE) that are used to manufacture permanent magnets for EVs and 'for electric generators that power wind turbines'.[45] China currently dominates the mining of REE and the manufacture of permanent magnets. Deakin University argued that there is an opportunity for Australia to take advantage of its reserves, to build local manufacture of value-added products and to do so in an environmentally responsible way.[46] The University of Adelaide submitted a similar proposition:

> Australia can also develop high quality brushless permanent magnet motor manufacturing facilities used in EVs which rely on two critical value added materials: copper and rare earth magnets.[47]

Research and development

4.33 Many witnesses and submitters highlighted the key role that R&D has, and could, continue to play in underpinning Australia's future automotive manufacturing capacity. This R&D runs the spectrum from academia through to in-house OEM R&D centres.

4.34 The Committee has heard that Australia is an R&D hub for major OEMs such as Ford, GM Holden and Toyota in the Asia-Pacific:

---

42 Nissan, *Submission 40*, p. 1.

43 Pilbara Metals Group, *Submission 17*, p. 2.

44 MTAQ, *Submission 41*, p. [4].

45 Deakin University, *Submission 35*, p. 4.

46 Deakin University, *Submission 35*, p. 4.

47 University of Adelaide, *Submission 91*, p. [2].

> Currently, Ford has a design/styling, engineering and homologation/testing team in Australia, and General Motors and Toyota have their design/styling and small engineering teams in Australia.[48]

4.35 Mr David Magill, Director, Government Relations and Public Policy, GM Holden explained that GM Holden 'are now doing over $120 million worth of R&D annually in Australia each year and our engineering program in advanced vehicle development is going to be working on electrification projects for GM'.[49] The Committee also heard that GM Holden is expanding this capacity in advanced vehicle development—the 'area between pure research and development and establishing programs that are technically feasible and business case feasible and can be produced'.[50]

4.36 In its submission, Hyundai noted that it invests in Australian R&D and the value of this work:

> This is valuable, highly skilled work that both secures and develops automotive engineering expertise in Australia and should continue to be supported through a dedicated program if the country is to recognise the sector as having strategic importance to the economy.[51]

4.37 Noting the importance of batteries not just in motor vehicles, but also for stationary energy storage, the CSIRO is contemplating establishing a new future science platform focusing on the lithium value-chain. This would place it as one of the CSIRO's six priority areas for future scientific research.[52] The CSIRO has also reiterated to the Committee the importance of its partnerships with industry as a means to commercialise research outcomes with benefits for both industry and CSIRO.[53]

4.38 Associate Professor Patrick Howlett from Deakin University told the Committee that research in the automotive sector is constantly evolving as a result of changing priorities and scientific breakthroughs. Associate Professor Howlett raised the example of advances in lithium metal electrodes in high-energy batteries:

> The [United States Department of Defence] made a directive to essentially investigate the lithium-metal electrode for high-energy batteries for electric vehicles, and they have the target of 500 watt-hours per kilo. There were a lot of slogans that went around that. What that has driven is research in the

48 Deakin University, *Submission 35*, p. 5.

49 Mr David Magill, Director, Government Relations and Public Policy, GM Holden, *Committee Hansard*, 31 August 2018, p. 62.

50 Mr Brett Vivian, Executive Director Engineering, GM Holden, *Committee Hansard*, 31 August 2018, p. 63.

51 Hyundai, *Submission 103*, pp. 12–13.

52 Dr Keith McLean, Director, Manufacturing, CSIRO, *Committee Hansard*, 17 August 2018, p. 47.

53 Dr David Harris, Research Director, Low Emissions Technologies, CSIRO, *Committee Hansard*, 18 October 2018, p. 11.

> US on the lithium metal electrode, and then that has further driven worldwide research to the point where now there have been rapid advances in that technology. Where not so long ago that was essentially ignored as a potential technology, now it's probably the most likely next technology. That's the metal electrode; that's only the bottom half of the battery, if you like. The cathode remains a problem, and there are a range of technologies that can be addressed there.[54]

4.39 In its submission, Deakin University flagged a number of constraints to research in the automotive sector. The most significant of these is the lack of students available to undertake post-graduate study and the difficulty in recruiting automotive engineering researchers. This difficulty stems from the perceived lack of employment opportunities in the automotive sector and complications accessing student visas.[55] During the Adelaide hearing, Professor Rocco Zito, Head of Civil Engineering, College of Science and Engineering at Flinders University noted the current professional development and employment pathways that exist, but flagged that more could be done to ensure that employment opportunities exist for these students at the conclusion of their studies:

> I think there is a need to bring some coherence to this debate in the form of an industry roadmap for EV and AV in Australia to provide short- and medium-term guidance to how we can maximise our participation in the value chain in both inputs like batteries and taking on that larger challenge and opportunity of being part of a global EV-AV industry into the future. We should never rule that out in the great sweep of history. Even in the wake of the closure of the auto industry, which hurt us in South Australia so badly, there are plenty of skills and capabilities available to be redeployed cleverly in a very high value industry at its best, EV and AV.[56]

Industry 4.0

4.40 A key opportunity for the manufacturing of EVs and associated componentry in Australia is the worldwide phenomenon of 'Industry 4.0'. This refers to what is being termed as the fourth industrial revolution—that is, technological developments such as the improvement of artificial intelligence and machine-to-machine integration across 'almost every industry worldwide'.[57] In a recent article, Dr Jens Goennemann, Managing Director, Advanced Manufacturing Growth Centre described the benefits of Industry 4.0:

> Industry 4.0 can start with as little as sticking a sensor on a piece of equipment so that one can monitor where it is or what it does. In the longer

---

54 Associate Professor Patrick Howlett, Deakin University, *Committee Hansard*, 31 August 2018, p. 42.

55 Deakin University, *Submission 35*, p. 6.

56 Professor Rocco Zito, Head of Civil Engineering, College of Science and Engineering at Flinders University, *Committee Hansard*, 10 August 2018, p. 46.

57 Department of Industry, Innovation and Science, *Industry 4.0*, https://www.industry.gov.au/funding-and-incentives/manufacturing/industry-40 (accessed 2 October 2018)

> perspective though, it is about establishing a relationship with embedded intelligence across the entire manufacturing process from research and design through to the final customer engagement. If we get this right, then customer feedback loops back into the R&D process and starts the next iterative step in delivering high-quality outcomes and rich customer experiences.[58]

4.41 Of most relevance to this Committee is the increase in manufacturing automation. The Boston Consulting Group explained how increased automation will also lead to significant decrease in battery price:

> By transitioning to the factory of the future [Industry 4.0], producers can reduce total battery cell costs per kilowatt-hour (kWh) of capacity by up to 20%. The savings result from lower capex and utility costs and higher yield rates. The production-related costs (excluding materials) can be reduced by 20% to 35% in each of the major steps of battery cell production: electrode production, cell assembly, and cell finishing. Electrode production benefits from faster drying times that increase yield rates and reduce capex for equipment. In cell assembly, data-driven automated adjustment of parameter settings increases accuracy and reduces production times. Cell finishing is enhanced by shorter times for formation and aging, which significantly reduces capex requirements.[59]

4.42 Professor Peter Newman highlighted the opportunities that Western Australia has in taking advantage of Industry 4.0 developments:

> Fourth stage technologies offer WA the opportunity to develop a much larger industrial base that is complementary to its world-leading resource extraction sector. These technologies shift the competitive advantage of early stage value adding away from low cost labour countries to the earliest point in the value chain where all the input materials can be brought together for highly automated manufacturing processes. Components are then shipped to the major global manufacturing centres for later stage manufacturing where proximity to markets or low-cost labour still afford an advantage. WA is in the unique position of having abundant quantities of almost all the New Energy metals, giving it a large advantage in electro-chemical processing.[60]

4.43 Automated manufacturing will have a lower labour requirement and allow Australian firms to compete globally. Deakin University's submission indicated the need for Australia to adopt and develop Industry 4.0 frameworks and technologies to be competitive in EV manufacturing:

---

58 Australian Institute of Company Directors, *Industry 4.0: a whole of economy opportunity*, August 2017, https://aicd.companydirectors.com.au/membership/company-director-magazine/2017-back-editions/august/industry-4-0-a-whole-of-economy-opportunity (accessed 28 November 2018).

59 Boston Consulting Group, *The Future of Battery Production for Electric Vehicles*, September 2018, https://www.bcg.com/en-au/publications/2018/future-battery-production-electric-vehicles.aspx (accessed 28 November 2018).

60 Professor Peter Newman AO, *Submission 23.1*, p. 13.

> The competitive manufacture of electric vehicles in Australia will need to leverage Australia's research and development capabilities to deliver future integrated factories. These Industry 4.0 facilities will operate as a 'system of systems' through intelligent machines, human factor integration, and integrated supply chains.[61]

4.44 Deakin University also anticipated the benefits that would eventuate from adopting Industry 4.0 framework in electric vehicle manufacturing through the ability to 'participate in the global supply chain' without having to commit to a full-scale 'end-to-end vehicle manufacturing industry'.[62]

4.45 The concept of Industry 4.0 was discussed in a November 2015 report of the intergovernmental Australia-Germany Advisory Group, *Collaboration, Innovation and Opportunity*.[63] Recommendation 10 of this report called for 'initiating a collaborative approach to the development of global Industry 4.0 standards'.[64]

4.46 The report of the Australia-Germany Advisory Group resulted in the creation of the Prime Minister's Industry 4.0 Taskforce (now the Industry 4.0 Advanced Manufacturing Forum).[65] The Taskforce and its successor have fostered an industry relationship with the German Plattform Industrie 4.0, and supported Industry 4.0 test laboratories in Australian universities.[66]

Battery manufacturing and commodity value-adding

4.47 Earlier in the report, the Committee discussed the benefits for the mining sector from an increased use of EVs both here and in Australia.[67] The future of EV manufacturing will lead to an increase in demand for a number of key resources including copper, nickel, cobalt and lithium. Given the anticipated increase in demand for EV manufacturing in the coming decades, there could be a significant upsurge in the value of these minerals.[68] The Electrical Trades Union highlighted Australia's natural advantages:

---

61 Deakin University, *Submission 35*, p. 1.

62 Deakin University, *Submission 35*, p. 1.

63 Australia-Germany Advisory Group, *Collaboration, Innovation and Opportunity*, November 2015, https://dfat.gov.au/about-us/publications/international-relations/Documents/australia-germany-advisory-group.pdf (accessed 22 October 2018).

64 Australia-Germany Advisory Group, *Collaboration, Innovation and Opportunity*, November 2015, p. 4.

65 Australia-Germany Advisory Group, *Collaboration, Innovation and Opportunity*, November 2015, p. 4.

66 Australian Advanced Manufacturing Council, *Industry 4.0 Advanced Manufacturing Forum*, http://aamc.org.au/industry-4-0/ (accessed 3 October 2018)

67 See, for example: AMEC, *Submission 20*; Bloomberg New Energy Finance, *Submission 127*; Pilbara Metals Group, *Submission 17*; Deakin University, *Submission 35*, p. 4.

68 Australian Electric Vehicle Association, *Submission 6*, p. 6.

> Australia has some of the highest grade, and largest, deposits of Lithium and Vanadium in the world, particularly in Western Australia. Western Australia is also currently the largest producer of lithium, which is necessary to supply batteries for the emerging EV market.[69]

4.48 Bloomberg NEF projected that 'global demand for metals and materials used to produce lithium ion batteries will increase 25-fold by 2030'.[70] Dr Howard Lovatt, Team Leader, Electrical Machines at the CSIRO made the point that Australia's diversity of mineral resources makes it well placed to take advantage of any changes to battery chemistry and composition:

> Generally in terms of batteries it most definitely is an area that's changing rapidly, and new developments are occurring, and that will mean that some minerals that were important suddenly become not important and vice versa. Particularly when you get a big growth in an industry like lithium batteries, it does put stress on the supply of some minerals, so then everyone's motivated to change the composition of the batteries to avoid those minerals. So this is very much a moving target. But I guess the good news for Australia is that we're well supplied with lots of different minerals, so it's likely to benefit Australia regardless of the final commercial outcome.[71]

Commodity value-add

4.49 Mr Warren Pearce, Chief Executive Officer of the Association of Mining and Exploration Companies explained the lithium value chain from mining to battery manufacture:

> we've broken the value chain into the five steps toward the creation of manufacturing of batteries: the first step being mining concentrate; the second step being refining and processing; the third step being electrochemical processing; the fourth step being the production of battery cells; and the final step being the assembly of batteries.[72]

4.50 Mr Pearce noted that Australia currently only participated in the first step—mining the raw materials—but that involvement in the subsequent stages could bring huge economic returns to Australia saying that many Australian companies 'are now quite legitimately looking to process or value-add their materials to see if they can get into a greater part of the value chain.[73]

---

69 ETU, *Submission 110*, p. 4.

70 Mr Ali Asghar, Senior Associate, Bloomberg NEF, *Committee Hansard*, 31 August 2018, p. 7.

71 Dr Howard Lovatt, Team Leader, Electrical Machines, CSIRO, *Committee Hansard*, 18 October 2018, p. 8.

72 Mr Warren Pearce, Chief Executive Officer, Association of Mining and Exploration Companies, *Committee Hansard*, 17 August 2018, p. 27.

73 Mr Warren Pearce, Chief Executive Officer, Association of Mining and Exploration Companies, *Committee Hansard*, 17 August 2018, p. 27.

4.51 Currently, it is estimated that Australian mining companies capture less than 0.5 per cent of the lithium chain.[74] Deakin University agreed with this estimation stating that 'there is a great opportunity for Australia to capture a larger part of the value chain of lithium ion batteries, by not only exporting the lithium minerals, but also by designing and manufacturing batteries'.[75]

4.52 Mr Pearce provided the Committee with examples of a number of Western Australian mining and exploration companies where Australian mining and exploration companies have partnered with larger international companies with capital and expertise in processing in order to build processing facilities for lithium and other commodities.[76]

4.53 Mr Pearce discussed the need for linkages to be facilitated between Australian mining and exploration companies with international processing companies in order to import much needed expertise and capital. This expertise would enable Australian businesses to value-add our mineral resources on-shore for export or domestic use:

> In order to achieve that, there are some barriers that our report has tried to identify, primarily being that our member companies are mid-tier or small-cap mining companies. They don't have large balance sheets and they require support to find investment to build these types of facilities. Also, in order to move into that space, we're capable explorers and miners but we are not processers or refiners. We need to access the proprietary knowledge and technical expertise to undertake that successfully. To make that possibility a reality, our organisation has been promoting the opportunity for partnerships between international companies that hold this knowledge and Australian mining companies.[77]

4.54 The 2018 report titled *Lithium Valley: Establishing the Case for Energy Metals and Battery Manufacturing in Western Australia* observed how trends such as automation are changing the economic paradigm of value-adding raw minerals:

> Historically, it was more cost effective to value add closer to large markets or in countries with large, low cost workforces. This is no longer the case. Information technologies, artificial intelligence, automation and new energy systems now favour manufacturing at the earliest point in the value chain

74 Professor Peter Newman AO, *Submission 23.1*, p. 14. See also: Regional Development Australia Perth, *Lithium Valley: Establishing the Case for Energy Metals and Battery Manufacturing in Western Australia*, 2018.

75 Deakin University, *Submission 35*, p. 4.

76 Mr Warren Pearce, Chief Executive Officer of the Association of Mining and Exploration Companies, *Committee Hansard*, 17 August 2018, p. 27.

77 Mr Warren Pearce, Chief Executive Officer of the Association of Mining and Exploration Companies, *Committee Hansard*, 17 August 2018, p. 27.

> where all the input materials can be brought together in a low, cost effective way.[78]

4.55 This same report quantified the projected economic importance of value-adding. An integrated approach that focused on mining, refining with 10 per cent electro-processing (the first three steps that Mr Pearce outlined) is projected to result in over 100 000 jobs, economic investment of over $34 billion and an economic contribution of $56 billion per annum by 2025. This compares to a mining only scenario whereby less than 30 000 jobs are created and total investment of nearly $14 billion.[79]

Battery manufacturing

4.56 In addition to processing and advanced refining of minerals, there is an opportunity for Australian companies to value-add refined minerals into battery cells and then assemble into batteries. The University of Adelaide stated that Australia could play a part in the 'automated production of batteries and battery management systems in [the] EV supply chain'.[80]

4.57 Mr Brian Craighead, Director of Renaissance Energy told the Committee about his company's intention to construct a lithium-ion battery factory in the Northern Territory.[81] Mr Craighead explained the benefits to his company of building tailored products in Australia:

> We are manufacturing a particular type of battery cell that works better in hot climates. That's South-East Asia and Australia. Part of the reason we're up in Darwin is that the export capability is very good for us when it comes to South-East Asian markets. Ours is, we think, about 70 per cent an export business, but Australia is an important market for us in both the grid market and the electronic vehicle market. We've met a few folks who seem to be quite ambitious with plans for electronic vehicle manufacturing. An EV, fundamentally, is a battery on wheels. So for us it's a very attractive market. We can customise batteries and stick them in EVs. For hot-climate [EVs], we think that there will be a very clear market.[82]

4.58 Mr Craighead also noted that the capital expense of building an automated factory is 'not what it once used to be', and explained the counterintuitive proposition that Australia could find itself as a leader in extracting the raw materials required in

---

78 Professor Peter Newman AO, *Submission 23.1*, p. 8. See also: Regional Development Australia Perth, *Lithium Valley: Establishing the Case for Energy Metals and Battery Manufacturing in Western Australia*, 2018.

79 Professor Peter Newman AO, *Submission 23.1*, p. 14. See also: Regional Development Australia Perth, *Lithium Valley: Establishing the Case for Energy Metals and Battery Manufacturing in Western Australia*, 2018.

80 University of Adelaide, *Submission 91*, p. [1].

81 Mr Brian Craighead, Director, Energy Renaissance, *Committee Hansard*, 27 September 2018, p. 11.

82 Mr Brian Craighead, Director, Energy Renaissance, *Committee Hansard*, 27 September 2018, p. 12.

batteries and manufacturing the batteries themselves but not having the capacity in Australia to process and refine the raw material to battery manufacturing grade:

> The great sadness of Australia—the kind of twist here—is that, although we have all the raw materials we need to manufacture competitively lithium-ion batteries in Australia, the reality is that all those raw materials without exception are mined and shipped overseas to be processed to battery grade and then reimported; we have to re-import. Most of the margin is given overseas because there aren't processing facilities locally for battery-grade raw material.[83]

4.59 Mr Craighead was confident that the establishment of a battery manufacturing sector in Australia could provide the critical mass to encourage local miners to develop processing and refining capabilities:

> What they need is security in offtake. If there is enough confidence in forward orders, people can justify and bank the capital investment to do the processing locally. In some cases—lithium, less so—it's quite expensive to bring a processing facility on shore. And it's the process as well, because some of them are power hungry and with some of them you have to be very careful that you're not hurting the environment. So because of the cost involved all of them need security in forward orders. Basically, they need to know if they have enough orders for the next three years to justify the capital investment.
>
> And here's how you get that: we will bring some level of security in forward orders to these folks locally, because, obviously, the reason you exist is to buy Australian. But if another factory comes up—if the Townsville comes up—it will be much bigger than ours; it's a very differently sized facility. If that goes up it would bring even more security in forward orders. So, really, it's just like any bankable project: the more forward orders you've got then the more comfortable the lenders are and the more comfortable the investors are. That's what will suit our local processing. For every dollar of benefit and economic benefit that our little factory brings there's about six that go to the raw material producers so that they can get processing. There's much more in it for Australia if we can have them processing to battery grade, rather than our little factory.[84]

83 Mr Brian Craighead, Director, Energy Renaissance, *Committee Hansard*, 27 September 2018, p. 13.

84 Mr Brian Craighead, Director, Energy Renaissance, *Committee Hansard*, 27 September 2018, p. 13.

4.60 Two battery manufacturers, Sonnen and Aplha ESS, have recently announced that they will manufacture lithium-ion home batteries in Adelaide.[85]

4.61 Professor Mainak Majumder of Monash University was more cautious in his advice to the Committee:

> My view is that because battery manufacturing is so well established in South-East Asia and in Japan and that they're so good at that we might not be able to compete with them in battery manufacturing. But we could possibly think about the resources that go into battery manufacturing, and that could be a much better approach for us to invest in.[86]

4.62 Mr Pearce observed that the establishment of a local battery manufacturing sector would be beneficial for mining and processing companies 'as a local market to sell their product into'.[87] An Australian-based battery manufacturing sector would also have flow-on benefits to other industries 'such as the manufacture of new submarines in South Australia which is expected to involve battery technology'.[88]

Battery technology and developments

4.63 At its Melbourne hearing, the Committee heard from a panel of academics specialising in battery chemistry research who spoke about their research areas and the implications this work would have on battery use into the future. Associate Professor Patrick Howlett from Deakin University stated that his focus was on 'next generation prototype batteries with new materials that have superior properties, for example, lighter weight'.[89] Associate Professor Howlett also described the industry's move to lithium-ion batteries with higher levels of cobalt:

> The main attractiveness there is their higher theoretical energy density or specific capacity, which is the amount of charge they can store per gram, as well as their higher voltage.[90]

---

85 See, for example: Giles Parkinson, 'Sonnen to manufacture home batteries at old Holden factory in Adelaide' *RenewEconomy*, 9 September 2018, https://reneweconomy.com.au/sonnen-to-manufacture-home-batteries-at-old-holden-factory-in-adelaide-92563/ (accessed 26 November 2018); Sophie Vorrath, 'Alpha-ESS to become second battery manufacturer to set up shop in Adelaide', *One Step Off the Grid*, 14 November 2018, https://onestepoffthegrid.com.au/alpha-ess-become-second-battery-manufacture-set-shop-adelaide/ (accessed 26 November 2018).

86 Professor Mainak Majumder, Department of Mechanical and Aerospace Engineering, Monash University, *Committee Hansard*, 27 September 2018, p. 45.

87 Mr Warren Pearce, Chief Executive Officer of the Association of Mining and Exploration Companies, *Committee Hansard*, 17 August 2018, p. 28.

88 ACTU, *Submission 107*, pp. 3–4.

89 Associate Professor Patrick Howlett, Deakin University, *Committee Hansard*, 17 August 2018, p. 38.

90 Associate Professor Patrick Howlett, Deakin University, *Committee Hansard*, 17 August 2018, p. 40.

4.64 Mr Ali Asghar, Senior Associate for Power, Energy Storage and EVs at Bloomberg New Energy Finance explained that as demand for particular minerals increases with battery demand, this will drive innovation and amongst the battery industry to modify the chemical composition of batteries to reduce battery input costs:

> We do look at battery chemistry changes in the chemical composition of batteries—the amount of cobalt, lithium, nickel, manganese composition within batteries. We do expect a change towards chemistries with a lower composition of cobalt, mainly because that is a metal that we expect to be a bottleneck in lithium-ion battery manufacturing. It is basically a road block in putting pressure down on lithium-ion battery pricing.[91]

4.65 Associate Professor Howlett noted that higher energy density can pose difficulties from an operating perspective as they are restricted in how quickly the batteries can be charged.[92]

4.66 Professor Baohua Jia, Research Leader at the Swinburne University of Technology highlighted her team's work on supercapacitors, which are 'a very good alternative for the current batteries in terms of safety issues, lifetime, cost and also environmental concerns'.[93]

4.67 The University of Adelaide has projected that by 2030 'silicon carbide and gallium nitride based switching devices will drastically change the power electronics systems used in EVs (including battery chargers and motor drives)'. The use of such devices will 'improve efficiency, operating temperature, reliability while significantly reducing system size and weight'.[94]

4.68 Nonetheless, many witnesses argued that despite these advances lithium-based batteries would remain the dominant underlying chemistry in batteries well into the future.[95] Mr Asghar affirmed this view:

> Absolutely, lithium-ion batteries have an incumbency advantage. They have governments that are supporting the technology, governments that are supporting the manufacturing—for the electric vehicle industry and lithium-ion battery manufacturing. That gives me a little bit of confidence that, at

91 Mr Ali Asghar, Senior Associate for Power, Energy Storage and EVs at Bloomberg New Energy Finance, *Committee Hansard*, 27 September 2018, p. 9.

92 Associate Professor Patrick Howlett, Deakin University, *Committee Hansard*, 17 August 2018, p. 42.

93 Professor Baohua Jia, Research Leader, Swinburne University of Technology, *Committee Hansard*, 17 August 2018, p. 38.

94 University of Adelaide, *Submission 91*, p. [3].

95 Professor Mainak Majumder, Department of Mechanical and Aerospace Engineering, Monash University & Associate Professor Patrick Howlett, Deakin University, *Committee Hansard*, 17 August 2018, p. 42.

> least in the next five to seven years, lithium-ion batteries will likely be the major source for electric vehicles.[96]

4.69 Associate Professor Howlett added to this noting that 'there are a number of fundamental barriers to making [lithium-ion batteries] work well, particularly when we try to achieve long cycle lives or the high rates that we need for acceleration'.[97]

4.70 Importantly, this dominance of lithium-ion is likely to underpin the continued fall in battery pricing and, in turn, the improved affordability of EVs. The Committee heard that the average pricing of lithium-ion battery pack is expected to fall from its current pricing of $209/kilowatt (kW) to $70/kW by 2030.[98] Mr Asghar explained the reasons for this projected trend:

> It's a story of mass manufacturing—so economies of scale—technology development and a major push towards electric vehicles. Electric vehicles are currently the biggest consumer of lithium-ion batteries. They've surpassed consumer electronics or stationary storage. Because of that demand for lithium-ion batteries there's been a lot of R&D into the technology and there's been a lot of investment into manufacturing capacity, specifically in Asia—in China, South Korea and Japan. Economies of scale have a big role in this. We've seen this in solar panels, where the Chinese started entering the solar PV manufacturing sector and brought the cost down considerably over the last decade. It's a similar trend that we see in lithium-ion batteries. I would say: technology improvement and economies of scale.[99]

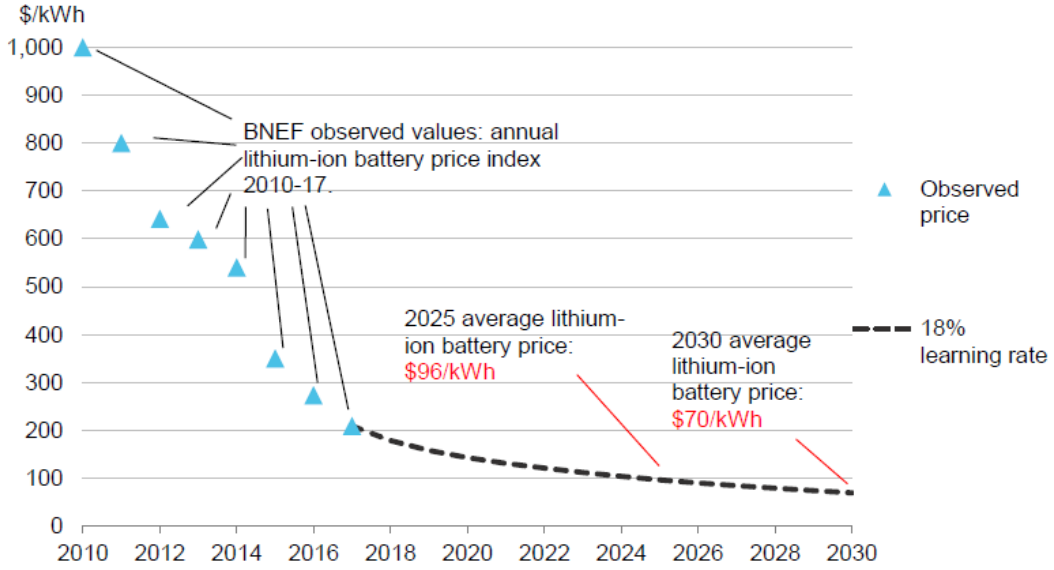
96 Mr Ali Asghar, Senior Associate for Power, Energy Storage and EVs, Bloomberg New Energy Finance, *Committee Hansard*, 27 September 2018, p. 11.

97 Associate Professor Patrick Howlett, Deakin University, *Committee Hansard*, 17 August 2018, p. 40.

98 Bloomberg New Energy Finance, *Submission 127*, pp.3–4.

99 Mr Ali Asghar, Senior Associate, Power, Energy Storage and EVs, Bloomberg New Energy Finance, *Committee Hansard*, 27 September 2018, p. 10.

Figure 4.1: Lithium-ion battery prices, historical and forecast[100]



Source: Bloomberg New Energy Finance Note: Prices are for EVs and stationary storage, and include both cell and pack costs. Historical prices are nominal, future prices are in real 2017 U.S. dollars.

4.71 Mr Fairweather also noted:

> With the technology developing and density increasing in batteries at the scale and rate that they currently are, in the very short term—maybe 12 months to two years—the battery sizes will start to be reduced with range still being retained.[101]

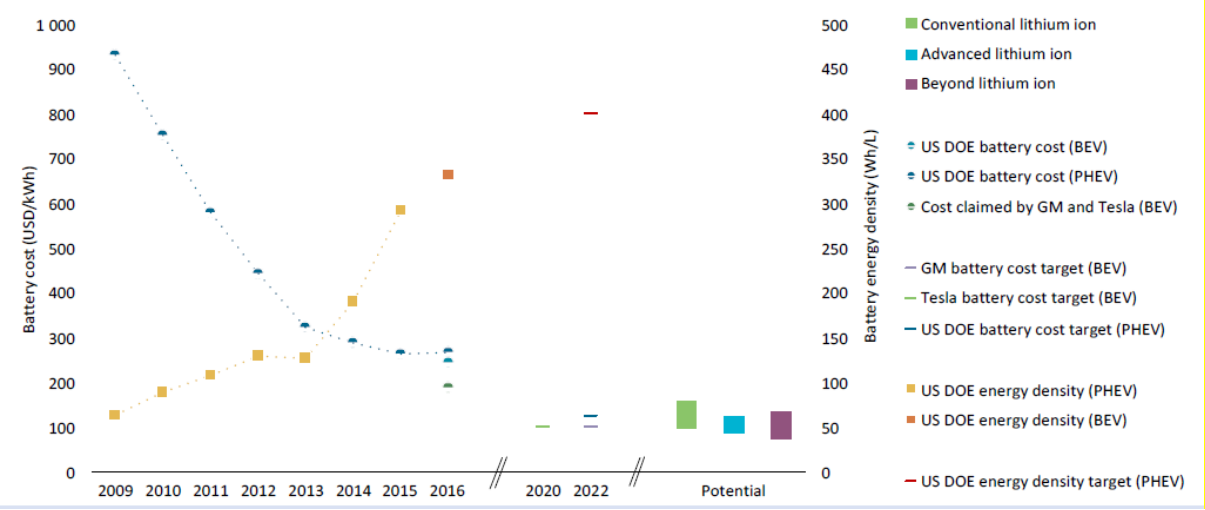
4.72 The International Energy Agency's (IEA) *Global EV Outlook 2017*, noted that '[r]esearch, development and deployment…and mass production prospects are leading to rapid battery cost declines and increases in energy density'.[102] Figure 4.2 is taken from the IEA's report and shows the evolution of battery energy density and cost.

100 Bloomberg New Energy Finance, *Submission 127*, p. 4.

101 Mr Tony Fairweather, Managing Director, SEA Electric, *Committee Hansard*, 31 August 2018, p. 2.

102 International Energy Agency, *Global EV Outlook 2017: Two million and counting*, 2017, p. 6.

Figure 4.2: Evolution of battery energy density and cost[103]



Battery recycling and repurposing

4.73 As the number of EVs rises and the batteries reach end-of-life, a number of witnesses have identified the recycling and repurposing of EV lithium-ion batteries as both a significant challenge and opportunity. The Queensland Department of Transport and Main Roads (DTMR) claimed that significant prospects exist for Australian businesses in relation to battery recycling:

> As a greater number of EVs are brought into the vehicle fleet, there will be opportunities to create industries around recycling and reusing EV batteries. EV batteries can be used for stationary storage, and following this, the raw materials can be recycled to create new batteries.[104]

4.74 According to the CSIRO only about three per cent of lithium batteries currently sold in Australia 'are being captured and sent for recycling off-shore'.[105] In its submission, MTAQ referred to a CSIRO report projecting between 100 000 and 188 000 tonnes of lithium battery waste by 2036, noting that 95 per cent of this waste could be recycled into 'new batteries or used in other industries' and yield an economic benefit of between $813 million and $3 billion by 2036.[106]

4.75 However, Dr David Harris, Research Director for Low Emissions Technologies and Energy at the CSIRO acknowledged that there are serious challenges in the recycling space, but that these are not insurmountable:

> We have projects underway now looking at how we can help companies who currently recycle some components of batteries adapt their processes to

---

103 International Energy Agency, *Global EV Outlook 2017: Two million and counting*, 2017, p. 14.

104 DTMR, *Submission 43*, p. 3.

105 CSIRO, *Submission 134*, p. 10.

106 MTAQ, *Submission 41*, p. [4]. See also: Sarah King, Naomi J. Boxall & Anand I. Bhatt, *Lithium battery recycling in Australia: Current status and opportunities for developing a new industry*, CSIRO, April 2018, https://www.csiro.au/en/Research/EF/Areas/Energy-storage/Battery-recycling (accessed 29 October 2018).

> accommodate the changing composition of batteries, the higher metal contents, the different metals that are coming on—so, how we fit into existing processes and add new capability as the batteries change. We're helping to do that. In some cases the materials get recycled either back to the manufacturer or for different purposes altogether in Australia. We're now working with groups looking at different applications and separating those safely, because just recycling them itself is not a trivial process; that's a process that requires safety procedures. Batteries still have some charge and can still catch fire in those processes. We are doing work with people to try to develop efficient processes for battery recycling.[107]

4.76 Some manufacturers such as Tesla and Toyota are already taking responsibility for 'whole of the battery life'.[108] Toyota has established a hybrid EV Battery Recycling Program with cash rebates and discounts for the return of EV batteries.[109] Whilst a recent media article claimed that 60 per cent of Tesla batteries are recycled with a further 10 per cent being reused in some form. Tesla is working towards a closed manufacturing loop that 'reuses the same recycled materials'.[110]

4.77 Dr Dale of the MTAQtold the Committee that there were many businesses excited by the commercial opportunities presented by battery recycling and ready to take up the challenge. Notwithstanding this confidence, many of these businesses need support to understand some of the technological issues associated with this industry. Dr Dale stated:

> If we can develop the technology to support businesses with that interest then that's where Australia will win in the longer term.[111]

4.78 In this context, the Committee notes the recent grants from ARENA and the CEFC to Melbourne-based company Reelectrify who are seeking to commercialise battery recycling technology.[112]

---

107 Dr David Harris, Research Director, Low Emissions Technologies and Energy, CSIRO, *Committee Hansard*, 18 October 2018, p. 10.

108 Dr Howard Lovatt, Team Leader, Electrical Machines, CSIRO, *Committee Hansard*, 17 August 2018, p. 50. See also: ACT Government, *Submission* 48, p. 3; Mr Gregory McGarvie, Managing Director, Australian Clean Energy Electric Vehicle Group, *Committee Hansard*, 27 September 2018, p. 55.

109 Toyota Australia, *Hybrid HV Battery Recycling Program*, https://www.toyota.com.au/hybrid/battery-recycling (accessed 28 November 2018).

110 John Forfar, 'Tesla's approach to recycling is the way of the future for sustainable production', *Medium*, August 2018, https://medium.com/tradr/teslas-approach-to-recycling-is-the-way-of-the-future-for-sustainable-production-5af99b62aa0e (accessed 28 November 2018). See also: Tesla, *Tesla's closed loop battery recycling program*, January 2011, https://www.tesla.com/en_AU/blog/teslas-closed-loop-battery-recycling-program (accessed 28 November 2018). See also: Mr Gregory McGarvie, Managing Director, Australian Clean Energy Electric Vehicle Group, *Committee Hansard*, 27 September 2018, p. 55.

111 Dr Brett Dale, Chief Executive Officer, Motor Trades Association of Queensland, *Committee Hansard*, 27 September 2018, p. 39.

4.79 Dr Matthew Stocks, Research Fellow at the College of Engineering and Computer Science at the Australian National University provided a practical example of how a used EV battery might be repurposed:

> Electric vehicle range is important. Electric vehicles have a more limited battery life than stationary energy. As battery capacity decreases, you are likely to say: 'I don't want this battery anymore; I want a new one.' That battery still has a significant life potentially for other applications like replacing a Tesla Powerwall in stationary energy, where I don't actually care if I put in another three batteries—instead of putting in 10, I put in 13—because there is no real space cost. So I suspect that a lot will go into re-use rather than recycling, to begin with.[113]

4.80 Dr Howard Lovatt, Team Leader, Electrical Machines, CSIRO noted that recycling car batteries may in fact be a more straightforward process than recycling batteries associated with smaller, personal devices:

> To make one observation on that, with a vehicle it is a lot easier to capture the battery at the end of life because there is already significant infrastructure for recycling the vehicle as a whole and the batteries could be an add-on to that, whereas, like your phone or your laptop batteries, it is much harder to actually capture the battery at the end of life.[114]

Manufacturing and installation of charging infrastructure

4.81 The lack of charging infrastructure is a barrier to increased uptake of EVs. The Royal Automobile Club of Victoria (RACV) cited a recent survey that found 80 per cent of 'respondents consider the availability of public fast charging (ie. 15 minutes to full charge) to be an important factor in influencing their decision to buy/own an electric vehicle'.[115] Furthermore, over half of respondents to the survey 'believe government should implement subsidies to reduce the cost of installing home charging, and provide public charging infrastructure'.[116]

4.82 Although Australia currently has a relatively high ratio of public chargers to EVs—about one charger to every six EVs—the low number of EVs and the large geographical area of Australia mean that this number will need to continue to grow to maintain this ratio and public confidence in using EVs across the country.

---

112 Giles Parkinson, 'ARENA, CEFC back plan to recycle EV-batteries for household storage', *RenewEconomy*, 4 October 2018, https://reneweconomy.com.au/arena-cefc-back-plan-to-recycle-ev-batteries-for-household-storage-65580/ (accessed 26 November 2018).

113 Dr Matthew Stocks, Research Fellow, College of Engineering and Computer Science, Australian National University, *Committee Hansard*, 17 August 2018, p. 13.

114 Dr Howard Lovatt, Team Leader, Electrical Machines, CSIRO, *Committee Hansard*, 17 August 2018, p. 50.

115 Royal Automobile Club of Victoria, *Submission 114*, p. 3.

116 Royal Automobile Club of Victoria, *Submission 114*, p. 3.

4.83 In its submission, the Australian Logistics Council (ALC) described the three types of charging infrastructure—'home charging, public charging and rapid/fast charging' and noted that :

> Home charging and public charging can further be grouped as *destination charging* – a slow charge designed to help motorists travel in metropolitan centres.
>
> Rapid/fast charging is analogous to highway petrol stations and is known as *journey charging*. As its name implies, it is designed to rapidly charge an electric vehicle for longer journeys.[117]

4.84 There are currently considerable opportunities for local companies to take advantage of the forecast increased demand for manufacture and installation of charging infrastructure for residential, commercial and government applications.

Home charging

4.85 The vast majority of EV charging is expected to occur at home, with about 70 per cent of EVs having a dedicated charging unit either at home or work.[118] Home charging at its simplest is connecting the EV to a regular household power outlet which provides the equivalent of 100 kilometres of charge in 17 hours. This can be upgraded to a basic AC charger known as a "slow" or "trickle" charger which can fully charge a vehicle overnight.[119]

4.86 About 85 per cent of kilometres travelled in Australian passenger cars are classified as short range driving, that is generally less than 100 kilometres from home.[120] Another survey showed that 'more than 99% of daily trips were under 50 kilometres, implying a round trip of 100 kilometres.[121] Most of this driving is commuting to work, study and recreation; visiting friends; and shopping. With newer EV models having a range of over 350 kilometres,[122] a home charger will meet the average day-to-day needs of most Australians. The Tesla Owners Club of Australia (TOC) confirmed this and made the point that most owners will not require public charging the majority of the time.

> The day to day requirement does not require high speed charging, with vehicles typically sitting idle for ten or more hours overnight or for a similar period during the day whilst the owner is at work.[123]

---

117 ALC, *Submission 104*, p. 13.

118 Energy Networks Australia, *Submission 60.5*, p. 6. See also: ARENA, *Submission 99.2*, p. 54. A US-based simulation undertaken in 2017 assumed that 88 per cent of all PEVs would be charged at home.

119 Royal Automobile Club of WA, *Submission 117*, p. 8.

120 Fast Cities Australia, *Submission 64*, p. 3.

121 Energy Networks Australia, *Submission 60.*5, p. 5.

122 Fast Cities Australia, *Submission 64*, p. 3. Converted miles to kilometres.

123 Tesla Owners Club of Australia, *Submission 28*, p. 7.

4.87 Even so, people for whom most charging is undertaken at home will still have a public charging requirement for long-haul trips.[124]

4.88 TOC noted that the limitation to home charging, particularly those who live in apartments is the availability of charging points:

> The key is availability, particularly for those who live in apartments. This can be addressed through building codes for new residential and commercial properties. As long as the electricity supply to the premises is appropriate the charging facilities do not need to be anything more complex than a standard 15A or 3 phase outlet which can be used with a suitable lead or adaptor.
>
> This will not immediately address the demand in existing buildings and it may be appropriate to make grants available to local councils or other authorities to provide publicly accessible charging points on street, in car parks and places of work.[125]

4.89 In its submission, the vehicle manufacturer Tesla confirmed the difficulties for apartment owners and observed that another barrier to home charging is for those who rent homes:

> Customers who are keen to purchase electric vehicles in Australia are often unable to do so if they live in apartments or are renting their home. Some are able to install charging quickly. However, others can be delayed because strata meetings for their building are very infrequent or have no clear process to follow for charging installations. Customers can also be faced with unreasonable demands or objections from landlords or strata Committees.[126]

4.90 An Energeia report also noted that EV 'drivers without access to home charging must rely entirely on public charging'.[127] The next section explores public charging stations.

Public charging stations

4.91 As noted earlier, 'two thirds of motorists indicate that a lack of adequate charging infrastructure is the greatest barrier to purchasing an [EV]'.[128] A small proportion of total Australian passenger vehicle kilometres are classified as long-range driving—about 15 per cent. Public chargers are primarily used for convenience but will also be used by drivers undertaking long-range trips and for those who do not have access to a charger at home or work. The Committee heard that public chargers form an 'important part of the electric vehicle ecosystem'.[129]

---

124 Energy Networks Australia, *Submission 60.5*, p. 6.

125 Tesla Owners Club of Australia, *Submission 28*, p. 7.

126 Tesla, *Submission 92*, p. [10].

127 Energy Networks Australia, *Submission 60.5*, p. 6.

128 ALC, *Submission 104*, p. 13.

129 ARENA, *Submission 99.1*, p. 13.

4.92 During the inquiry, the Committee heard about some of the businesses that are benefiting from the growing demand for public charging infrastructure. Mr Nathan Dunlop, the New Markets and Sales Analyst at Tritium, a Brisbane-based company, provided a background on his company:

> we're almost 250 staff now at Tritium. Those staff are in engineering, automotive and high-tech roles, working on exporting our product overseas. I guess the thing to note here is that those jobs also create downstream jobs throughout the supply chain. We create installation, maintenance and field service opportunities for installers that are putting our product in the ground. That's worldwide and in Australia. We also create jobs in regard to the supply chain. As you saw, our product has very many components in it, and 40 per cent of that procurement spending goes to Australian businesses at the moment. So those jobs are coming to Tritium but are also creating downstream job impacts.[130]

4.93 Chapter 2 of the report described the different types of public charging infrastructure. Level 2 chargers (slow chargers) can charge an average car in 4–6 hours; whereas level 3 chargers (fast/ultra-fast chargers) can charge a car in as little as 20 minutes (even less for ultra-fast chargers currently under development).[131] A recent Energeia report estimated that up to 30 per cent of EV drivers will rely on public chargers for 100 per cent of their EV charging needs.[132] Level 2 public chargers are primarily used 'for public destination-based charging locations to attract drivers' such as supermarkets or shopping centres.[133] Level 3 chargers are mainly used for long-distance charging where an EV needs to quickly recharge in order to continue its journey.

Highway charging

4.94 In its submission, Fast Cities Australia estimated that the optimal spacing for an ultra-fast charging network would be 150 kilometres, and that a network of this type would cost a minimum of $100 million.[134] Fast Cities Australia also stated that 'ultrafast highway charging networks are capital-intensive but cannot attract conventional equity and debt in medium term due to revenue uncertainty'.[135]

4.95 A number of state governments and other organisations are establishing, or planning to establish, new public charging infrastructure. Mr Paul Fox, Head, Corporate Development at Fast Cities Australia told the Committee of their intention to complete a network of fast chargers along the major federally funded highways:

---

130 Mr Nathan Dunlop, New Markets and Sales Analyst, Tritium, *Committee Hansard*, 27 September 2018, p. 1.

131 Energy Networks Australia, *Submission 60.3*, p. 30.

132 Energy Networks Australia, *Submission 60.5*, p. 5.

133 Energy Networks Australia, *Submission 60.5*, p. 5.

134 Fast Cities Australia, *Submission 64*, p. 4.

135 Fast Cities Australia, *Submission 64*, p. 1.

> My colleague tells me that he could knock out 42 sites very quickly. It's really a matter of the timing of funding. But our intention is to have the Melbourne to Brisbane completed by the end of next year, and then we would roll out the remaining 42 sites in the following year and six months. So it's about a two and a half year process in total. We could go faster; we have to be careful about going faster, because we need to match it to the growth in demand. We're already going ahead of ourselves; we don't want to go too far ahead of ourselves.[136]

4.96 The DTMR described the Queensland Government's Electric Super Highway (QESH), which stretches from Coolangatta to Cairns and Brisbane to Toowoomba. DTMR explained:

> Fast charging stations have been built in Cairns, Tully, Townsville, Bowen, Mackay, Carmila, Marlborough, Rockhampton, Miriam Vale, Childers, Maryborough, Cooroy, Brisbane, Coolangatta, Springfield, Gatton and Toowoomba. An additional charging site will be built at the Helensvale Queensland Rail carpark now that the Commonwealth Games have finished, once the carpark upgrade is complete.
>
> Each site is no more than 200km apart and was chosen considering the driving range of EVs, local amenities, and the local energy network capacity. Sites are located close to amenities, such as cafes, shopping centres and restrooms, allowing drivers to take a break to stop, revive and survive while they recharge their vehicle.[137]

4.97 DTMR stated that the large rollout of charging stations has resulted in a reduction in the ratio of EVs to public chargers from 10.5 to 4.9. This is despite a 70 per cent increase in the EV fleet over the last two years.[138] Ms Sally Noonan, Chief Economist at DTMR stated that the Queensland Government's reasons for building the QESH was not just about refuelling vehicles but also encouraging people to spend time in various locations around Queensland:

> It's quite a different experience. The Queensland government's Electric Super Highway is not about just filling up in 10 minutes and then you're gone. It's actually trying to, in particular, look at that range anxiety around tourists, for example. That is where we see there's a real opportunity, where people are going to spend some time in the location where their vehicle is charging. It's quite a different proposition to the petrol station kind of scenario that I understand.[139]

---

136 Mr Paul Fox, Head, Corporate Development, Fast Cities Australia, *Committee Hansard*, 27 September 2018, p. 27. See also: Fast Cities Australia, *Submission* 64, p. 8. In its submission, Fast Cities Australia has stated that it intends to install up to 100 chargers.

137 DTMR, *Submission 43*, p. 3.

138 DTMR, *Submission 43*, p. 5.

139 Ms Sally Noonan, Chief Economist, Queensland Department of Transport and Main Roads, *Committee Hansard*, 27 September 2018, p. 36.

4.98 The Royal Automobile Club of Western Australia (RACWA) also described the RAC Super Highway, 'a network of 11 publicly accessible EV fast charging DC stations located between Perth and Augusta' (520 kilometres) in south-west Western Australia.[140] The NRMA stated that it intends to build 'Australia's largest charging [EV] fast charging network' in NSW at a cost of $10 million.[141]

4.99 Mr Tim Washington, Chief Executive Officer at Jetcharge, a Melbourne-based business explained how his business is benefitting:

> JET Charge is what I would call a small business, one of the beneficiaries of the downstream jobs that Tritium are talking about. We started about five years ago, and we're now the leading installer of electric vehicle charging stations in Australia, being the recommended installer for nine vehicle brands nationwide. If you think of us as, basically, the people on the ground actually making sure the infrastructure gets installed, we're those people. We're the largest hardware distributor of charging stations in the Australian market. We've seen a large growth period over the last two years in the market. We currently employ 14 people in the head office and have a large contractor network of electricians who perform installations for us. That comes from a base of only two to three people, two years ago, and so we've seen some good growth in the market. From my perspective, it's really important that small businesses like ours have the room to grow into this new industry.[142]

4.100 Mr Washington also described an associated business called Chargefox:

> Chargefox is basically a software business that controls the charging stations. You need software to control the charging stations, and Chargefox was born out of a joint venture between us and a software business. It is another example of the new age of automotive, in terms of the technologies that are required, and is another Australian-born business, which currently employs four people.[143]

Metropolitan charging

4.101 A number of local governments have also declared their interest in establishing public charging infrastructure within their local areas.[144]

4.102 The Committee heard that the ACT Government is funding '50 new EV public charging stations in Canberra' at a cost of about $450 000.[145] That works out to be $9 500 per charger.

---

140 Royal Automobile Club of Western Australia, *Submission 117*, p. [1].

141 NRMA, *Submission 78*, p. [6].

142 Mr Tim Washington, Chief Executive Officer, Jetcharge; and Founder, Chargefox, *Committee Hansard*, 27 September 2018, p. 2.

143 Mr Tim Washington, Chief Executive Officer, Jetcharge; and Founder, Chargefox, *Committee Hansard*, 27 September 2018, p. 2.

144 See, for example: City of Darebin, *Submission 51*, p. [2]; City of Adelaide, *Submission 93*, p. 10.

4.103 Ms Michelle English, Associate Director at the City of Adelaide spoke about the how the City of Adelaide was seeking to leverage private sector capital to build charging infrastructure:

> At a local level, we have several initiatives that demonstrate our commitment and our leadership. In the last 12 months we have co-funded with the state government, Esso power networks and Mitsubishi Motors the installation of 30 off-street electric vehicle charging stations in our council owned UPark stations and an additional 10 on-street electric vehicle charging stations. We've also partnered with Tesla and our eight-bay electric vehicle charging hub in Franklin Street to enable them to install four 120-kilowatt superchargers. We offer two hours free parking in selected high-profile locations, such as the Franklin Street EV charging hub.[146]

4.104 Ms English continued describing incentives for local businesses and community members:

> In addition to infrastructure, our Sustainability Incentives Scheme provides financial rebates to our businesses, property owners and community for rebates of up to $1,000 for each fast charger less than 20 kilowatts, $5,000 for each superfast charger over 20 kilowatts, and $250 for each electric bike charging station installed in the city.[147]

4.105 In its submission to the Committee, Jolt explained that it is building a network of public chargers, 'providing free charging for users and free installation for cities, funded by the billion dollar digital out-of-home advertising market'.[148]

4.106 The UK Government, in its Road to Zero Strategy, noted that in addition to charging at home overnight, charging at workplaces during the day will be one of the 'most attractive options' as 'EVs go mainstream'.[149] The UK Government has made funding available to private businesses and public bodies through a Workplace Charging Scheme and recently announced an increase in the levels of the scheme to

---

145 350 Canberra, *Submission 21*, p. 4. See also: Mr Geoffrey Rutledge, Deputy Director-General, Sustainability and the Built Environment, Environment, Planning and Sustainable Development Directorate, Australian Capital Territory, *Committee Hansard*, 17 August 2018, p. 5.

146 Ms Michelle English, Associate Director , Sustainability, City of Adelaide, *Committee Hansard*, 10 August 2018, p. 48.

147 Ms Michelle English, Associate Director , Sustainability, City of Adelaide, *Committee Hansard*, 10 August 2018, p. 48.

148 Jolt, *Submission 96*, p. 1.

149 Department of Transport (UK), Road to Zero: Next steps towards cleaner roads transport and delivering our industrial strategy, July 2018, p. 82, available at: https://www.gov.uk/government/publications/reducing-emissions-from-road-transport-road-to-zero-strategy (accessed 2 January 2019).

provide up to £500 off installation costs of charging sockets deployed at workplaces.[150]

Rural charging

4.107 The Victorian Government Department of Environment, Land, Water and Planning identified that some gaps may emerge in the deployment of public charging infrastructure particularly in rural and regional parts of the country:

> Research has found that the private sector will develop charging infrastructure at destinations such as shopping centres as there is an economic benefit. However, the areas less enticing for private investment are regional areas. A charging network along key regional routes could unlock tourism and economic development opportunities.
>
> Tourists and residents are more likely to rely on public charging stations in regional and rural areas. Those living in rural areas travel further to access services than metropolitan residents, including education and employment precincts, and do not have as many public transport options. Vehicle ownership is perceived as more of a necessity for those living in regional Victoria. Similarly, tourists driving through regional Victoria need easy access to public charging infrastructure along popular tourist routes. Fast charging is particularly beneficial for long trips.[151]

Concluding comments

4.108 With increasing global demand for EVs, the Committee has heard that there are tremendous opportunities for Australian manufacturers. The Committee notes evidence suggesting that increasing automation will lead to fundamental changes to the processes and costs of manufacturing opening niches for Australian industry. The Committee has also heard that the Australian automotive sector might look differently to the mass manufacturing model of the past. The sector may choose to identify and play to its strengths, building specialist componentry, or assembling imported and locally made parts.

4.109 The Committee is encouraged by the companies that it has had heard from and visited who are at the forefront of the transition to EVs. For example, Nissan Casting Australia is already making components for EVs that are then assembled overseas; SEA Electric is fitting EV technology to truck gliders and has recently announced an expansion into EV bus manufacturing. In addition to these companies, there is a significant skilled workforce available to migrate from conventional automotive manufacturing to EVs; and a substantial and growing automotive research and development capacity.

4.110 Australia has significant reserves of a range of minerals essential to the production of lithium-ion batteries, the preferred battery type for EVs currently and

150 Department of Transport (UK), Road to Zero: Next steps towards cleaner roads transport and delivering our industrial strategy, July 2018, p. 86.

151 Victorian Government Department of Environment, Land, Water and Planning, *Submission 129*, pp. 8–9.

into the foreseeable future. A number of large lithium deposits have been developed with more on the way. The Committee is concerned that Australia is primarily engaged in the raw material extraction and export which only captures 0.5 per cent of the lithium value chain. Clearly more of this value chain can and should be captured by Australian companies.

4.111 Some mining and exploration companies are partnering with international companies with processing experience as a means to build processing capability. The Committee has heard that there are currently four lithium battery factories under development in Darwin, Townsville and Adelaide. These and other similar developments may provide the catalyst for an increased refining and processing presence for lithium and other minerals used in battery manufacture. The Committee is concerned about the likelihood of a surge in end-of-life EV batteries requiring recycling or repurposing. There is a need to ensure that companies interested in battery recycling are guided by comprehensive regulatory frameworks and the latest R&D to minimise any environmental and safety risks.

4.112 It is clear that the demand for charging infrastructure will continue to grow in line with EV numbers. Production of charging units and componentry for both home and public use, and the installation of such equipment is already providing economic benefits in states such as Queensland and Western Australia. This is being led by both the private sector and government. Although it is likely that the private sector will primarily fund public charging infrastructure in cities, public funding and planning will be required for highways and regional areas. Government has a role to play in enabling the private sector to rollout public charging infrastructure to all parts of the country.

4.113 A targeted approach will ensure that Australian industry optimises its economic participation in the transition to EVs. The next chapter will examine a range of possible federal and state government policies that could support the Australian industry to seize the opportunities associated with manufacturing EVs.