Centre for Energy and Environmental Markets

OPPORTUNITES TO FACILITATE ELECTRIC MOBILITY IN AUSTRALIA

Submission in response to the Senate Select Committee on Electric Vehicles

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About CEEM

The UNSW Centre for Energy and Environmental Markets (CEEM) undertakes interdisciplinary research in the design, analysis and performance monitoring of energy and environmental markets and their associated policy frameworks. CEEM brings together UNSW researchers from the Faculty of Engineering, the Australian School of Business, the Faculty of Arts and Social Sciences, the CRC for Low Carbon Living, the Faculty of Built Environment and the Faculty of Law, working alongside a number of Australian and International partners.

CEEM's research focuses on the challenges and opportunities of clean energy transition within market-oriented electricity industries. Key aspects of this transition are the integration of large-scale renewable technologies and distributed energy technologies – generation, storage and 'smart' loads – into the electricity industry. Facilitating this integration requires appropriate spot, ancillary and forward wholesale electricity markets, retail markets, monopoly network regulation and broader energy and climate policies.

Electric Vehicles are a vitally important technology for low carbon energy transition and CEEM has been exploring the opportunities and challenges they raise for the electricity industry for over a decade. More details of this work can be found at the Centre website – www.ceem.unsw.edu.au.

We welcome comments, suggestions and corrections on this submission, and all our work in the area. Please contact Associate Professor Iain MacGill, Joint Director of the Centre

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Introduction – Electromobility Framework

CEEM welcomes the opportunity to contribute to this important Senate inquiry regarding the great opportunities, yet also challenges, that accelerated electric vehicle uptake offers Australia.

Battery Electric Vehicles (BEVs) deployment is growing rapidly in many jurisdictions worldwide, with many cities, countries and automobile manufacturers declaring their intent to shift towards 100% electromobility. Importantly, the electrification of transport is happening across almost all transport modes including not only cars but also buses, motorbikes, scooters and bicycles.

It is happening during a time of unprecedented change in the electricity sector, as new technologies and business models create opportunities to reduce environmental impacts whilst improving energy service delivery and reducing costs. Key amongst these technologies are a range of distributed energy resources (DERs), including rooftop PV and battery energy storage as well as 'smart loads'. These provide new opportunities for energy consumers to more meaningfully participate in their energy service provision, while facilitating a more sustainable energy future. Electric mobility technologies are a potentially highly valuable DER, but only if deployment is appropriately managed.

Our submission first presents our key views on how electromobility can and should be managed in Australia. We then address the specific questions posed by the Select Committee on Electric Vehicles ('the Committee') in its Terms of Reference, dated 27 June 2018.

From 'Electric Vehicles' to 'Electromobility'

The term Electric Vehicles (EVs) is often used to refer only to passenger vehicles, which while potentially significant in their benefits, cannot provide the full suite of benefits available through broader electric vehicle modes (e.g. cars, buses, commercial vehicles, bikes, trucks etc.). This broader range of EV options is often referred to as Electromobility. This broader framing is a far more useful framework for the Committee's work for reasons including:

- Passenger vehicles alone represent just under half of domestic transport emissions [1], with emission reduction potential via electrification of approximately 18% of emissions from domestic transport[1] under Australia's current electricity generation mix (refer to Table 1). Targeting other road-based transport modes extends this opportunity to a 42% reduction in domestic transport emissions.
- The number of vehicles and emissions from other modes such as light commercial vehicles (LCVs) and trucks are forecast to grow through to 2030, while passenger vehicle numbers and emissions are expected to decrease [1].

[1] Please note that domestic transport refers to all domestic road-based transport as well as domestic shipping and aviation as according to [1].

- Impacts on and benefits for the major electricity markets (the NEM and the WEM) may well be understated if other modes are neglected.
- Other more space efficient mobility modes such as buses, bicycles and scooters can help to address urban congestion issues and mode share.
- Each mode has unique barriers and stakeholders that should be considered in policy design, and the potential interaction between policies for each mode needs to be considered[2].

Electromobility, therefore, presents as an opportunity to fundamentally rethink the transport sector, in pursuit of multiple policy aims, including decarbonisation, energy security, improving mode share and decreasing traffic congestion.

Electromobility falls within a broader context of electricity and transport transitions

Electromobility is emerging alongside a number of other significant developments, challenges and opportunities, in both the transport and electricity sectors.

Policy support and rapidly decreasing cost has driven strong uptake of distributed PV generation in Australia. New distributed energy technologies for monitoring, prediction and control, and battery storage are now also on a favourable cost trajectory. Electromobility technologies are part of this broader set of distributed energy resources (DERs), which at high penetrations present integration challenges in the distribution network and for power system operation, but also opportunities to improve economic efficiency, reliability and security of the grid.

DERs transform electricity consumers from passive to active participants in the grid, able to both buy and sell energy, as well as potentially offer power quality and security services. As both a new electrical load and an inverter connected battery energy storage system, electromobility technologies have the potential to increase demand, but also to shift load to reduce prices in the wholesale market, provide demand response for managing peak load or system security services, and via inverter control, provide network power quality services such as voltage management or supply of reactive power. Unmanaged electromobility technologies, however, also have the potential to create challenges, for instance by increasing peak demand and expanding the range of voltages that need to be managed in the distribution network. There are a number of trials and stakeholder consultations underway exploring how best to incentivise and manage distributed energy resources (DERs). Electromobility technologies should be considered within these processes, while policy-making regarding them should also take into account the impacts on the electricity sector of their uptake and the way they are operated.

By comparison, there has been far less technology progress in the transportation sector than the electricity sector over the past decade. However, this is now changing due

[2] For example, bus lane access for passenger vehicles to improve traffic flow reduces the attractiveness of bus transport, therefore having a perverse impact on congestion.

to pressures both local and global – regional air quality and congestion, as well as transport's major contribution to global greenhouse gas emissions.

We are now seeing the emergence of global low emission zones in cities[3], emission standards and country wide electric vehicle targets, as well as new Mobility as a Service (MaaS) business models and autonomous vehicles that lessen the need for private car ownership.

Australia has been a leading jurisdiction in terms of DER deployment in its electricity sector over the past decade, but is, with a few exceptions, lagging in these transportation developments. Effective coordination across transport and electricity sector regulation, market design and policy could assist Australia in taking a leadership role in electromobility.

We need new modelling tools and approaches to better understand our electromobility opportunities and challenges

Credible and accessible data and modelling tools have a key role to play in better understanding electromobility opportunities and challenges in the Australian context. Both sectors are transitioning quickly and are interrelated through electromobility, therefore it is vital that the modelling tools and data are freely available to all and accepted by both sectors Models for both the electricity and transport sectors exist. However, they are not currently integrated. As CEEM has previously commented, modelling in the Australian electricity sector has tended to rely on proprietary models from consultancy firms, with limited transparency around assumptions, scenarios and methods [2]. An emerging industry requires clarity and transparency to foster innovation and to remain flexible and therefore we believe the government should require any funded modelling to be open-sourced.

Tools should ideally be constructed in collaboration with experts from both sectors to capture issues, insights and constraints unique to each. Open source tools and data collection will be invaluable to the core stakeholders including:

- *The electricity sector*; to maintain high quality power supply
- *Governments;* to better design informed policy and ensure sufficient transport infrastructure recovery
- *The transport sector;* to better predict and serve consumer's requirements
- *Manufacturing and value chain service industries;* to better innovate and stay competitive internationally

Appropriate incentive design is key to maximising the benefits and minimising the costs and risks of electromobility uptake

Tariff and incentive design is one key area of market design that needs attention with increasing electromobility technology penetration. Uncontrolled charging at high penetrations will likely exacerbate electricity network peaks [3] and occur

[3] Such as the Low Emission Zone in London; https://tfl.gov.uk/modes/driving/low-emission-zone/about-the-lez and the ZRC in Paris; http://urbanaccessregulations.eu/countries-mainmenu-147/france/paris

"disproportionally during periods of high existing power system load" [4] for passenger vehicles, likely raising costs for consumers. This signals the need for more sophisticated retail market arrangements and well-informed incentives, which would be supported by the use of open-sourced data and tools.

However, as CEEM has commented on previously, "proposals to impose cost reflective network pricing on BEV charging in the absence of wider retail market transformation that treats all electrical loads in an equitable manner risks the technology and participant neutrality that is a key tenant of the NEM design." [5]. Effective governance will be required to ensure equity and avoid unfavourable grid effects.

Good incentive design requires good governance

A key challenge for appropriately managing electromobility is the present disfunction seen in electricity industry governance. It is clearly 'unfit for purpose' in facilitating our transition to a secure, affordable, zero emission electricity industry over a matter of decades. While CEEM does not focus on transport sector governance, there would seem to similar reasons for concern given the steady growth in transport sector emissions over the past two decades.

We certainly can't leave electromobility's future in the hands of the market. Markets are a 'means' rather than an end in themselves, and while markets can certainly drive major transformation in some circumstances, they typically require careful guidance and a 'firm hand' if they are to provide assured, robust delivery of desired societal outcomes.

Planning has a key role in both the electricity and transport sectors, but there is little evidence of the necessary coherence and comprehensiveness in the existing frameworks in either at present, let alone effective integration across them.

What is needed is at least some measure of bipartisan agreement, and a coherent and comprehensive regulatory, market and policy framework that is robust to a wide range of possible future scenarios for both transport and electricity. Furthermore, the associated planning process must be continuous to adapt to changing conditions; 'plans are nothing, but planning is everything'.

The stakes are very high. Poorly managed, very rapid, electromobility uptake could create significant challenges, for example in road infrastructure cost recovery and expensive grid augmentation. There is also a risk of emerging monopolies. Governance is needed to ensure that we don't get locked into a technical framework[4] that will eliminate future competition and innovation. Any regulation needs to remain flexible to adapt with the ongoing sector transitions.

However, frameworks that hinder appropriate electromobility transformation present a risk that Australia will not reap the benefits of such transformation while our international trade partners do. Australia has one of the slowest BEV adoption rates within APEC [6] and therefore risk missing out on the increased energy security, reduced fuel costs and reduced pollution that they offer. Clarity and certainty in

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[4] For example, a certain public charging infrastructure that is only compatible with one brand of vehicle or regulations that restrict new entrants.

governance is particularly required to attract electromobility manufacturers and incentivise uptake to realise these benefits.

We thank-you for the opportunity to make a submission to the review and would welcome any opportunity to further contribute to the efforts of the Commission in this area.

Q1 – Benefits of Widespread Uptake

Question 1: The potential economic, environmental and social benefits of widespread electric vehicle uptake in Australia

Environmental benefits are widespread – especially with more renewable energy

Previous CEEM modelling has suggested that moving to 100% zero emission passenger vehicles represents a potentially highly cost-effective carbon abatement opportunity, with the total cost of transition ranging from $0-20 per capita per week to achieve net zero emissions for passenger cars[5] [7].

The carbon emissions of electric vehicles are already less than the incumbent ICE vehicle technology, even given Australia's present emissions intensive electricity sector. Table 1 shows that the upper limit of carbon reductions from a transition to electric road transport alone[6] is 40 $MTCO_{2\text{-}eq}$ per annum, equivalent to 42% of total 2017 domestic transport emissions (including domestic air and shipping, which makes up around 15% of sector emissions). The largest reduction comes from passenger vehicles, but the contribution of LCVs and trucks should not be ignored.

As the energy sector transitions to low carbon renewable energy generation, the carbon reduction scope for electromobility increases - to 85% of road transport emissions under a 100% renewable energy generation scenario (Table 1). The economic and environmental benefits of a transition to electromobility can be maximised by high renewable energy penetrations in the power system.

In addition, tailpipe emissions are significantly reduced under electric drive trains, reducing local pollution in cities and the associated healthcare and productivity costs.

Economic benefits for the electricity sector depend on market design

Electromobility represents a significant new load on the electricity grid, likely to be one of the largest loads for a residential consumer, comparable to hot water heating load. Because electromobility technologies contain batteries, and many consumers are likely to be flexible about when they are charged, they represent a flexible load resource[7]. Batteries connected to the grid via inverters can also provide a range of power quality services. Some examples of the value electromobility technologies could deliver to the grid are given below.

- ***Increasing Demand and Improving Network Utilization****;* While it may seem counter-intuitive to regard increasing demand as a benefit, decreasing demand for electricity in Australia has contributed to recent electricity price rises, due to

[5] Modelling done assuming 100% renewable energy generation for charging and includes fuel, maintenance, capital and battery replacement costs borne by each vehicle owner. Price variations depend on low and high estimates of future costs and prices. Total NPV is calculated between 2015-2035.

[6] Results are displayed on 2016 levels to avoid future uncertainty of increased fleet size, potential future mode shifting or technology improvements.

[7] Previous CEEM work has aimed to define EV's distributed energy resource potential for the Greater Sydney Region [8] and found that their potential is significantly linked to charging infrastructure – the more locally available, non-residential public infrastructure, the higher the potential for EVs to actively help the grid.

two factors. Firstly, network capacity investments were made over the past decade to meet increasingly peaky loads driven by high air conditioning uptake. Secondly, these investments were made on the basis of higher peak demand forecasts that have not eventuated as consumers have taken measures to reduce their consumption and bills via PV and energy efficiency investments. High penetration electric vehicle charging would increase demand and, if managed, improve load factors (ratio between average and peak demand) in the network. If all vehicles in 2016 were electric, this would represent an approximate increase of 50TWh/year across Australia, a 23% increase in NEM & WEM demands in 2015/16 as shown in Table 1. It should be emphasised that if electromobility charging is not well managed, it could exacerbate low load factors and require further network investment to meet increasing peaks.

- ***Improve Competition, Price and Revenue Outcomes in the NEM;*** Uncertainty in energy and climate policy has been blamed for lack of investment and increased exercise of market power in the NEM. This exercise of market power generally occurs when supply and demand balance is tight due to high demand and/or supply problems. EVs could provide valuable assistance in reducing the severity of such periods as both a controllable load and, with vehicle-to-grid, distributed generation.

  Also, high instantaneous penetrations of variable renewable energy can result in low or negative residual demand to be met by dispatchable generators, and hence low spot prices. Incentivising BEVs to charge during the day at times of high solar generation[8] can increase day time demand and prices underpinning greater investment certainty for new flexible generation as well as renewables.

- ***Load Shifting to Reduce Ramping***; High penetrations of PV (both utility scale and distributed) in some NEM regions (notably South Australia) is leading to steep increases in demand over 1-3 hours in the afternoon as the sun sets and evening peak demand builds. Meeting these ramps requires dispatch of generators with the capability to start up and ramp quickly. At present, expensive gas generators provide this type of flexible generation capacity in the NEM. Electric vehicle charging could be used as a flexible demand resource, charging during the day when PV generation is at its peak and reducing charging as PV in the afternoon to reduce the ramping requirements.

- **System security services:** The NEM is experiencing challenges of managing system security with increasing VRE penetrations, withdrawal of old coal capacity and a stalled investment environment due to climate and energy policy uncertainty. The battery storage capabilities in electromobility charging could be used to provide frequency regulation services, as the utility-scale Hornsdale Power Reserve battery system has recently proven in SA. There is a potential to use the demand response capabilities of battery charging to provide reserve capacity to meet demand during extreme peaks or contingency events, as a number of demand response providers are doing

[8] Assuming appropriate public charging infrastructure is available. See more CEEM work about PV and EV alignment in [9] and [10].

through the ARENA-funded reliability and emergency reserve trader (RERT) pilot in the NEM.

- ***Network Power Quality Services;*** *Uptake of first air conditioning and then PV in residential parts of distribution networks has increased the challenge of voltage management within the network, particular at times of high rooftop PV generation.* BEVs have the potential to use PV power behind the meter, effectively 'smoothing' the voltage profile that the distribution network sees, reducing the need for augmentation. Inverters can also provide a range of other power quality services, including providing reactive power and managing harmonics.

We would encourage any BEV economic modelling to consider the direct and indirect benefits and costs to the grid, including: the energy and ancillary service market value, loss reduction value, carbon abatement, renewable energy integration value, deferred network investment value, value of available firm capacity and security of supply [11].

Charging schedules and incentives will become increasingly important as penetrations increase and will impact the broader electricity grid. All of the above benefits can only be realised through diversified, well designed retail tariffs or incentives for private consumers and businesses. CEEM has done extensive work in this space and is discussed in more detail in "Q6- Other Related Matters".

Economic and social benefits from decreased reliance on liquid fuels

Transitioning to 100% BEVs could save in the order of 33,000ML of fuel[9] each year, compared to approximately 58,000ML crude oil consumed domestically in 2016 [13] as shown in Table 1. Per vehicle, trucks and buses have the largest potential to decrease fuel consumption annually. Reducing total oil consumption would increase our national security, depending less on international import security and price fluctuations while reducing our IEA stockpiling requirement.

Other benefits

Some other benefits include:

- The reduction of tailpipe and carbon emissions to the local environment have indirect benefits for public health and therefore less burden on the medical system.
- Autonomous electric vehicles offer the potential of safer road travel and reduced private car ownership, as well as better "end-of-trip" transfers for suburban consumers.
- Reduced transport costs for vulnerable persons, especially "captive" users without sufficient public transport options.
- Potential reduction of noise pollution, particularly coming from larger vehicles i.e. LCVs or public vehicles (garbage trucks etc.), which may give the potential to lift some existing night curfews. Improved opportunities to move some travel

[9] Includes petrol, diesel and other fuels as defined in [12].

to lower environmental impacts modes – for example, electric bikes substituting for car travel over relatively short trips.

Table 1: Indicative Road Transport Electrification Effects in Australia – Static 2017 Scenario at Various Penetrations

Note that these estimates are intended as order of magnitude estimates only to demonstrate the scale of opportunities.

Mode	**# Vehicles**	**Electricity Consumption (GWh/a)** *(% of 2015/6 total NEM & WEM demand) (1)*			**Petroleum Based Fuel Avoided (ML)** *(% of 2015/6 total domestic crude oil consumption) (2)*			**Carbon Avoided (2016 generation mix) ($MTCO_{2-e}$)** *(% of 2017 total domestic transport emissions) (3)*			**Carbon Avoided with 100% RE Generation ($MTCO_{2-e}$)** *(% of 2017 total domestic transport emissions) (3)*		
% of fleet electrified		***10%***	***25%***	***100%***	***10%***	***25%***	***100%***	***10%***	***25%***	***100%***	***10%***	***25%***	***100%***
Passenger Vehicle	13,712,810	3200 (2%)	8000 (4%)	32000 (15%)	1900 (3%)	4700 (8%)	19000 (32%)	1.7 (2%)	4.4 (5%)	17 (18%)	4.4 (5%)	11 (12%)	44 (46%)
Light Commercial Vehicle	2,983,034	790 (0%)	2000 (1%)	7900 (4%)	610 (1%)	1500 (3%)	6100 (10%)	0.89 (1%)	2.2 (2%)	8.9 (9%)	1.5 (2%)	3.8 (4%)	15 (16%)
Motorcycle	824,572	5.7 (0%)	14 (0%)	57 (0%)	12 (0%)	31 (0%)	120 (0%)	0.024 (0%)	0.061 (0%)	0.24 (0%)	0.029 (0%)	0.073 (0%)	0.29 (0%)
Trucks													
Rigid Truck	470,849	410 (0%)	1000 (0%)	4100 (2%)	290 (0%)	720 (1%)	2900 (5%)	0.44 (0%)	1.1 (1%)	4.4 (5%)	0.78 (1%)	2 (2%)	7.8 (8%)
Articulated Truck	96,214	460 (0%)	1100 (1%)	4600 (2%)	430 (1%)	1100 (2%)	4300 (7%)	0.81 (1%)	2 (2%)	8.1 (8%)	1.2 (1%)	2.9 (3%)	12 (12%)
Non-Freight Carrying Truck	21,581	11 (0%)	27 (0%)	110 (0%)	7.4 (0%)	19 (0%)	74 (0%)	0.011 (0%)	0.027 (0%)	0.11 (0%)	0.02 (0%)	0.05 (0%)	0.2 (0%)
Buses	82,615	90 (0%)	230 (0%)	900 (0%)	68 (0%)	170 (0%)	680 (1%)	0.099 (0%)	0.25 (0%)	0.99 (1%)	0.17 (0%)	0.43 (0%)	1.7 (2%)
Total	**18,191,675**	**5000 (2%)**	**12000 (6%)**	**50000 (23%)**	**3300 (6%)**	**8200 (14%)**	**33000 (56%)**	**4 (4%)**	**10 (10%)**	**40 (42%)**	**8.1 (8%)**	**20 (21%)**	**81 (85%)**

(1) N.B. total electricity consumption from EVs includes vehicles in all states, % is calculated as a proportion of NEM (191,777GWh, 2016) and WEM (18,895GWh, 2015/16 [14]) demand only and excludes all other electricity demand.
(2) Total domestic crude oil consumption in 2015 was converted from Australian Government figure of 2,243 PJ, or approximately 57,966 ML crude oil [13]. Vehicle petroleum-based fuel consumption is calculated using vehicle numbers, distances and fuel consumptions per year from ABS Survey of Motor Vehicle Use, Australia in 2017 based on 2015/16 data [12]. These figures are not directly comparable, and the comparison is provided for order of magnitude only.
(3) Avoided emissions per vehicle type are calculated using average BEV energy intensity figures per mode as per [15]. Emission factors are taken from [16] Australian Emission factors in August 2016, using Scope 1 factors for gasoline, diesel and LNG and Scope 2 factors for electricity. Total domestic transport emissions of 96MTCO2 in 2017 is from [1]. Please note that domestic transport refers to all domestic road-based transport as well as domestic shipping and aviation as according to [1].

Q2 – Manufacturing, Supply and Value Chain Opportunities

Question 2: Opportunities for electric vehicle manufacturing and electric vehicle supply and value chain services in Australia, and related economic benefits

Australia has a vast supply of lithium and cobalt; the main components of lithium-ion battery technology in modern BEVs, which could be investigated as an export or to be refined in Australia. There exists an opportunity to manufacture the batteries in Australia rather than just export the raw materials.

More generally, EVs represent an opportunity for Australia to participate right across the value chain from manufacturing to integration and services – an opportunity which we no longer have with conventional ICE cars. We note that Australia already has some companies manufacturing EVs, including but not limited to:

- **Buses**: Precision Buses (SA), Carbridge Australia, Bustech (QLD), AVASS (VIC)
- **Trucks**: SEA Electric (VIC), AVASS (VIC)
- **Light Commercial Vehicles**: AVASS (VIC), ACE Electric Vehicles (QLD)
- **Passenger Cars**: AVASS (VIC)
- **Motorcycles**: AVASS (VIC)
- **Bicycles**: Velectrix (QLD)

This industry could be further developed using the knowledge of skilled workers who previously worked for the ICE vehicle industry in Australia, as well as in supporting technologies.

We encourage the Committee to consider the broader value chain opportunities in charging infrastructure, battery reuse and supporting software. Australia has an enviable track record in the system integration, power electronics and niche high technology equipment space which should be supported. Existing Australian companies in this space include Tritium, FastCities, Everty, and Evee. Tritium is already a global market leader and is exporting charging stations internationally, namely to Norway. The Victorian start-up Relectrify is a start-up in the battery reuse space and has received ARENA funding.

Q3 – Acceleration measures

Question 3: Measures to support the acceleration of electric vehicle uptake

Electric vehicle uptake requires both the demand and supply to exist, both of which appear to be stagnating in Australia currently. Public policy is required to incentivise both to develop a sustainable market place able to accelerate deployment.

On the supply side, many vehicle manufactures have publicly stated their hesitation to enter Australia due to the perceived lack of government support compared to other countries[10]. We believe a clear target at the federal government level as well as a credible and actionable plan to achieve this is the first step to attract more manufacturers. Targets for government fleet purchases could also help, as well as implementing emission standards for passenger vehicles to restrict poor performing vehicles from entering the country or even direct fuel bans in certain areas as now being implemented in France and UK. Such approaches send a strong signal for investment and can be achieved at little to no extra cost.

On the demand side, increasing the available options for low-mid cost vehicles will promote uptake as the high upfront cost is a large barrier across every BEV mode. Direct (grants and subsidies, buy-back schemes) and indirect incentives (no/reduced import taxes[11], no/reduced luxury taxes, free registration) have all been used to internationally to overcome this barrier. For centralised controlled modes such as buses or commercial fleets, subsidies could extend to the associated infrastructure augmentations required (for example upgraded substation transformers for bus depots), representing another major cost for the owner/operator. As for any policy, it is important that the design of such a scheme adjusts as circumstances change – in this case for future decreasing costs of battery storage and EV manufacturing.

To improve the payback period of BEVs, financial (i.e. free public charging, free parking, increased taxes on petroleum or emission taxes, business tax incentives) or non-financial incentives (i.e. use of priority / bus lanes, designated parking, low emission zones, relaxed after hour access restrictions for trucks / commercial vehicles) have been used internationally.

Limited public charging infrastructure in urban areas is a large barrier for privately owned vehicles, as is designated charging infrastructure for buses and urban / non-urban charging for trucks. Internationally this has generally been constructed either purely by government or in a private/public partnership model.

Q4 – Manufacturing Measures

Question 4: Measures to attract electric vehicle manufacturing and electric vehicle supply and value chain manufacturing to Australia

As mentioned previously, attracting manufacturing to Australia will first require transparent federal level intentions and a viable market. A vibrant market is almost certainly a necessary, yet alone insufficient, measure to ensure local manufacturing and value adding.

[10] For example, BMW: https://www.news.com.au/technology/innovation/motoring/motoring-news/bmw-arcs-up-again-govt-idling-on-electric-vehicle-policy/news-story/8d239a837dec778d9c540419d68c54ca

[11] Note that import taxes exist for many modes including e-bicycles, motorcycles and cars.

After that point, incentivising domestic research and manufacturing through funded grants and tax incentives for manufacturing has been used successfully internationally, for example China successfully developed their BEV manufacturing industry partially through their 863 program, as did Japan since 1971 [6]. Indeed Australia has done the same previously; the South Australian Government has awarded Precision Buses a $2m grant for electric buses[12] and the Victorian Government awarding SEA Automotive $517,000 for commercial vehicles[13]. Funding through programs link ARENA has also helped the Relectrify start-up.

Q5 – Multi-level Government Support

Question 5: How federal, state and territory Governments could work together to support electric vehicle uptake and manufacturing, supply, and value chain activities

BEVs are an inherently cross disciplinary technology and need policy guidance by the energy and transport specialised portfolios in the federal and state/territory levels. This may require a separate body to govern as penetrations increase, but in the interim, it is important that all organisations are using and have access to similar data and tools.

Currently due to an absence of a clear federal policy, state-based or even city level policies exist alone with differing targets and incentives. Ideally, coherence can be achieved across all levels of government. The risk is of course that the price of such coherence in Australia would often seem to be 'lowest common denominator' outcomes that stifle technology innovation and progress. Instead, particularly in still emerging electric mobility areas, we need frameworks that allow different jurisdictions to support different pilots and trials, while seeking federal and State government policy measures to drive wider deployment and value adding progress.

As with any emerging industry, there is a risk of monopolies and technological lock in. Governance is needed to ensure that any regulation is sufficiently flexible and doesn't unduly favour any individual early movers or stifle new entrants. It needs to remain flexible to adapt with the ongoing sector transitions (i.e. autonomous vehicles, future mobility ownership and business models and high renewable grids).

Q6 – Other Related Matters

Question 6: Any other related matters

Charging Schedules & Incentives

Incentives, regulations and control over the operation of BEVs will become increasingly important as penetrations increase. Based on existing passenger vehicle trip data, CEEM research [4] indicates that uncontrolled charging at would primarily take place

[12] Read more at https://www.businessinsider.com.au/south-australia-just-built-the-nations-first-electric-bus-2017-6#bm46W0pQdxuakkAD.99

[13] Read more at https://www.solarquotes.com.au/blog/australia-electric-truck-mb0123/

during periods of high existing power system load. High BEV penetrations will therefore likely exacerbate electricity network peaks [3]. However, many consumers are likely to have a large degree of flexibility about when their vehicle charges. Price-based incentives could be used to incentivise consumers to either schedule charging to minimise industry costs, or to make load resources available for dispatch for network peak load reduction or other services such as power system regulation and reserves. This could be achieved either via a retail tariff that reflects the efficient wholesale electricity and network costs, or via a payment to be available to be controlled by a network, retail market participant or system operator.

CEEM modelling of BEV charging under existing tariff designs such as Time-of-Use (ToU) demonstrate that tariffs can assist to reduce peaks compared to uncontrolled charging, but that in high penetration scenarios, BEVs still add to peaks [3] particularly if they do not incentivise charging diversity. CEEM modelling of hybrid EV passenger vehicle charging found that a managed charging strategy that aligned charging with solar generation saved 2% of overall NEM generation portfolio costs compared to unmanaged charging, approximately \$200m/year. [9]. New retail tariff structures or incentives for controlled 'smart charging' are likely to be an important part of aligning BEV operation with industry benefits. However, as CEEM has noted previously, "proposals to impose cost reflective network pricing on BEV charging in the absence of wider retail market transformation that treats all electrical loads in an equitable manner risks the technology and participant neutrality that is a key tenant of the NEM design" [5].

While most modelling to date has focussed on passenger vehicles, managing non-passenger vehicle charging will also need to be considered. The spatial aspects of this charging will be important, as aggregated electric fleets i.e. buses, light commercial vehicles and taxis may require local substation and / or network augmentation to handle high rated power chargers in a concentrated area.

Autonomous Vehicles

Because the technologies are under concurrent development, autonomous vehicles (AVs) are very relevant to the discussion of EVs, and look to have many potential benefits including safety, efficiency, reduced private car ownership and reduced congestion. These and other outcomes of a transition to AVs are likely to interact with the transport and electricity industry impacts discussed above. While AVs are not necessarily electric, electric AVs should certainly be included in BEV modelling scenarios. Australia is already undertaking AV trials and there is room to expand these trials to include BEV vehicles in order to explore the interactions.

References

1. Australia, C.o., *Australia's Emissions Projections 2017*. 2017, Commonwealth of Australia.
2. MacGill, I., et al., *Submission to the Independent Review into the Future Security of the National Electricity Market*. 2017, CEEM.
3. Young, S., et al. *Impacts of Electric Vehicles on Australian National Electricity Market and Household Expenditure under Different Charging Regimes*. in *2015 Asia-Pacific Solar Research Conference*. 2015. Brisbane: Australian PV Institute.
4. Mills, G. and I. MacGill, *Potential power system and fuel consumption impacts of plug in hybrid vehicle charging using Australian National Electricity Market load profiles and transportation survey data.* Electric Power Systems Research, 2014. **116**: p. 1-11.
5. Mills, G., I. MacGill, and R. Passey, *EMO0022 – Energy Market Arrangements for Electric and Natural Gas Vehicles*, in *Submission to AEMC 2011 Review: EMO0022 – Energy Market Arrangements for Electric and Natural Gas Vehicles*. 2011, CEEM.
6. APEC, *The impact of government policy on promoting new energy vehicles (NEVs) - the evidence in APEC economies*. 2017, Asia-Pacific Economic Cooperation.
7. Riesz, J., et al., *Quantifying the costs of a rapid transition to electric vehicles.* Applied Energy, 2016. **180**: p. 287-300.
8. Mills, G. and I. MacGill, *Assessing Electric Vehicle storage, flexibility, and Distributed Energy Resource potential.* Journal of Energy Storage, 2018. **17**: p. 357-366.
9. Vithayasrichareon, P., G. Mills, and I.F. MacGill, *Impact of Electric Vehicles and Solar PV on Future Generation Portfolio Investment.* IEEE Transactions on Sustainable Energy, 2015. **6**(3): p. 899-908.
10. Vithayasrichareon, P., G. Mills, and I. MacGill, *Assessing the Potential Role of Large-Scale PV Generation and Electric Vehicles in Future LowCarbon Electricity Industries*, in *Solar Integration Workshop*. 2015: London, UK.
11. Mills, G. and I. MacGill, *A Framework for Maximising the Economic Value of Electric Vehicle Integration into the Australian NEM*, in *2012 22nd Australasian Universities Power Engineering Conference (AUPEC)*. 2012, IEEE: Bali, Indonesia.
12. ABS, *92080.0 Survey of Motor Vehicle Use, Australia, 12 months ended 30 June 2016*, A.B.o. Statistics, Editor. 2017, Australian Bureau of Statistics: Canberra, Australia.
13. DOEE, *Energy Update Report 2017*. 2017, Department of the Environment and Energy, Australian Commonwealth: Canberra.
14. AEMO, *2017 Electricity Statement of Opportunities for the Wholesale Electricity Market*. 2017, AEMO.
15. Energeia, *Electric Vehicles Insights: Prepared by ENERGEIA for the Australian Energy Market Operator's 2017 Electricity Forecast Insights*. 2017, Energeia.
16. DOEE, *National Greenhouse Accounts Factors*, in *Australian National Greenhouse Accounts*. 2016, Department of the Environment and Energy.