Submission
No 17

ELECTRIC BUSES IN REGIONAL AND METROPOLITAN PUBLIC TRANSPORT NETWORKS IN NSW

Organisation: Electric Vehicle Council

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Electric Vehicle Council submission: NSW Upper House Inquiry into electric buses in regional and metropolitan public transport networks in NSW

The Electric Vehicle Council is the national peak body representing the electric vehicle industry in Australia. We represent members involved in providing, powering and supporting electric vehicles. We are a cross sectoral organisation whose engagement with a wide range of stakeholders supports the advancement of a strong domestic electric vehicle industry.

The Electric Vehicle Council commends the establishment of this Inquiry and appreciates the opportunity to participate.

The Electric Vehicle Council supported the recent announcement by the NSW Roads and Transport Minister, the Hon Andrew Constance MP, that the Government will be seeking to transition Sydney's bus fleet to electric. If implemented, this transition will reap economic, environmental and social benefits for Sydney. It is important that this announcement is followed up with a strong detailed commitment and staged plan to oversee this transition.

Benefits of electric buses and factors that limit their wider uptake

The Electric Vehicle Council supports the electrification of bus fleets to reduce emissions, provide health and economic benefits, and create amenity improvements.

In NSW, transport greenhouse gas emissions comprised 21% of total emissions in 2016/17, making it the second largest source of emissions in the state. Road transport accounts for 85% of transport emissions and therefore needs to be a priority area of focus in order to reduce emissions.[1] Electrifying public and private vehicle fleets are a proven technology and cost-effective way to address emissions in road transport.

Benefits of electric buses

Emissions reduction

A significant benefit of electric buses is the absence of tailpipe (or exhaust) emissions which results in a lower total emissions profile for CO_2 and other harmful emissions. Tailpipe emissions account for around half of all emissions from vehicles, with the remainder coming from non-exhaust emissions such as tyre and brake wear.

How much an individual bus emits depends on several factors including:

- fuel type (e.g. diesel, hybrid, natural gas etc.)
- exhaust emissions control technology (e.g. Euro IV, Euro V etc.)
- size and tare weight (e.g. small, double decker etc.)
- passenger carrying capacity and average loading
- average speed and distance travelled[2]

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[1] NSW Government https://climatechange.environment.nsw.gov.au/About-climate-change-in-NSW/NSW-emissions

[2] Gerda Kuschel et al (2017) *Evaluating Bus Emissions: What colour, how big and how much is that elephant in the window?* https://www.australasiantransportresearchforum.org.au/sites/default/files/ATRF2017_115.pdf

The below table provides estimated exhaust emission factors of buses:[3]

Table 2: Exhaust emission factors for different bus types travelling at 20km/hour

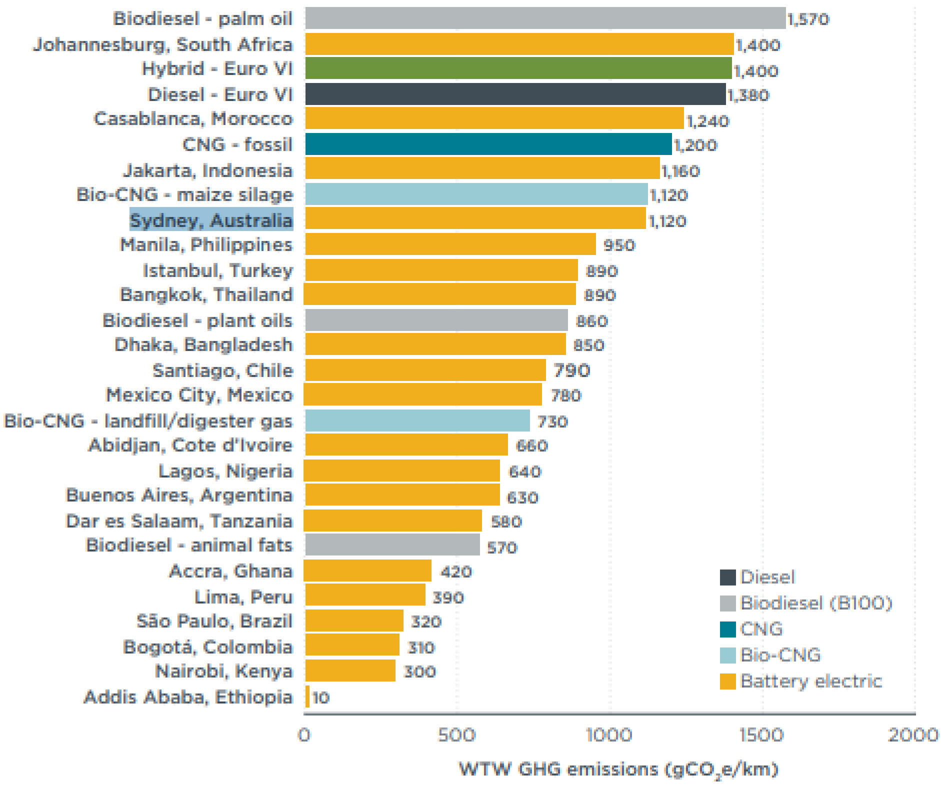
Bus type	Bus size	Emission Factors in g/km @ 20km/hour				
		CO	HC	NOx	PM_{10}	CO_2
Euro III	Large (LV)	3.46	0.70	12.56	0.25	1281
Euro IV	Large (LV)	1.61	0.09	7.58	0.06	1175
Euro V	Large (LV)	2.82	0.07	8.96	0.07	1138
Euro VI	Large (LV)	0.33	0.05	0.62	0.01	1163
Euro V diesel hybrid	Large (LV)	2.82	0.07	7.17	0.07	759
Euro VI diesel hybrid	Large (LV)	0.33	0.05	0.62	0.01	776
Low carbon emission bus	Large (LV)	0.03	0.01	1.56	0.003	763
Electric	Large (LV)	0	0	0	0	0
Natural gas	Large (LV)	1.12	1.13	4.58	0.01	1392

In terms of whole of lifecycle emissions, while electric vehicles are more energy intensive to manufacture due to the battery component, they still are much less emissions-intensive than their internal combustion engine counterparts. The total extent of the emissions footprint of an electric bus will depend on the emissions intensity of the energy being used at the time of manufacture and during charging activities.

The International Council on Clean Transportation analysis calculated Well-to-Wheel greenhouse gas emissions of electric buses when compared with Hybrid and Diesel Euro VI and CNG in 20 major cities, including Sydney. The below graph[4] shows that despite Sydney's reliance on a primarily coal-powered grid, electric buses still generate lower emissions over its lifecycle.

[3] Gerda Kuschel et al (2017)

[4] ICCT (2017) *Low-carbon technology pathways for soot-free urban bus fleets in 20 megacities* https://theicct.org/sites/default/files/publications/Low-carbon-tech-pathways-soot-free-buses-megacities_ICCT-working-paper_31082017_vF.pdf



It is important to note that this table does not include Euro 3 Diesel or CNG, Euro 5 diesel and Euro 4 CNG buses which comprise the majority of NSW's State Transit fleet.[5]

Over time, as the NSW electricity grid becomes greener, electric vehicles will have a much lower footprint during charging activities. There will also be significant opportunities to charge electric vehicles using solar PV and battery storage.

Public health and amenity

In addition to considering well-to-wheel greenhouse gas emissions, it also important to consider the other harmful emissions that are generated through the exhaust pipe and are therefore emitted directly in our local streets. Transitioning to electric buses will result in reduced air and noise pollution, leading to lower health costs and improved amenity.

The Electric Vehicle Council released the *Cleaner and Safer Roads for NSW* report earlier this year which details the health and safety benefits of transitioning to electric vehicles in NSW. The report detailed that in NSW alone, around 650 people die each year from vehicle emissions, which is 60% more deaths than from car crashes. Vehicle emissions also cause 21,000 serious health impacts each year. The report estimates that vehicle emissions lead to $3 billion in annual health costs in the Sydney-Newcastle-Wollongong region alone. The Electric Vehicle Council found that for each electric vehicle that replaces an internal combustion engine vehicle, NSW will save at least $2,400 in health costs.[6]

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[5] State Transit (2019) *State Transit Annual Report 2018-19 Volume 1* https://www.transport.nsw.gov.au/news-and-events/reports-and-publications/state-transit-annual-report-2018-19-volume-1

[6] EVC (2019) *Cleaner and Safer Roads for NSW* https://electricvehiclecouncil.com.au/wp-content/uploads/2019/06/EVC-Cleaner-and-Safer-Roads-for-NSW_V3-Single.pdf

The Chicago Transit Authority calculated its own health savings from adopting electric buses in its fleet. It found that operating one electric bus is the equivalent of removing 23 cars from the road each year. The reduction in harmful emissions also reduces incidents of illnesses and respiratory diseases, which is valued at US$55,000 annually per bus, or US$660,000 over the expected 12-year bus lifespan. [7]

Vehicle emissions also disproportionately impact the health of already vulnerable people including children, unborn babies, the elderly, and those with pre-existing medical conditions such as asthma, lung disease or cardiovascular disease. Many schools are built near main roads to increase accessibility however such exposure can have lifelong effects; children living within 75 metres of a major road have a 29% increased risk of lifetime asthma.[8] Electrifying buses (and other vehicles) would likely have the biggest benefit for these vulnerable populations.

Noise pollution from road transport also leads to health and social costs. Conventional buses and trucks often reach sound levels of 80 decibels, 100 times louder than a typical residential street.[9] The World Health Organisation ranked noise second among environmental threats to public health, only behind air pollution. A 2004 NSW survey had 46% of respondents report that they considered road traffic noise to be a problem in their neighbourhood[10]. The *Cleaner and Safer Roads for NSW* report estimates the social costs from vehicle noise in NSW is $1.4 billion annually, which is nearly one quarter of the social costs of smoking in NSW.

Transitioning to electric buses would help to reduce noise pollution. Electric buses are significantly quieter than their diesel counterparts, especially at low speeds. This is because electric motors do not require a combustion process and have a simpler mechanical construction.[11]

The health benefits of electrification are not only important for the wider community, but also for drivers of the bus who are behind the wheel for hours each day.

Economic benefits

Transitioning to an electric bus fleet will provide economic benefits to NSW.

In general, electric buses have a lower total cost of ownership, saving money for taxpayers and transit operators. While upfront vehicle purchase costs are higher, and initial purchases will require investment in infrastructure (which can be used for subsequent generations of buses), electric buses typically have lower recharging costs and lower maintenance costs meaning lower costs over the full lifecycle of the vehicle.

The Chicago Transit Authority found the estimated annual net savings in fuel costs for each electric bus is US$25,000, or $300,000 over the expected 12-year lifespan of each bus.[12]

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[7] Chicago Transit Authority https://www.transitchicago.com/electricbus/#Benefits

[8] McConnell et al. (2006) *Traffic, Susceptibility, and Childhood Asthma* https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1459934

[9] NSW Environment Protection Agency (2013) *Noise Guide for Local Government* https://www.epa.nsw.gov. au/-/media/epa/corporate-site/resources/noise/20130127nglg.pdf

[10] NSW Department of Environment, Climate Change & Water (2011)

[11] https://research.aalto.fi/files/27322839/ENG_Veps_l_inen_Jari_Driving_Style_Comparison_IEEE_Vehicle_Power_and_Propulsion_Conference_2017.pdf

[12] Chicago Transit Authority https://www.transitchicago.com/electricbus/#Benefits

As outlined above, electric buses will also provide further economic benefits to NSW through low-cost carbon abatement and reducing public health costs.

Electric buses could also improve productivity of bus routes in high-traffic areas. The electric motor produces maximum torque right from start, which results in good starting characteristics and driveability. Faster acceleration could deliver benefits to buses at traffic lights and bus stops and improve overall traffic flow.

The electrification of buses will also provide greater fuel security. Moving away from importing oil to utilising homegrown electricity will reduce risk and deliver economic revenue directly to the state rather than sending revenue offshore. BNEF estimates that 500 barrels of diesel are displaced each day for every 1,000 electric buses on the road.[13]

Grid integration

The electrification of some or all of the bus fleet could provide significant benefits to the electricity grid. The addition of several hundred or more buses with large batteries into the energy system could offer significant potential for demand-side participation such as vehicles discharging electricity to the grid, load reduction during peak events, and voltage and frequency control. Through managing charging times and use of onsite storage at depots, an electric bus fleet could also consume surplus renewable supply e.g. midday solar.

Barriers to electric bus adoption

As with all emerging transport technologies, electric buses will bring new challenges and require changes to the status quo. Innovative policy making, collaborative planning and extensive industry engagement will allow for a more successful implementation. The Electric Vehicle Council and its members will continue to engage with the NSW Government to address the following challenges.

Regulatory barriers

The current regulatory regime for heavy vehicles impacts on the viability of buses transitioning to electric. Electric vehicle bodies are heavier than their counterparts because of the weight of the battery. When existing gross mass limits are applied to electric buses, heavier vehicle body weights necessitate a reduction in payload i.e. a reduced number of passengers, to remain under gross mass limits. This ultimately means that more electric buses are needed to carry the same number of passengers as diesel buses.

Manufacturers are currently investigating the design, components and materials to reduce the body weight; however, it is unlikely that this will breach the gap between electric buses and diesel buses.

The Electric Vehicle Council proposes that the NSW Government provides waiver process either exempting or raising the mass limit for electric buses to support the adoption of electric buses, while providing time for the industry to address this issue.

Specific Australian design standards also create a barrier to the adoption of electric buses as imported products often do not automatically comply. Australia has comparatively stricter heavy vehicle regulations and standards meaning less off-the-shelf options are

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[13] Bloomberg (2019) *The U.S. Has a Fleet of 300 Electric Buses. China Has 421,000* https://www.bloomberg.com/news/articles/2019-05-15/in-shift-to-electric-bus-it-s-china-ahead-of-u-s-421-000-to-300

available. Governments should review Australian design standards to ensure alignment with international standards to increase the availability of compliant imports.

Infrastructure requirements

The electrification of some or all buses will require the rollout of charging infrastructure. There are two types of models of charging infrastructure: depot-based charging or on-route charging. Depot-based charging utilises installed chargers in depots to charge buses when parked, usually overnight. On-route charging requires the installation of fast chargers along bus routes so buses can charge when stopped for only a short period of time.

Depot-based charging is the most widely used model of charging in cities with electric buses and has several advantages:

- Lower upfront capital cost
- Allows for off-peak charging, reducing costs
- Allows for uses of smaller chargers
- Is generally located on property already owned/leased by transit operator, and doesn't require locating limited street space for chargers

The advantages of on-route charging include:

- Allows for smaller battery packs while covering longer driving distances, reducing costs and enabling a relatively higher passenger count (due to lower vehicle body weight)
- Allows greater flexibility in bus operations as buses do not need to come back to base for an extended period of charging.[14]

Transit operators will need to undertake significant analysis prior to selecting how much depot charging and how much on-route charging will be used. It is possible that a combined model approach may be appropriate.

Upskilling

Electrifying the bus fleet will require new skills in the bus sector across procurement, operations, driving and maintenance.

Transit operators will need to have the right skillset to procure and operate an electric bus fleet. Electric buses have a lower range than their diesel counterparts, require longer refuelling time, and have different and fewer maintenance needs – all of which will require a new approach to operations. Given the franchise model currently in place in Sydney, this will require multiple operators to get across these new needs

Electrifying the bus fleet will also require training of drivers to ensure optimal operation of the vehicle. Training can help improve the operation behaviour of drivers, increase the efficiency of buses, extend the life of batteries, and reduce the need for maintenance.[15] Diesel mechanics will also need to be retrained to service electric vehicles.

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[14] Wendel https://wendelcompanies.com/battery-electric-buses-things-you-need-to-know/

[15] WRI (2019) *How to Enable Electric Bus Adoption in Cities Worldwide* https://wriorg.s3.amazonaws.com/s3fs-public/how-to-enable-electric-bus-adoption-cities-worldwide.pdf

There is also a need to engage early with drivers to manage their needs throughout the transition. Without proper education, some drivers continue to have concerns about range and performance which can affect driver morale and impact on operation.

Procurement barriers

Procurement culture may also act as a barrier to adopting electric buses. Electric buses have different capital and operating costs, different infrastructure requirements, and different benefits. Procurement decision makers will need be aware of these differences to enable them to accurately quantify the cost and benefits involved with transitioning to electric buses. Procurement processes for buses should be reviewed to ensure that that are fit-for-purpose for new technologies.

Procurement processes will need to be able to quantify external benefits such as public health savings and amenity improvements to fully measure the opportunities and savings that electric buses provide.

Procurement processes will also need to consider the different cost profiles of electric buses. As stated above, electric buses currently have higher upfront vehicle costs than diesel buses but significantly lower running costs, generally making the total cost of ownership for an electric bus lower than a diesel bus.

An electric bus in the U.S. costs around US$750,000 whereas a diesel bus costs around US$550,000.[16] Higher upfront costs are mostly due to the cost of batteries, which are expected to fall over the next decade. BNEF forecasts that electric buses should be cheaper upfront in most countries by 2030.[17]

Electricity pricing/impacts

Transit operators will also need to ensure electricity costs are optimally managed. This means that transit operators will need to consider optimal charging times for buses from both an electricity perspective and from a route perspective. Some international jurisdictions have found demand charges have led to significantly high electricity costs,[18] so there will likely be a need going forward to consider the appropriateness of existing tariff structures.

Minimum energy and infrastructure requirements to power electric bus fleets.

The World Resources Institute examined energy requirements for an electric bus fleet. Assuming a typical electric bus with a battery capacity of approximately 300 kWh and one electric bus per 1,000 people, it calculated that:

> *"the electricity consumption of a whole e-bus fleet roughly equals 14 percent of the electricity consumption of a lower-middle-income city, 5 percent of that of a*

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[16] Inside Climate News (2019) *U.S. Electric Bus Demand Outpaces Production as Cities Add to Their Fleets* https://insideclimatenews.org/news/14112019/electric-bus-cost-savings-health-fuel-charging

[17] BNEF (2018) https://about.bnef.com/blog/electric-buses-cities-driving-towards-cleaner-air-lower-co2/

[18] The Denver Post (2019) *RTD's electric 16th Street Mall buses cost nearly 60% more to operate than diesel coaches* https://www.denverpost.com/2019/05/14/rtd-mallride-shuttle-electric-diesel/

> *middle-income city, 3 percent of that of an upper-middle-income city, and 1 percent of that of a high-income city."*[19]

This means that for Sydney, the requirements for electricity generation should be met relatively easily, outside of major peak events.

The most significant impact will be felt on the local grid infrastructure. The extent of this impact will depend on the type of chargers installed, the number of chargers installed, the level of simultaneous charging, and the time of charging.

Therefore, the electrification of depots will likely require grid infrastructure upgrades which will add a significant cost. However, many overseas depots with electric buses have utilised onsite battery storage to reduce the need for grid upgrades.

From a grid management perspective, it will also be important to use appropriate price signals and other demand management strategies. One of the advantages of depot-based charging is that most charging can occur during the off-peak.

Based on experiences from case studies from around the world, the World Resources Institute recommended that together with utility and urban planning, transit operators should:

- create a site plan to address the reality of land scarcity
- analyse and define the technical specifications of charging stations
- explore innovative charging mechanisms, such as smart charging
- develop plans to deal with power outages.[20]

Applying this recommendation to NSW, the Electric Vehicle Council recommends that the NSW Government works with relevant stakeholders to develop a staged plan for the roll out of bus electrification. This will provide time for planning and even early works to be completed to ensure a smoother and speedier electrification process.

Engaging now with stakeholders such as Ausgrid and Endeavour Energy will enable them to include bus electrification more clearly into their future planning and may allow for faster grid connection times. Recent experience with connecting public charging sites to the electricity grid has found that this process can take a significant period of time. This is in part due to a significant program of work needing to be undertaken to assess whether and what level of upgrades to grid infrastructure is needed. Completing grid upgrades further adds to time.

The World Resources Institute found that the type of charging equipment that should be installed will depend on a number of considerations. These include the charging time necessary to ensure adequate vehicle availability, the power ratings available from the existing electricity network, and potential downtime for the charging facilities due to maintenance and other activities. Faster chargers will allow electric buses to charge more quickly but are more expensive and may require more extensive upgrades to the grid. Generally, a 50-kilowatt charging station is the minimal rating that would be appropriate for charging fully-electric buses to ensure a full overnight charge.[21]

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[19] WRI (2019)
[20] WRI (2019)
[21] WRI (2019)

It is also important to consider future needs to ensure that charging locations, equipment and supporting infrastructure are future-proofed where possible to minimise costs. Integrating the planning for the electrification of buses with planning for future transport will help achieve this.

Other renewable, emissions neutral energy sources

Charging electric buses with renewable energy will allow greater reductions in carbon emissions in the transport sector. There are significant opportunities to power electric buses from onsite solar PV generation coupled with onsite storage. In some locations, charging could support renewable generation by timing charging to meet surplus renewable generation – either from the grid or from onsite solar PV. This could be assisted through using large onsite storage.

Ways to support manufacture and assembly of electric buses in NSW

The NSW Government should encourage the development of manufacturing and local assembly industries for electric buses. There is already an appetite for domestic participation in the electric bus market as evidenced by companies such as Avass and Volgren.

The Electric Vehicle Council's 2019 *State of Electric Vehicles* report examined the opportunities for an increased Australian involvement in the electric vehicle supply chain. In addition to Australia's endowment of minerals required for batteries, Australia also has potential for involvement along the battery and electric vehicle supply chain (including manufacturing, assembling and recycling) given our access to skilled labour and infrastructure.[22]

To attract both domestic and international companies to manufacture or assemble electric buses in NSW, the Government must send a clear and certain commitment to industry about its transition plans. Without a committed minimum level of demand for electric vehicle products, industry will not have the required certainty to establish operations onshore.

Attracting local assembly operations would also help meet local content procurement targets thereby creating local jobs, often in regional locations, as well as facilitate any product augmentation required to meet Australian design standards.

[22] EVC (2019) *State of Electric Vehicles* https://electricvehiclecouncil.com.au/wp-content/uploads/2019/09/State-of-EVs-in-Australia-2019.pdf

Experience with introducing electric bus fleets in other jurisdictions.

By the end of 2018, there were 425,000 electric buses worldwide – 421,000 were in China (estimated to be 18% of China's total bus fleet) and 2,250 were in Europe. 2018 saw the global electric bus fleet grow by 32%, with the growth mostly occurring in China.[23] Shenzen in China now has a 16,000 electric bus fleet. [24]

By 2025, China's electric bus fleet is projected to rise to 600,000, while the US electric bus fleet is expected to reach 5,000.

This growth will be driven by a number of commitments for zero-emission buses. The EU will require certain new buses to be emissions-free by 2025 while California will require all new buses to be zero-emission from 2029. Santiago has set a target for an 80% electric bus fleet by 2022, while all of Chile aims to have a fully electric public transport system by 2040.[25] London has more than 200 electric buses and will be adding a further 78 electric double-decker buses in 2020.[26] Falling battery prices will help also drive new growth as the upfront purchase costs fall.

There are numerous case studies of electric bus adoption to learn from. The World Resources Institute collated experiences of 16 cities from around the world. Through this, they have identified the variety of technical, financial and institutional barriers to electric bus adoption, and designed a planning and implementation framework to overcome these barriers.[27]

Domestically, there have also been a number of electric bus pilots and trials, including within NSW. The ACT recently conducted an electric bus pilot as part of its commitment to transition to a zero emissions public transport fleet by 2040. The trial found the electric bus performed better than the Euro VI Diesel bus and Hybrid Euro V bus in terms of environmental emissions, energy efficiency and whole of life economic costs.[28] While there were reliability issues with the electric bus during the trial, this was found to be primarily due to an issue with the build of the bus as opposed to its battery.[29]

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[23] Bloomberg (2019)

[24] South China Morning Post (2018) *Shenzhen's all-electric bus fleet is a world's first that comes with massive government funding* https://www.scmp.com/business/china-business/article/2169709/shenzhens-all-electric-bus-fleet-worlds-first-comes-massive

[25] Electrek (2019) *Electric buses surging in Latin America, Chile adding to fleet as it aims for all-electric by 2040* https://electrek.co/2019/05/24/electric-buses-latin-america/

[26] Intelligent Transport (2019) *The London electric bus fleet is the largest in Europe* https://www.intelligenttransport.com/transport-news/87086/the-london-electric-bus-fleet-is-the-largest-in-europe/

[27] WRI (2019)

[28] Chris Steel (2019) *Electric bus trial results released* https://www.cmtedd.act.gov.au/open_government/inform/act_government_media_releases/chris-steel-mla-media-releases/2019/electric-bus-trial-results-released

[29] ACT Government (2019) https://www.transport.act.gov.au/__data/assets/pdf_file/0008/1427561/Alternative-Fuel-Bus-Trial-Summary-Assessment.pdf

Opportunities and challenges of transitioning the entire metropolitan bus fleet to electric.

The benefits and barriers for adopting electric buses are outlined in detailed above. Transitioning the entire bus fleet to electric will maximise these benefits including emissions reduction, health benefits and cost savings. As noted above, having a committed level of demand for electric buses will also entice manufacturers to locate product building onshore which will create local jobs and revenue for the NSW economy.

Committing to a fully electric bus fleet is sensible given the benefits, but it will however require extensive planning with a number of stakeholders across transit operators, landowners, utilities and drivers.

It is likely that the transitioning the entire metropolitan bus fleet will require a staged roll out to provide time to trial innovative approaches and conduct any necessary pre-work on infrastructure. It is imperative that engagement with relevant stakeholders occurs early in the process.

An extensive community engagement campaign should also be undertaken. The community should be informed about the benefits they will accrue to justify why this change needs to happen.

Any other related matters.

There will also be a need to plan for end-of-use for each electric bus and battery. The electric vehicle industry is already working to develop processes for battery recycling and repurposing. Electric vehicle batteries are well placed to be repurposed; batteries from light passenger vehicles have already been demonstrated to be used for energy storage.[30] The potential for secondary use and recycling should be considered as a benefit and not a barrier to electric bus adoption.

The World Resources Institute recommends that the transit operators:

> *craft a responsible retirement plan for each electric bus and explore innovative bus and battery scrappage mechanisms with other stakeholders, especially bus and battery manufacturers, to reduce the total costs and risks. This, in turn, can help incentivise the adoption of electric buses and reduce the negative impacts on the environment.*[31]

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[30] Bloomberg (2018) *Where 3 million electric vehicle batteries go when they retire* https://www.bloomberg.com/news/features/2018-06-27/where-3-million-electric-vehicle-batteries-will-go-when-they-retire

[31] WRI (2019)