Submission
No 21

ELECTRIC BUSES IN REGIONAL AND METROPOLITAN PUBLIC TRANSPORT NETWORKS IN NSW

Organisation: Ausgrid

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Ausgrid Submission

Parliamentary Inquiry: Electric buses

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Attn: Robyn Preston
NSW Legislative Assembly
Committee on Transport & Infrastructure
6 Macquarie Street
Sydney, NSW 2000

Dear Ms. Preston

We welcome the inquiry into the transition to electric buses on NSW public transport networks.

The electrification of the NSW bus fleet has the potential to deliver significant environmental and social benefits. Not only could it lower the carbon footprint of the NSW public transport system, the transition to electric buses would reduce traffic noise along busy routes and unlock health and amenity benefits for the community, through reduced air pollution.

Ausgrid expects to play an active and early role in facilitating this transition. We operate and maintain an electricity grid that is shared by 4 million Australians living and working across an area that stretches from the Sydney CBD to the Upper Hunter. To ensure we maintain a safe, reliable and secure electricity grid, Ausgrid and the NSW government must work closely together on the transition to electric buses. Such collaboration will also help identify the least cost solutions to accommodating charging infrastructure into our grid.

To this end, our submission extends an offer to the NSW government to collaborate with Ausgrid on an electricity infrastructure strategy for electric buses. By taking into account existing bus routes and our network needs, we envisage co-developing an engineering planning study that identifies the least cost options for accommodating electric buses into our grid. More information about this offer is set out in our submission attached to this letter.

We shared a draft version of our submission with members of our Customer Consultative Committee (CCC). This is part of a new practice Ausgrid has started where we seek the views of customer advocates before lodging a final version of a policy submission. Among the CCC members who provided feedback, we received support for Ausgrid developing a Master Plan. We will update customer advocates about any progress or developments relating to this plan at future CCC meetings.

If you would like to discuss our submission in more detail please contact Shannon Moffitt, Senior Regulatory Analyst, on [redacted] or [redacted].

Yours sincerely

[redacted]

Iftekhar Omar
Head of Regulation

Submission

Our submission addresses each of the terms of reference (TOR) released by the Legislative Assembly’s Committee on Transport and Infrastructure.

1. Benefits of electric buses and factors that limit their wider uptake

The transition from diesel to electric powered buses will deliver significant benefits for NSW and its residents. The key benefits include improvements in air quality, lower carbon emissions and reduced noise pollution.

1.1 Air quality

Electric buses produce no exhaust pipe pollution. They therefore have the potential to enhance the air quality and overall liveability of NSW’s metropolitan and regional areas. As NSW’s population is forecast to grow from 7.7 million in 2016 to 9.9 million people in 2036,[1] this is likely to become increasingly important. The removal of airborne pollutants released by fossil fuel powered buses in the public transport system is also likely to have long-term health benefits for NSW citizens.

1.2 Emissions reduction

Electric buses have a lower carbon footprint than public transport powered by fossil fuels. This means electric buses can play a key role in the NSW government meeting its aspirational target of net zero emissions by 2050.

To maximise emissions reductions, there may be opportunities to co-locate the charging stations for electric buses with distributed energy resources (DER). This could be done, for example, by installing solar photovoltaic (PV) systems on the rooftops of depots. Electric buses could then draw down on the energy produced by the solar PV systems, so they are powered by a 100 percent renewable source of energy.

The electricity grid, of which Ausgrid is the largest operator in NSW, is also rapidly decarbonising. The share of renewable generation in the National Electricity Market (NEM) is now above 21 percent, with the Australian Energy Market Operator (AEMO) forecasting this to rise over the coming years. Over 4.7 GW of wind and solar is already committed to become fully operational before 2021-22, and another 41 GW of wind and solar projects are known to AEMO.[2] This means that recharging electric buses through the grid will not just be the most reliable source of energy supply; it is rapidly becoming a global leader in clean, low carbon intensive power.

We understand that the recent NSW Government tender for its electricity supply is seeking responses underpinned by low emissions capabilities. This will be an effective mechanism for the entire bus fleet to be powered by a high mix of renewable energy resources.

1 The Department of Planning and Environment (2016) “NSW population projections”
2 AEMO, *2019 Electricity Statement of Opportunities*, August 2019, p.65.

1.3 Noise pollution

Buses are heavy vehicles that can produce significant noise pollution. This is particularly prevalent in residential areas where a bus can have a major impact on the noise levels in an otherwise quiet street. This may change, however, with the introduction of electric buses. As they are powered by battery packs rather than internal combustion engines, electric buses create less noise. Their introduction is therefore likely to have a positive impact on the liveability of residential areas located on or close to busy bus routes.

2 Energy and infrastructure requirements to power electric buses

Ausgrid wants to play an active and early role in supporting the energy requirements of electric buses. We expect that this will primarily involve our electricity network infrastructure and how it can best be utilised to power electric buses.

2.1 Background

The electrification of transport has the potential to have a significant impact on our electricity network. This is given that the charging requirements for electric vehicles (EV) adds more electrical load that our grid must be capable of supplying.

Home chargers for EVs are among the largest single loads for those households that have them, akin to a split-system air-conditioner or electric hot water tank. Larger charging facilities for heavy vehicles, such as electric buses, add an even greater electrical load. Where these loads cannot be incorporated in to our existing network capacity envelope, we generally have two options: (1) augment our network to add capacity or (2) improve demand side management systems.

2.2 Network hotspots

The potential for bus charging facilities to give rise to network constraints will most likely be focused around certain locations, or 'hotspots', on our network.

As the electrification of transport in NSW gathers pace, we expect that these hotspots could begin to emerge in areas where there is a high penetration of EVs. Hotspots could also arise where there are rapid DC charging units, or where there are existing large commercial loads such as data centres.

For the transition to electric buses, this means that a single charging station, on its own, is unlikely to trigger network capacity issues. If, however, a charging facility for buses is placed in the wrong location, where there is a convergence of chargers or other large loads, then network issues may arise.

2.3 The role Ausgrid can play

We want to see a successful transition to electric buses and can help the NSW government in making this happen. We envisage doing this by sharing information about our network and working collaboratively on:

- the optimal location of bus charging units
- the optimal size of a charging station given its location
- the most efficient time of day for recharging electric buses.

Our goal in collaborating on these matters is to avoid a scenario where electric bus charging stations give rise to reliability, safety or system security issues on our network. We also expect to identify ways of meeting the minimum energy and infrastructure needs for electric buses in the least cost way.

Collaboration on these matters can happen in multiple ways. This includes on an ad hoc basis each time a new bus charging facility is connected to the grid or, as outlined further in section 6.1.2 below, via a system wide plan that covers all bus depots, routes and other potential sites within Ausgrid's network service area.

3. Other renewable, emissions neutral energy sources

The use of other sources of energy to power NSW buses does not fall directly within Ausgrid's field of expertise. We would, however, note that one of the benefits of electric buses is they can leverage existing infrastructure that has already been built – namely, the shared electricity grid. Hydrogen and other emerging, renewable energy sources, by contrast, are likely to require significant new investment in supporting infrastructure, such as refuelling stations, that may have a long lead time to deliver and come at a high capital and operating cost.

4. Ways to support manufacture and assembly of electric buses in NSW

We have no specific comments about how to support the manufacture and assembly of electric buses in NSW.

5. Experience in introducing electric bus fleet in other jurisdictions

Some of the experiences of introducing electric buses in London, California and China are outlined below. Innovative charging strategies trialled internationally are also noted.

5.1 London – Air pollution

London has more than 200 electric buses, making it Europe's largest electric bus fleet.

The electrification of buses in London has had significant health benefits. In 2015, a Kings College report concluded that almost 10,000 Londoners die prematurely because of polluted air.[3] The Mayor of London has noted that transitioning to electric buses is helping to address

3 https://www.london.gov.uk/press-releases/mayoral/mayor-announces-10-new-low-emission-bus-zones

this health crisis, with the level of Nitrogen Oxide (NO) emissions from public transport falling by 84 percent following the introduction of 12 Low Emission Bus Zones.[4]

5.2 California – Bottom up approach

California has set a target to transition to a 100 percent zero-emission bus fleet by 2040.

To achieve this, the Californian Air Resources Board has set a rule requiring a quarter of all new buses purchased by state transit authorities to be electric by 2023. This requirement then increases to a half of all new buses by 2026, and then all new buses by 2029.

These targets will transition California to electric buses gradually from the "bottom up" as diesel powered, and hybrid petrol-electric, buses reach the end of their technical life and are replaced with fully electric models.

5.3 China – Top down approach

In 2009, China began the electrification of its bus fleet as part of a strategy for dealing with widespread urbanization and reducing reliance on fossil-fuel imports.[5]

Today China has more than 420,000 electric buses and is forecast to have more than 600,000 by 2025. In amassing this fleet, Bloomberg New Energy Finance (BNEF) notes that China has taken 'a typically top-down approach to its manifest destiny of vehicle electrification: establish national mandates, subsidise manufacturers, and nurture policy competition among its cities'.[6] Following this "top down" model, Shenzhen in Southern China became the first city in the world to reach full bus electrification in 2017 by replacing all of its previous buses with electric models.

5.4 Innovative charging model

The default charging approach for electric buses typically involves installation of 'plug-in' chargers at bus depots. The table below sets out innovative alternatives to this default model that have been trialled or are currently in use in other jurisdictions.

Model	Approach
Battery swapping	Battery swapping, which removes depleted batteries on electric buses and replaces them with fully charged ones, was used during the 2008 Beijing Olympic Games. However, it raised security concerns and, since manufacturers have been reluctant to promote battery standardisation, is unlikely to be a viable charging model.

4 https://www.london.gov.uk/what-we-do/environment/pollution-and-air-quality/cleaner-buses

5 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

6 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

Wireless charging while stationary	In 2015, Transport for London began wireless charging for their diesel-electric hybrid buses. These buses are fitted with on-board batteries that can wirelessly receive a charge boost from plates fitted at bus stops at either end of a route. Utah State University has also used wireless charging technology for an electric bus with a peak power of 25 kW.[7]
Wireless charging while moving	In Germany, 10kms of the Autobahn has also become an 'eHighway' that enables electric charging of hybrid trucks while moving. Trials have also been undertaken in Japan with in-wheel charging motors that charge over charging lanes with embedded transmission coils and sensors.
Large scale charging centres	The Chinese city of Shenzhen did not install plug in chargers at existing bus depot sites, but instead built 26 large-scale charging centres at new locations that service its entire fleet of 16,359 electric buses. Each charging centre is multi-storied, which assists with land scarcity constraints. It also provides efficiencies through economies of scale.

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

In navigating the opportunities and challenges of electric buses, we want to work closely with the NSW government on a range of matters. As outlined in section 6.1.2, this includes collaborating on an electricity infrastructure plan for electric buses.

6.1 Minimising network costs

A new bus charging station could trigger a need to augment our network. This may include the need to build new substations, transformers or electricity lines – all of which could come at a potentially significant capital cost. Ways Ausgrid can help minimise these network costs are outlined below.

6.1.1 Background

The new connection proponent (NSW government) would be required to fund the cost of any new network infrastructure dedicated to recharging the batteries of electric buses. This is in accordance with the NSW contestable arrangements for new connections.

Under these arrangements, the proponent would engage an Accredited Service Provider (ASP) to design and construct the required network infrastructure. The proponent would then pay the ASP, not Ausgrid, for the cost of the new connection or augmentation. Ausgrid's role would be limited to operating and maintaining the new network assets once they are energised and 'gifted' to us.

7 Liu, Z.; Song, Z. Robust planning of dynamic wireless charging infrastructure for battery electric buses. Transp. Res. Part C Emerging Technologies **2017**, 83, 77–103.

6.1.2 Master Plan for electric buses

As the custodians of an electricity grid shared by more than 4 million NSW residents, Ausgrid will be responsible for approving the design of any new or updated connections to our network. These design approvals can either be:

i. provided on an ad hoc basis when each charging facility is installed; or
ii. facilitated via a system wide planning study undertaken across all bus routes, depots and potential sites for charging facilities lying within Ausgrid's network area.

We extend an invite to the NSW government to pursue the second of these options and co-develop a system wide 'master plan' for electric buses. We envisage this working by undertaking an engineering assessment of the electricity infrastructure requirements for charging electric buses based on existing bus routes and the capacity limits of our electricity network.

There are likely to be significant benefits to undertaking a system wide study. It would provide scope to develop an integrated view of transit and electricity network infrastructure requirements. Taking a "whole of system" approach should also provide scope for a common strategy to be developed across the suite of changes that are required to transition to electric buses and would allow for innovative solutions, such as off-peak or battery-buffered charging (see 6.1.3 and 6.1.4 below), to be employed consistently. The table below sets out some of the matters which we can help with, in developing a system wide master plan.

Matters	Overview
Long term plan	A master plan could set a long-term view of the electrical charging infrastructure needs for electric buses. This is by considering the age and retirement plans of existing bus assets, their routes and the type of electric buses needed to service each location.
Integrated view of different charging strategies	The impact electric buses have on our network will vary according to the charging strategies employed. For example, exclusively charging at depots will have a different impact to charging at both depots and mid-route. A master plan can help with selecting the optimal strategy at each location by taking a system wide view that integrates both the needs of the NSW bus transit system and our electricity grid.
Redundancy and other considerations	The charging of electric buses will trigger different grid connection needs. At some locations, this may lead to grid augmentations that provide additional network redundancy (n-1 reliability) or the construction of dedicated 11kV feeders direct from zone substations to specific depots. The development of a master plan would help guide stakeholders, including the NSW government and ASPs, on the connection options available and assist in the identification of the most efficient option that should be pursued.

Ausgrid would expect that the customer advocacy groups we work with would want to take part in the development of a system wide plan for electric bus charging infrastructure. This presents an opportunity for us to develop a strategy with not just the NSW government, but also with input from our customers.

6.1.3 Off-peak charging

The timing of when electric buses are charged can have a significant impact on our grid.

The demand for electricity has large peaks and troughs as energy demand from customers varies throughout the day. These fluctuations create a window, known as an off-peak period, for when there is large capacity on our network to support flexible electrical loads, at the least cost.

Off-peak windows present an opportunity for electric buses. By charging them at these times, Ausgrid can better accommodate their electrical load within our existing network capacity 'envelope'. This could be a key cost saving measure in the transition to electric buses, as using our existing network capacity would avoid the need to make potentially large investments in augmenting our network infrastructure.

The benefits from charging electric buses at off-peak times would also extend to all energy customers. More electricity flowing through our assets, especially at off-peak times, puts downward pressure on the unit cost of our service – in effect, lowering our prices for our entire customer base.

6.1.4 Battery-buffered charging and on-site generation

Charging electric buses from the grid at off-peak times may not always be possible. One possible way around this is to couple charging facilities with battery storage.

Known as 'battery-buffered' charging, this would offer additional flexibility to shift when electricity is drawn from the grid. For example, a battery co-located with a charger could store energy at off-peak times overnight and then discharge that energy the next day when an electric bus returns to the depot after the morning transit rush hour.

Pairing batteries with charging facilities could also facilitate a smoother, more predicable demand at bus charging stations that would help alleviate network stress in areas with minimal available capacity.

The electricity that charges electric buses could also come from co-locating bus charging infrastructure with on-site solar PV generation. This would enable the electricity generated from solar PV systems to charge buses during the middle of the day when some buses return to base, with any excess electricity stored in a 'stationary' battery for later use.

The installation of solar PV systems would be in line with NSW government's aspirational target of reaching net zero emissions by 2050. These systems could be installed on depot roofs or bus canopies. As technology evolves, there may also be an opportunity for more innovative locations. The Byron Solar Train, for example, is powered by solar PV systems installed on the rooftop of the train itself. In the future, this may be a charging model suitable for buses too.

6.1.5 Dynamic connection agreements

The terms of access for a customer to connect to our network are set out in a connection agreement. Traditionally, these agreements have static connection limits that are typically based on the available grid capacity in worst case network conditions.

In transitioning to electric buses, the adoption of dynamic – rather than static – connection agreements should be considered. Dynamic connection agreements take into account that the available capacity on the shared electricity grid varies significantly throughout the day as demand from customers goes through peaks and troughs. They do this by allowing connection limits imposed by electricity grid operators to dynamically 'flex' up and down according to network conditions at a point in time.

The flexing of connection limits in this way could unlock substantial benefits. There is potential for dynamic connection arrangements to defer or avoid network augmentation by better incorporating electric buses into the existing capacity envelope of the shared electricity grid. It would also promote greater utilisation of our network, which as outlined in paragraph 6.1.3 above, would put downward pressure on the unit cost, and hence price, of our energy network services.

6.1.6 Other electricity market services

There may be opportunities for electric buses to offer services in other energy markets.

With the installation of vehicle to grid infrastructure, excess energy stored in the batteries of electric buses stationed at a depot or at other resting sites could be sent back to the grid where it efficient to do so. Alternatively, this energy could be aggregated and used to provide valuable services such as Frequency Control Ancillary Services (FCAS) in ancillary markets.

There could also be an opportunity to take advantage of reforms introducing a wholesale demand response mechanism. Under a recent draft rule, this mechanism would provide electric bus operators with greater opportunities to participate in the wholesale market by bidding in demand reductions as a substitute for generation.[8]

Using electric buses as a platform to enter other energy markets could be valuable cost saving measure as any additional revenue streams from these markets could be used to offset the operating costs of electric buses, to the benefit of NSW public transport users.

6.2 Grid support

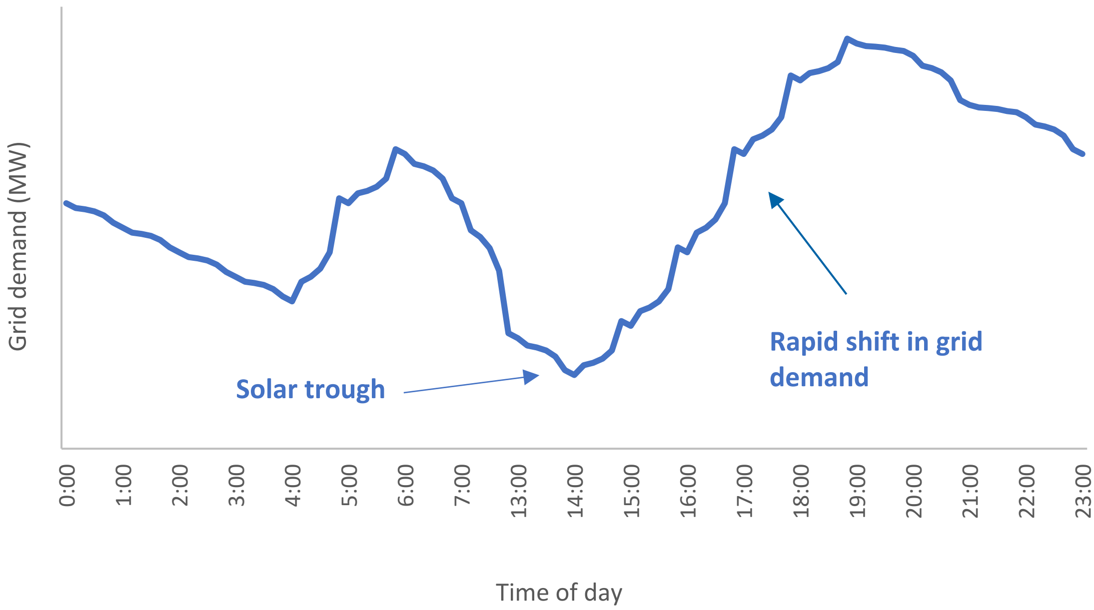
There may be opportunities for electric buses to be used as a grid support device. One way in which this could work is by helping to flatten out the 'duck curve' that is being caused in a

8 AEMC, Draft determination: Wholesale demand response mechanism, 18 July 2019

number of areas across Australia by high rates of solar PV being installed on residential rooftops.

6.2.1 Background

In some areas of our network, the rapid growth in solar PV has meant that far more electricity is generated in the middle of the day than is needed to meet demand. This can create voltage issues and problems in terms of grid stability – an illustrative example of this "duck curve" shape of electricity demand is outlined below.



Source: Ausgrid analysis (illustrative example only)

The problem with the duck curve is that it leads to large shifts in supply and demand. While during the day energy supply outstrips demand, there is a sudden and steep change in the evening. This is when solar PV stops generating and there is a large spike in demand, due to residential customers returning home and turning on their appliances.

Ultimately, this phenomenon puts pressure on the stability of our network and can lead to issues in the wholesale market, with the sudden ramping up and down of generation. One option for addressing this is to invest more in network infrastructure and on-call generators, yet this can be expensive for customers.

6.2.2 Using buses as a solar sponge

There is potential for electric buses to act as a solar PV 'sponge'. This would involve charging the batteries of electric buses when solar PV over-generation typically occurs i.e. during midday to early afternoon hours. In key areas where there is significant solar PV penetration, this would help stabilise the grid and potentially avoid or delay network investment.

7 Any other related matters

The electrification of buses in NSW will deliver significant benefits. Ausgrid looks forward to working closely with the NSW government in exploring these benefits and playing an active role in the transition.


Thank you