Submission No 16

ELECTRIC BUSES IN REGIONAL AND METROPOLITAN PUBLIC TRANSPORT NETWORKS IN NSW

Organisation: Climate Change Balmain-Rozelle

Date Received: 20 December 2019

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20 Dec 2019

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Submission from

Climate Change Balmain-Rozelle[1]

on

Electric buses in regional and metropolitan public transport networks in NSW [2]

Abstract

The challenges and benefits of powering electric buses principally from renewable energy are discussed; in particular, the potential for symbiosis with PV.

We find that this is already feasible for urban routes but requires significant coordination between bus scheduling, bus model selection, and the rate and geographical distribution of PV rollout.

The time taken to recharge, whether with renewables or not, is much more of an issue for regional routes. Electrifying these routes may have to await technological advances.

Who we are

Climate Change Balmain-Rozelle is an independent community group in inner west Sydney, promoting local and national action to reduce fossil fuel use, increase the adoption of renewable energy, and head off catastrophic global warming.
We count over 1000 supporters.

We appreciate the opportunity to make a submission on this topic, but but only have a user's understanding of existing bus operations. We beg your indulgence for our ignorance.

1 Recommendations

We recommend that

- Urban bus service patterns be reviewed to determine the extent to which recharging could be done during 10:00 to 15:00 so as to match PV generation.
- Options be explored for substantial PV generation located near where the buses would be charged, including the possibility of roofing depots.
- Negotiations be entered into with the electricity service provider and charge point manufacturers re Demand Response.
- Clarification be sought from eBus manufacturers as to what the maximum charging rates are.
- Options for regional electrification and/or use of "green hydrogen" be reviewed as the technologies advance.

1 http://www.climatechangebr.org/
2 https://www.parliament.nsw.gov.au/committees/inquiries/Pages/inquiry-details.aspx?pk=2563

Table of Contents

2 Terms of Reference

Of the Terms of Reference listed, our comments relate to items 1, 2, 6 and 7.

1. Benefits of electric buses and factors that limit their wider uptake
2. Minimum energy and infrastructure requirements to power electric bus fleets.
3. Other renewable, emissions neutral energy sources.
4. Ways to support manufacture and assembly of electric buses in NSW.
5. Experience with introducing electric bus fleets in other jurisdictions.
6. Opportunities and challenges of transitioning the entire metropolitan bus fleet to electric.
7. Any other related matters.

We note that item 3 mentions "Other renewable, emissions neutral energy sources." From this, there appears to be a presumption that any electric buses operated will be powered by renewable energy. However, that would not be the case by default.

This submission centres on the issues in achieving that.

3 eBus Technologies

At present, rechargeable battery is the technology ready for commercial use, but two others are worth watching.

3.1 Rechargeable battery

eBuses with lithium batteries typically hold around 100-300km of charge. Table 1 gives a sample of available buses.

Make	Model	Battery type	Capacity kWh	Charging kW	Range, km[3]	Recharge, minutes
BYD	40 ft [4]	$LiFePO_4$	352	80	250/280	300

3 It is unclear from the available data how much allowance is made for air conditioning

Make	Model	Battery type	Capacity kWh	Charging kW	Range, km	Recharge, minutes
Solaris	Urbino 12[5]	Li-ion	145	250	100	24
Solaris	Urbino 18[6] HP	Li-ion	203	560	140?	22
Volvo	7900[7]	Li-ion	250	300[5]	200[5]	50[8]

Table 1: A sample of available electric buses

3.2 Swappable Battery

A US company[9] is developing a 12.2 m electric bus powered by a zinc–air battery along with an ultracapacitor. The batteries are not recharged *in situ*; instead, the spent (zinc oxide) cartridges are swapped out for new zinc ones. A range of 160 km is claimed.

3.3 Ultracapacitors

Ultracapacitors have a very low energy density and must be recharged every few kilometres. But this can be done very quickly from charge points at selected bus stops[10], adding nothing to the travel time.

4 EVs and Renewable Power

4.1 The Benefits

There is much to be gained from shifting transport to electric and arranging that the increased electricity demand is sourced from solar and wind.

1. Cheaper average wholesale power. As coal plant retires, new build solar and wind is much cheaper per kWh than new build coal.
2. To the extent that the added demand makes the profile flatter, lower grid infrastructure cost per kWh.
3. Reduced CO_2 emissions and other pollutants from tailpipes.
4. A more reliable grid[11,12].
5. Vehicle recharging is a prime candidate for Demand Response. Recharging could be deferred during undersupply and grid congestion. The charging points would earn income for this[13].
This also allows more solar and wind into the mix than just for the increased demand, reducing total emissions from electricity generation.

4 https://en.byd.com/bus/40-foot-electric-transit-bus/#specs ; This appears to be the model currently under test in NSW: https://www.transitsystems.com.au/electric-buses
5 https://www.mdpi.com/1996-1073/12/16/3114/pdf
6 https://insideevs.com/news/377408/solaris-urbino-18-electric-553-kwh-battery/
7 https://www.volvobuses.co.uk/en-gb/our-offering/buses/volvo-7900-electric/specifications.html
8 The MDPI reference (5) quotes 76kWh, 300kW charging for 15 minutes and 200km range, but 76kWh would be insufficient for 200km. The Volvo site (7) quotes capacity up to 250 kWh and "CCS charging" (300kW) for that range. That implies a charge time closer to 50 minutes. Since the battery system is modular, it may be that it is 300kW *per module*. We are endeavouring to get clarification from Volvo.
9 https://en.wikipedia.org/wiki/Electric_bus#Zinc-air_battery
10 https://en.wikipedia.org/wiki/Electric_bus#Capacitors
11 There are solutions for synthetic inertia, but not for coal-fired plant outages
12 PV inverters can supply reactive power: https://www.uts.edu.au/research-and-teaching/our-research/institute-sustainable-futures/our-research/energy-futures-0-0
13 Vehicles being charged could serve as power sources ("vehicle to grid") in emergencies, earning yet more, but that is a matter for the future.

4.2 Supply constraint

In principle, there is no difficulty meeting the additional demand created by transport electrification with renewables. Converting all of NSW's road transport to electric would add 30-40% to grid energy demand. Nationally, potential *rooftop* solar power alone is 120% of today's demand[14].

4.3 Profile and Network constraints

Electrifying transport interacts with renewable supply and the grid in a complex manner. Charging during the day is most convenient for PV power, minimising the need for energy storage external to the vehicles, but increases the peak load on the poles and wires.

If the generation is distributed, there is no need for transmission upgrades and only modest need for distribution upgrades, but it becomes important that the grid management systems be able to control the distributed generation.

4.4 Wind v. solar

PV power is already the cheapest available, certainly in NSW[15], and still getting cheaper faster than wind. Its key drawback is its dependence on sunlight. The time will come when midday PV supply will exceed grid demand[16], and the cheapest power will be from 10am to 3pm.

Wind is output is relatively uncorrelated with that of PV, and it can be used for night-time charging without storage. It is only suited to grid scale generation.

4.5 Daytime v. night time charging

Daytime charging absorbs the surplus PV power, but unless that is generated locally to demand it increases peak grid loads.

Night time charging would help flatten transmission and distribution demand, but is unsuited for PV generation. Its main downside from a carbon emissions perspective is the risk that it will help prolong the life of coal-fired plant. Although the extra demand could come from wind, wind power LCoE does not yet undercut *old* coal.

	Night-time charging	*Daytime charging*
Grid scale PV generation	• Grid scale storage	• Transmission upgrade • Ample charge points at places of work, transport hubs, shopping centres
Grid scale wind generation		• Transmission upgrade • Ample charge points at places of work, transport hubs, shopping centres
Distributed PV generation	• Local storage • Distributed management	• Distributed management • Ample charge points at places of work, transport hubs, shopping centres

Table 2: Requirements under six models of widespread EV charging

Modelling would be needed to establish the optimal mix (under assumptions of foreseeable technology costs) and the necessary incentives to navigate towards it.

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14 https://www.cefc.com.au/media/402125/isf-rooftop-solar-potential-report-final_.pdf gives 245TWh/y as rooftop PV potential

15 https://reneweconomy.com.au/which-parts-of-australia-deliver-the-cheapest-wind-and-solar-29721/

16 On 10/11/19, rooftop solar peaked at 2/3 of SA's demand: https://reneweconomy.com.au/the-day-rooftop-solar-met-two-thirds-of-south-australias-total-demand-67549/

This has consequences also for the price the retailers charge on a time-of-use tariff. Although the per-kWh charge adapts to time of day, the monthly grid connection charge is based on the peak demand by the user in that month, regardless of the time of day when it occurred. If the PV power is coming from distant solar farms, there is little to be done about this, but if more local then this charging algorithm is not justified. A large customer may be able to come to an arrangement with the retailer.

4.6 *Hydrogen*

Hydrogen fuel cell buses have some advantages over plug-in electric.

- They occupy less space when charging.
- The range on one charge is similar to that of Diesel.

Unfortunately, this is not yet a 'green' option. The renewables-to-hydrogen technology is still under development.

5 Urban Bus Route

5.1 *Time of day for charging*

One challenge for electric buses in relation to PV is that although 10am-3pm is not the peak period for bus use, neither is it the lowest. Illustration 1 shows the usage pattern of buses aggregated across four Sydney routes. For each route, a primary stop in the route was selected.

The average speed of Sydney buses in service is 15km/h. Presuming the peak to represent the fleet size (surely an underestimate), each bus averages 12 hours on road and is idle for an average of 1.6 hours during the 10:00-15:00 ideal charging interval for PV.

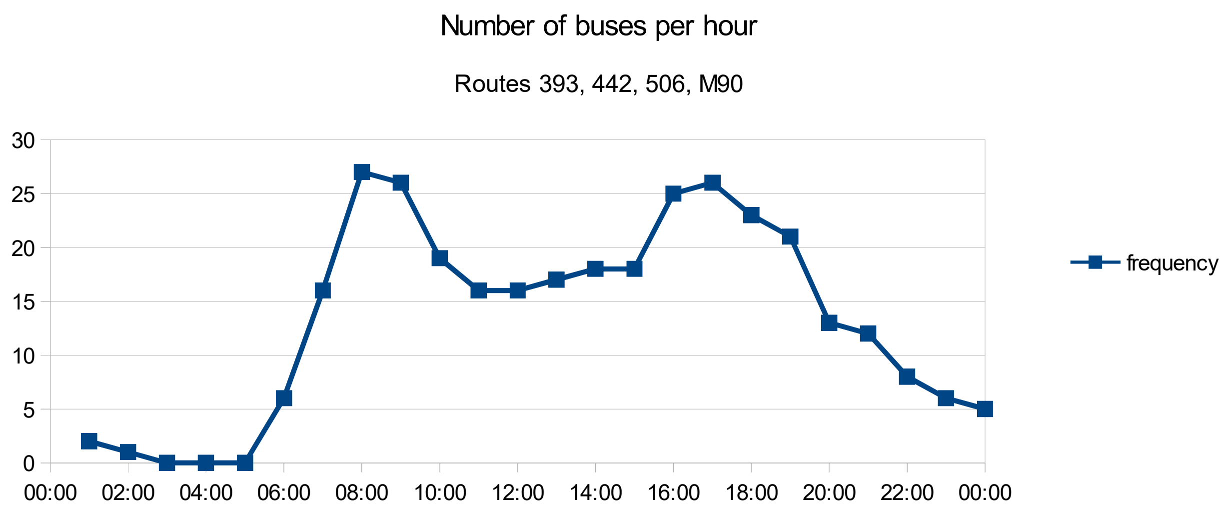

Illustration 1: Bus service pattern, Mon-Fri, based on sample of four routes

Based on these numbers, the BYD 60ft [5] could be recharged just enough for a whole day in 1.5 hours of idle time during the PV-optimal hours. Of course, current schedule arrangements may mean that many individual buses are not idle for 1.5 hours within the 5 hour optimal band. As against that, to the extent that the fleet size as estimated above is an underestimate, more time is available for charging each on average.

On balance, it appears feasible that at least half of the recharging is during 10:00 to 15:00.

5.2 Depot real estate

A bus being recharged would require more space than one merely parked at a depot.

We understand that many timetables involve midday driver breaks of around 15 minutes at the distal point of a route. In many cases, there would be rooftop PV on nearby houses. It may be feasible to add a useful level of recharge in those intervals, but unlikely to justify dedicated charging equipment there. Sharing the facility with private vehicles would be problematic in several ways.

5.3 Behind the meter PV

A possibility worth considering is to put PV panels on roofs over depots. Retrofitting panels to large area roofs can be prohibitively expensive because of the strengthening required, but less of an issue for purpose-built roofs if adding the roof has sufficient other benefits.

The 120kWh/day charge calculated for urban routes would require 200m^2 of panels per bus, about five times the bus' own footprint.

6 Regional Routes

On regional routes buses average much greater speeds as well as longer duration end-to-end journeys. The need to recharge during one journey will likely increase the journey time unless it can be overlapped with other pauses.

In NSW, buses serving journeys in excess of 2 hours are fitted with toilets, and likely none require refuelling mid journey today. That leaves only the breaks required for the driver.

The Law[17] requires that the driver take half an hour of rest at or before the five hour mark. Further, that this consist of either one break of 30 minutes or two breaks of at least 15 minutes each.

> ***Example***
>
> Regional route, route 569, Lithgow to Nyngan via Bathurst is 500km and takes 6 hours 15 minutes. With the data for the Volvo 7900 in Table 1, recharging could be done after, roughly, 170km and 340km, taking 40 minutes each and adding 50 minutes to the journey time.
>
> Note that this assumes the bus is fully recharged at the start of the journey. That would require charging outside the PV-optimal window, leaving at most two-thirds to be charged from PV.
>
> However, as noted at footnote 8, this may seriously understate the maximum charging rate.

17 https://www.legislation.gov.au/Details/F2016C00721