**Submission No 32**

# ELECTRIC BUSES IN REGIONAL AND METROPOLITAN PUBLIC TRANSPORT NETWORKS IN NSW


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**Electric buses in regional and metropolitan public transport networks in NSW**

Terms of reference that will be addressed

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.

## Recommendations

The use of electric buses will improve Australia's transport fuel security.

The metropolitan bus fleet should be transitioned to electric buses as quickly as possible. Small trials have already taken place within Sydney. These should be scaled up.

Many regional buses can also be transitioned now.

Where possible, buses should be charged in such a way as to support the deployment of renewables. Smart charging should be used in order to support the stability of the grid.

Private bus operators (for example schools, sports clubs etc.) should also be supported to electrify their fleets.

For more information on anything discussed within this submission, please do not hesitate to contact us.

## Background

When compared with conventional buses, electric buses greatly reduce local emissions including particulate matter, $NO_x$, $SO_x$, and carbon dioxide emissions [1]. Smog can cause chronic bronchitis in adults, episodes of bronchitis in children, and trigger asthma attacks [2]. Poor local air pollution is a problem in many cities, and electric bus fleets are being deployed in part to improve air quality [3] [4] [5] [6]. New York City has just launched 15 electric buses [7]. London has a fleet of 200 and is expecting more [8]. Paris will soon have 800 electric buses [9]. The city of Shenzen in China has completely electrified the 16,000-strong bus fleet [10].

Apart from improving air quality, these buses are also much quieter, have far superior acceleration, and can use regenerative braking to reclaim energy that would otherwise be dissipated as heat.

One of the main disadvantages of electric buses is that they are relatively new technology and so have higher purchase prices. This is offset by lower maintenance and fuel costs, such that total lifetime costs are usually lower for electric buses [11].

In general, metropolitan bus fleets can be electrified now. Transit Systems in the Inner West of Sydney is trialling four electric buses, which each have a range of 350 km. Many regional routes could also be electrified now. At this stage, intercity routes may be too long for batteries, but hybrid or hydrogen fuel cell buses could be used.

## Energy Security

Bloomberg New Energy Finance report that for every day a fleet of 1,000 electric buses is used, 500 barrels of diesel are avoided [10]. Australia currently imports 90% of its total liquid fuel needs, compared to 60% in 2000. As more local refineries are closed this figure will reach 100%. Purchasing oil from the international market means prices can be volatile, and are tied to events outside of domestic control [12]. In December 2018, Australia only had the equivalent of 18 days of consumption cover for petrol and 22 days for diesel. In the event of a supply-chain disruption, emergency rationing would take three weeks to implement, by which time reserves could be exhausted [13].

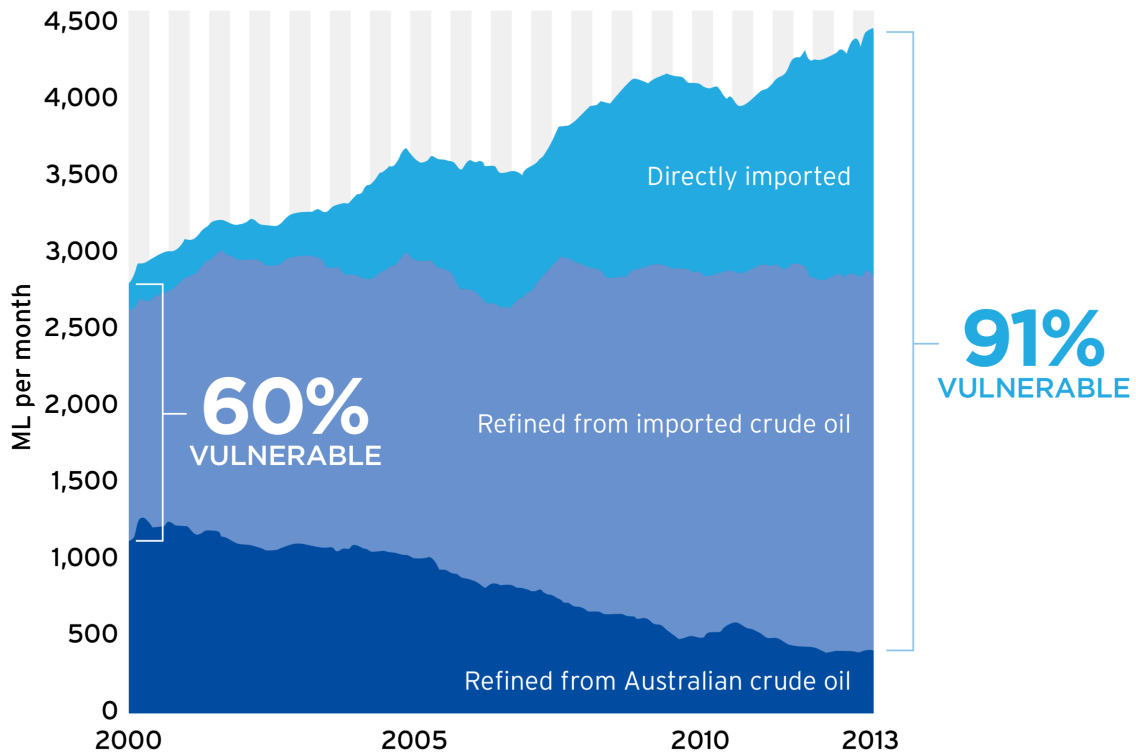


*Figure 1: Australia has been relying more and more on imported liquid fuel. Image from* [12]

Transitioning to an electric vehicle fleet would improve transport fuel security. Electric buses can be powered with electricity which is domestically generated.

This would also result in lower emissions. A study from the United States shows that electric buses already result in fewer emissions than conventional ones, even for areas that are highly dependent on coal for electricity generation [14]. The Australian Federal Government predict that the grid will be supplied with at least 50% renewable generation by 2030 [15]. This transition is happening because wind and solar photovoltaics (PV) are the cheapest form of electricity generation [16]. The figure below shows the global net new capacity additions in 2015-18 for each generation technology. PV and wind are well in front.

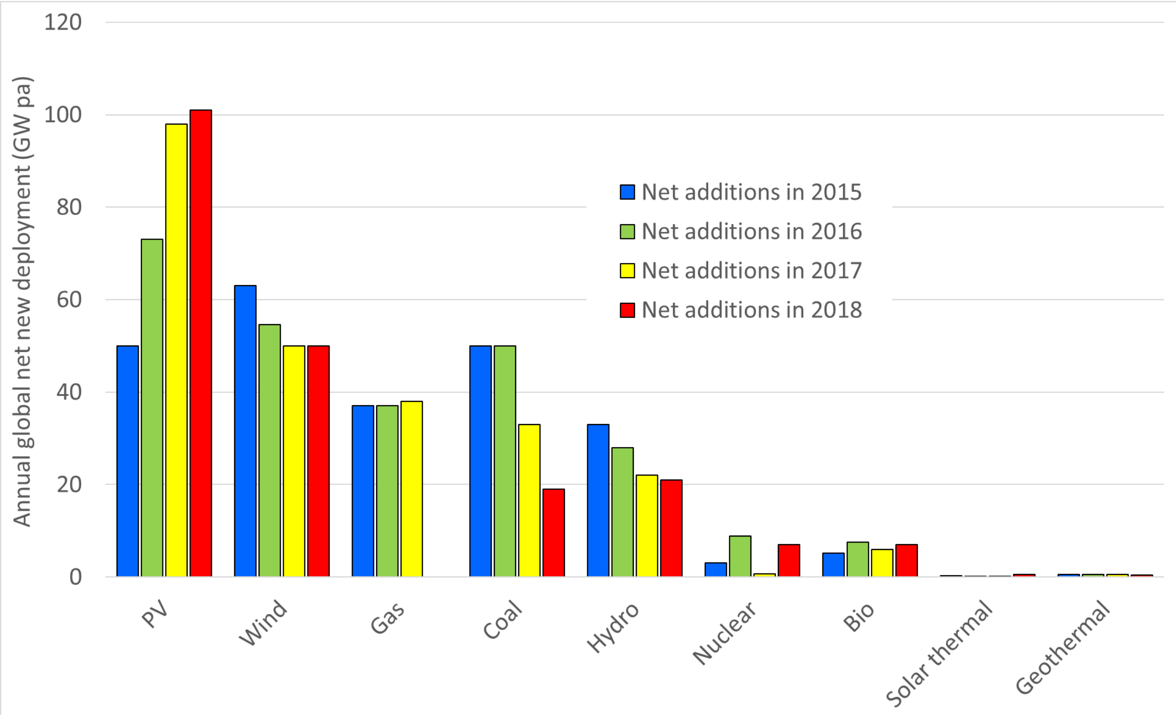


*Figure 2: Global net new generation capacity added in 2015-18 by technology type* [17]–[21]. *In 2018, over 150 gigawatts (GW) of net new wind and PV was deployed, which is more than everything else combined.*

The price of electricity from large-scale PV and windfarms in Australia is currently $45-55 per MWh and falling. This is below the cost of electricity from existing gas-fired power stations and is also below the cost of new-build gas and coal power stations. The cost of electricity from PV and wind is already similar to the cost of fuelling and maintaining much of the black coal fleet (more information can be found in the attached article below). Premature retirement of many existing black coal power stations is likely during the 2020s, enlarging the market for PV and wind. A recent report shows that it is possible to replace the capacity of the Yallourn power station before its earliest possible retirement date, which could be 2023. The renewable electricity would result in lower wholesale grid electricity prices [22].

## The electricity grid requires new, flexible load

66 066 GWh was generated in NSW in 2014 [23]. In order to use batteries to electrify all of the buses in the State, around 900 GWh would be needed each year – which represents 1.4% of current electricity consumption. (This calculation was performed using data from the Australian Bureau of Statistics [24], which includes those buses which travel longer distances. These would probably need to be electrified using hydrogen fuel cells rather than battery technology. For more information, please see the attached paper below).

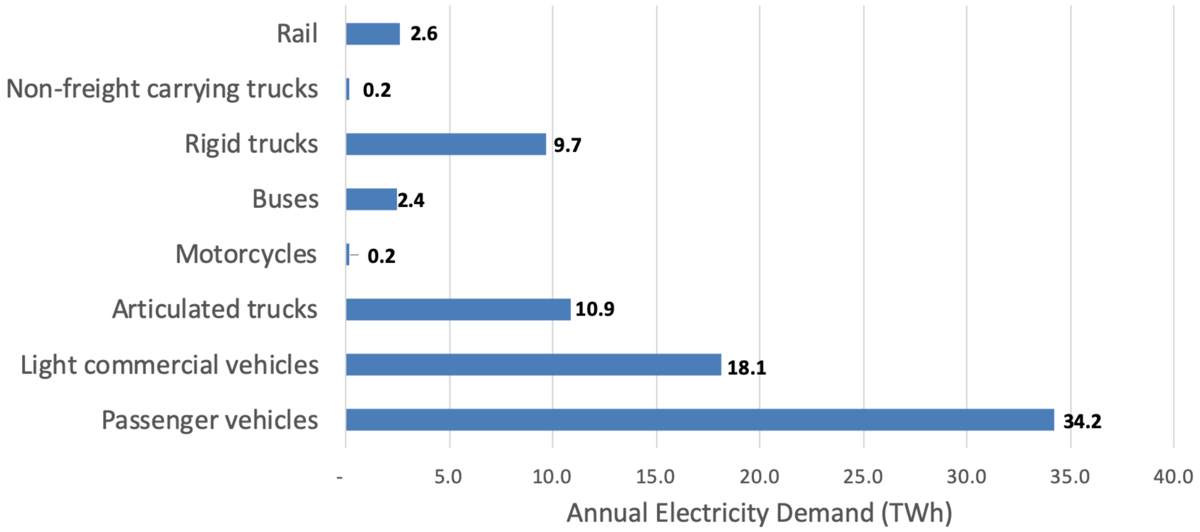


*Figure 3: Additional electric load added by each mode of transport within the National Electricity Market*

In order to ensure stability, the electricity grid needs new, flexible load. The chart below shows the new normal in South Australia during Spring and Autumn, when demand is low. Rooftop solar generation is plentiful and has reduced total midday demand [25]. Without management, this could create problems. New load that can be deployed flexibly could soak up this generation. Demand management through electric vehicle charging is an ideal candidate. Where possible, charging should be performed during the hours around midday, but at any time it can be controlled and interrupted in order to support grid stability. This is important as more wind and solar PV come online.

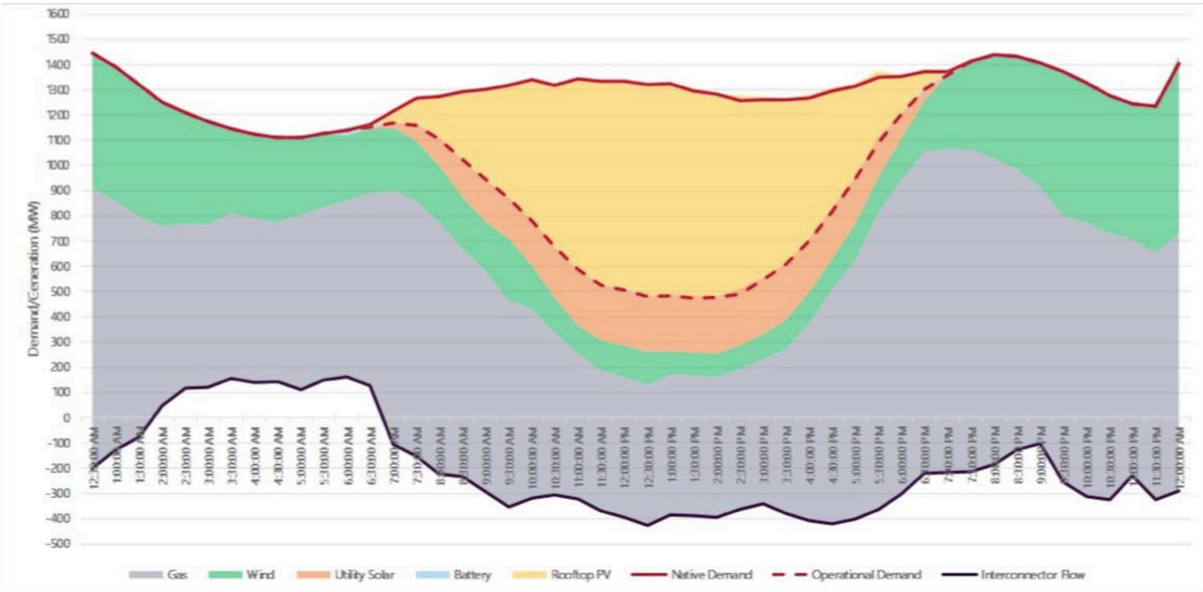


*Figure 4: South Australian grid generation for Sunday 20th October 2019 – showing the operational demand (red dotted line) which represents a new low on the system* [25]

In the near future, bus depots could benefit from installing solar car park shading systems. These would provide shade at the bus depots, and would generate solar PV directly where it is used. The solar car park at Vicinity Centres in Adelaide's North is a pertinent example. This system provides shade for 1400 car spaces, is rated at 2.7 MW and is expected to generate 11.5 GWh per year [26].


*Figure 5: Transit Systems Leichhardt Bus Depot – image from Google Maps*

## Stabilising the grid with large amounts of PV and wind

Energy balancing for a 50-100% renewable grid is straightforward and can be done using off-the-shelf techniques that are already widely used. These techniques comprise energy storage, demand management (i.e. controlled charging of electric buses etc.), and strong interconnection over large areas using high voltage transmission lines. Occasional spillage of energy on sunny/windy days when storages are full is cheaper than providing unlimited storage to avoid spillage. Deployment of both wind and solar can reduce the required storage capacity compared with equivalent capacity in either alone, because wind and solar availability are often counter-correlated.

The cost of hourly balancing of the Australian National Electricity Market for 100% renewables has been estimated at about $25/per Megawatt-hour (MWh) [27]. This comprises additional storage and transmission and includes the cost of occasional spillage of electricity. The amount of storage required was determined to be about 500 Gigawatt-hours (GWh) of storage energy and 20 GW of storage power [27]. For comparison, Snowy 2.0 is 350 GWh of storage energy and 2 GW of storage power.

In response to rapid deployment of PV and wind, about a dozen new pumped hydro energy storage systems are being considered in Australia, including about 2.5 GW that is approved or is under construction. Some (like Snowy 2.0) utilize existing reservoirs and others are located away from any significant river, for example [28]–[30].

Pumped hydro offers system inertia, rapid start (20-200 seconds) and black start capability, which helps to overcome the void left for such services when coal and gas power stations retire.

Continental-scale transmission smooths out the effect of local weather and demand, and greatly reduces the required storage [27]. State-of-the-art high voltage direct current (HVDC) systems transmit 12 Gigawatts (GW) of electricity over 3,000 kilometres at voltages of 1.1 megavolts, and with losses of around 10%.

Continued development of storage and transmission is critical for the development of the large Australian PV and wind pipeline.

## Novel charging example

The following system shows an example of what can be achieved with battery technology in order to avoid costly network augmentation. An electric ferry in Norway has been built with two 520 kWh batteries on-board, to transport vehicles and passengers six kilometres over a fjord. In order to recharge without overloading the grid, the ferry plugs into a 260 kWh battery at each pier, and quickly charges from this. The pier battery then trickle charges back to capacity. This system was installed so that the network did not need to be augmented. The ferry has also been designed to deliver a 40% energy saving compared to a conventional ferry [31] [32] [33].

*Figure 6: Electric ferry in Norway* [32]

## Employment implications

All windfarms, solar farms, pumped hydro systems and high voltage transmission are being built in regional areas. Construction, maintenance and renewal (after 30 years) will bring thousands of long-term jobs to regional areas.

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We have attached a paper that has been submitted to the journal *Applied Energy* for your consideration below. As this paper has not yet been published, we request that this is manuscript not be made available to the public. Once the paper has been published, we can provide a non-confidential copy. This paper discusses the feasibility generating 100% renewable electricity for all grid consumption and also for all land transport, and uses the National Electricity Market as a case study.

Pages 10 - 32 redacted