Submission
No 36

ELECTRIC BUSES IN REGIONAL AND METROPOLITAN PUBLIC TRANSPORT NETWORKS IN NSW

Organisation: InvertedPower Pty Ltd

Date Received: 2 March 2020

Parliamentary Inquiry into electric buses in regional and metropolitan public transport networks in NSW.

Dear Committee,

InvertedPower welcomes the opportunity to make a submission to the Parliamentary Inquiry into Electric buses, and to share our insights from involvement in bus electrification programs worldwide.

InvertedPower is a Melbourne based start-up company designing and manufacturing novel charging equipment in Australia specifically for electric buses. InvertedPower has partnered with commercial vehicle charging industry leader, Heliox BV of the Netherlands, to bring to market a new type of charger with integrated battery storage based on InvertedPower's Australian-owned novel intellectual property. Named SprintCharge, this charger aims to ameliorate the barriers to entry of electrifying fleets such as access to high power capacity and lowering capital and operational expenditure.

InvertedPower is also commercialising traction drive integrated flash charging with renowned partners, providing significant cost/weight/size improvements to the underlying principal of the ABB TOSA solution awarded in the recent Brisbane BRT tender.

InductEV Pty Ltd, an affiliate company of InvertedPower, uses the expertise of its members to provide consultancy services to achieve the optimum electrification strategy of fleets, and has worked on some of the world's largest electrification projects, including fleets well over 100 buses.

1. <u>Benefits of electric buses and factors that limit their wider uptake.</u>

Electric buses have been shown to provide social benefits such as reduced noise, heat, and local particulate matter emissions, which is crucial to public health and wellbeing especially in urban environments. Studies have shown that passengers prefer riding on electric buses over combustion powered alternatives, which in turn increases passenger count. An increased patronage combined with the more efficient electric driveline is therefore able to yield a significant reduction in emissions per passenger.

When implemented proper planning and due consideration, electric buses have been shown to significantly reduce the total cost of ownership for a bus fleet. This is primarily due to significantly reduced operational and maintenance costs. Therefore, an electric bus fleet can increase the profitability of running bus services, leading to the justification of further services.

Electric buses have been proven worldwide as a mature technology. China is the single largest adopter of electric buses, with entire fleets being electrified. However, there has been some controversy about the success of earlier Chinese implementations, where adoption rates, driven by government subsidies, were arguably faster than technological progression leading to mixed results. Luckily, the world was able to learn from the resulting positive and negative experiences, and undoubtably the rapid Chinese deployments accelerated the development of the industry worldwide. Elsewhere, for example in Europe and North America, operators conducted more thoughtful trials of electrification over the past decade, which resulted in successful full-scale deployments procurement of increasing magnitude based on prior learnings. In the last few years, especially in Europe, it has not uncommon for orders and deliveries of 100+ electric buses at a time.

This recent surge in electric orders is reflective of the maturity of the market and product offerings, with most electric bus OEMs proving to be ultra-reliable, and providing significant operating expense reductions when implemented correctly. There has been a noticeable turning point for independent and publicly listed transport operators who are now procuring new orders of electric buses primarily due to their proven lower total cost of ownership, rather than any environmental or social benefits.

The wide-ranging implementations worldwide helps with electric bus adoption planning in Australia, as most of the electrification strategies have now been tried-and-testing, and clear strategy winners have emerged. Previous deployments can be analysed, to aid in planning a successful Australian deployment whilst avoiding any mistakes previously undertaken. Different jurisdictions have had different successes based on a range of factors including climate, urban density, topography, access to renewable energy, electricity pricing including demand charges, and reliable access to power. Any prior results or findings must therefore be adjusted to differences in these factors.

Some of the challenges to be overcome during planning include:

- Developing an accurate model and optimal strategy for a staged fleet electrification transition, including adequate redundancy and resiliency to network outages.
- Obtaining accurate modelling data for worst-case vehicle efficiency, with due consideration for battery capacity loss during winter, weather, route terrain, and air-conditioning loads without first undertaking extensive trials.
- Misleading information from bus manufacturers surrounding maximum electric range and effect of depth of discharge on life expectancy. This can lead to a mismatch of expectations and failure to meet duty cycles, life expectancy, and ultimately negatively impacting total cost of ownership.
- Developing a plan for permitting and novel ownership structures of fast charging en-route infrastructure, where access can be shared between multiple operators to reduce costs (for example, at park-and-rides, shopping centres, transport modal interchanges, etc).
- Minimising impact of an electric bus fleet on the wider electricity network and avoiding over-capitalisation of network assets.
- Planning for the future grid system of distributed renewable energy resources, DC micro-grids, and the approaching reversal of “cheap” power from overnight baseload to daytime “duck curve”.
- Lack of access to state-of-the-art technologies in Australia due to an immature electric vehicle industry stemming from an absent policy direction from government.
- Lack of local knowledge as no significant trials have been undertaken prior. This could result in poor planning and optimisation, leading to a repeat of mistakes already discovered overseas.
- Retirement strategy of existing diesel and CNG fleet.

Most of these issues are easy to solve with due consideration and proper planning, and the authors find no insurmountable challenges with electrifying the entire TfNSW bus fleet.

2. Minimum energy and infrastructure requirements to power electric bus fleets.

InvertedPower and associated consultancy firm InductEV have been involved in paid and pro bono analysis and modelling to determine the minimum infrastructure requirements for a range of electrification projects worldwide from 5 buses to 100+ buses. Although there is no one-size-fits-all energy and infrastructure requirements for an electric bus fleet, the minimum requirements can always be determined through comprehensive analysis and modelling.

For the electrification of entire fleets, in most cases, Australia's grid is mature and capable of handling significant electrification of our bus networks without causing wider distribution issues. However, due consideration should be made to avoid over-capitalisation of traditional network assets without adequate planning for embracing the future grid of distributed energy resources and DC micro-grids. Australia is blessed with good solar irradiation, and an electric bus depot presents an ideal to opportunity to co-locate a solar photovoltaic array and battery storage for local renewable energy generation and consumption.

Generally, for small electric fleets and trials of just a few buses, an overnight charging strategy can be deployed with good success. This is because specific routes can be selected with light duty cycles, and redundancy/resiliency is taken care of by the pre-existing diesel fleet. Often, range is stated by OEMs for ideal conditions with batteries at the beginning of their life, however, real world range in worst-conditions is significantly less. Small trials of electric buses in a wider diesel fleet are able to adapt to this decreasing range by adapting their route selection over time or based on daily weather conditions.

For larger electrification projects, a strategy making use of overnight and day-time opportunity charging is generally chosen with the best success. When implemented correctly, this combined strategy eliminates all perceived range issues of electric buses, enabling even the most intensive routes to be electrified. This strategy most often provides the lowest total cost of ownership as many buses can optimally make use the same fast charging infrastructure, thereby bringing down the effective cost of infrastructure per bus. Distributing the charging infrastructure increases power resiliency and also reduces grid stress and operational costs by increasing the load factor and reducing peak demand charges respectively. Furthermore, with adequate en-route charging infrastructure, the onboard battery requirements of each bus (which are the heaviest, most expensive component of an electric vehicle) can be significantly reduced, as the vehicle need not carry all of its energy for the day, but rather top-up throughout the day. Therefore, as the fleet size increases, the savings per bus are compounded, with more buses making use of the same infrastructure. This strategy also enables direct consumption of renewable energy like solar, thereby lowering the fleets operational carbon footprint. The embedded emissions of each bus is also significantly reduced as each bus requires fewer batteries, and therefore less minerals and manufacturing.

In Europe and US, the preferred charging method is to fit pantographs as an automated coupling to ensure no manual labour or safety concerns (e.g. unions/labour laws) for plugging in. Overhead systems also reduce or eliminate the risks of hitting the charging infrastructure, and enable high power charging (up to 1MW) to occur, rapidly reducing charging times.

The overall total cost of ownership of different infrastructure strategies can be investigated and modelled, and final selection based on the most economical solution.

3. Other renewable, emissions neutral energy sources.

As the electrification of an entire fleet would transition a significant energy load from fossil fuels to electric, it is imperative to align TfNSW's fleet electrification program with the future grid. Therefore, emphasis must be placed on planning recharging schedules around higher penetration of renewable and distributed resources, demand response, resiliency, DC micro-grids, and the resulting future energy profile.

Electric bus fleets represent an ideal candidate for integrating renewable energy sources as a primary source of power. This can be implemented through signing a PPA with large solar or wind farms, or by co-locating renewable sources at bus depots and en-route charging stops.

With the transition to a renewable grid, the cheapest power is often no longer overnight, but during the day when there is a surplus of solar energy (the so-called "duck curve"). It is expected that this trend will continue, and therefore the authors advise TfNSW to plan for this future grid to maximise charging via cheap and abundant renewable energy, rather than relying on overnight baseload coal-fired power. This decision will affect the charging schedule and infrastructure procurement to focus on self-consuming renewable energy, whilst using spare capacity of said infrastructure to interact and provide benefit to the wider network.

The footprint of a bus depot is inherently large in order to accommodate all of the buses when not in service, and also often includes offices for staff. This leads to lots of square meterage which is available to install solar arrays. Solar is particularly well suited to supply energy to bus fleets, as bus peak times are generally morning (6-10am) and afternoon/evening (3-7pm). This often means the depot is full of buses during the day (10-3am) which also happens to be during peak solar irradiation. This enables high self-consumption of any solar energy generated and minimises exports to the grid.

For depots which primarily are in the open air, adding a solar canopy provides many benefits:

- Provides a significant portion of the daily energy requirements, thereby lowering operational costs and greenhouse gas emissions
- Shades the buses during the off-peak day period, leading to lower cooling requirements for the afternoon shift (and thus greater efficiency), and increases battery life expectancy (cell life is adversely affected by heat)
- Provides a structure for mounting above vehicle pantograph systems
- Provides a structure for placing charging infrastructure to maximise depot floor space

In most regions, adding stationary storage for charging infrastructure can provide significant economical benefit by buffering grid demand, and enabling further self-consumption of solar. When combined with charging infrastructure which is bidirectional, the aggregate of distributed infrastructure required to support the TfNSW fleet would become a significant asset to the wider network.

From overseas deployments it has been shown that, even when optimised, the load factor of charging infrastructure is often low compared with the installed base capacity. Therefore this surplus capacity can be used to provide services in the ancillary market to improve grid stability. This provides an opportunity for world-leading Australian distributed asset aggregators to include these loads into their virtual power plants, thereby strengthening Australia's grid network for higher renewable hosting capacity, and further solidifying Australia's lead in energy innovation.

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

The primary support would be to create a market for electric buses in NSW. Australia is currently lagging worldwide in the adoption of electric vehicles, so there has been little incentive to initiate local manufacturing or R&D without a local market. Once a market for electric buses and associated infrastructure is created, NSW could further support local manufacturing by attributing points specifically to manufacturing location in tenders.

Any chosen measures to support the manufacture and assembly of electric buses in NSW, also apply to the manufacturing and supply of associated charging infrastructure.

5. **Experience with introducing electric bus fleets in other jurisdictions.**

InvertedPower and associated consultancy firm InductEV have led a number of analysis and modelling projects for electrification deployments worldwide. InvertedPower and InductEV have thus developed and built up a range of modelling tools, with validated results against numerous case studies worldwide.

For example, InductEV performed extensive analysis and modelling for Seattle's King County Metro as published in the report "South Base Battery Electric Bus Interim Facility – Conceptual Design Report". The report presented the most ideal charging strategy and layout for electrifying a new depot of 120 electric buses. This report may be available under the US Freedom of Information Act (US FOIA).

InductEV is also currently involved in other reports and programs currently unpublished.

InvertedPower is also a member of the Canadian Urban Transit Research & Innovation Consortium (CUTRIC), working on the pan-Canadian electric bus demonstration & integration trial.

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

One of the most exciting opportunities for electrifying an entire metropolitan bus fleet to electric is the potential for the required extensive charging infrastructure to become a valuable asset to the wider electricity network. That is, when optimally deployed, electric fleets create a distributed network of recharging stations, focused around depots, park-and-ride locations, train stations, transport hubs, and along popular bus routes. If each charging station is bidirectional, such a distributed network of charging infrastructure doubles as a distributed energy resource (DER) which could be controlled in the aggregate for demand response, energy arbitrage, voltage and frequency regulation and the like, forming a virtual power plant (VPP) asset. That is, the infrastructure which services the bus network, could also become the network which enables higher penetration of renewable energy network hosting.

For example, a well-known electric fleet of 100 electric buses in Amsterdam (Schiphol) uses 13MW installed base of charging infrastructure. If 8,000 NSW buses are to be electrified, this could comparatively create a virtual power plant asset for TfNSW or partners for 1GW/1GWh, or 100x the South Australian big battery. When this revenue generating asset potential is combined with the reduced cost of fleet operations due to electrification, TfNSW could be in a much more favourable economic position after the electrification of its fleet. Therefore, electrifying the TfNSW bus fleet to electric with adequate planning could improve grid resiliency, enabling a higher penetration of renewables and furthering Australia to meet its Paris accord commitments, all whilst providing significant economic benefit to TfNSW and taxpayers.

7. **Any other related matters.**

[redacted]

Please visit www.invertedpower.com or www.heliox.nl/SprintCharge for further details on InvertedPower's market offerings for ultra-fast electric bus charging.

The Heliox-InvertedPower SprintCharge is ideally suited for depot and en-route charging, by accumulating grid and/or solar energy in an internal energy storage system, and then providing bursts of high-power to rapidly charge buses. In this way, the charging infrastructure is able to achieve a 100% load factor from the grid, with software able to reduce the grid consumption to a continuous power equal to the average power consumption of the fleet. This enables full optimisation of charging infrastructure and strategy, and the lowest possible total cost of ownership.

Furthermore, the system is about half the size of traditional charging infrastructure without integrated storage, and therefore reduces footprint requirements, which is especially important for depots and en-route locations. The maximum grid connection of the system is 165kVA, but can output up to 450kW, and therefore can replace an ultra-fast charger with a connection to LV instead of MV. This increase the number of sites suitable for such infrastructure without careful consideration of capital-intensive augmentation or access to MV. Connecting to commonly available LV also can reduce approval requirements, cost, and time, therefore enabling a much faster adoption of an electric fleet. The SprintCharge is also fully bidirectional, enabling the ability to aggregate Sprintchargers into a wider VPP to provide ancillary grid services such as FCAS.

Again, I thank the committee for inviting this submission. Through this inquiry, I hope the committee is able to recommend a cost-effective policy which enables the successful transition to a fully electric fleet. I also hope that due consideration is given to the impact such adoption will have on the electricity market and distribution, as well as potential benefits for Australian local manufacturing and innovation. If the committee requires any further information or clarification on InvertedPower's submission, please do not hesitate to contact me.

Kind Regards,
Stefan Smolenaers
InvertedPower Pty Ltd
[redacted]

Submission attachment redacted