INNOVATIVE WORLD

ISSN: 3030-3079
Impact Factor: SJIF X.XXX

ORIENTAL JOURNAL OF ACADEMIC AND MULTIDISCIPLINARY RESEARCH

Open Access, Peer Reviewed Journal

Scientific Journal

COMMON FAILURES OF ELECTRIC BUS TRIALS AND WHAT WE CAN LEARN

Zulfikarova G.A.,
PhD student zulfiqorovaguldona@gmail.com
Bahrom Kayumov
PhD, Professor of Automotive department
kayumov.bahrom74@gmail.com
Andijan Mechane Building Institute

KEY WORDS

electric buses, BEB trial, engine vehicles, Climate Issues, Terrain issues, Breakdowns, Discussion and advice

ABSTRACT

This article provides information about the potential of electric buses and the results of experiments. The potential of battery electric buses (BEB) has been proven time and time again in successful trials the world over and has led to incredible growth in the industry over the past five years. Pilots with favourable results have been conducted in many challenging conditions. BEBs in Auckland negotiate steep slopes up to a 12% grade (2), Proterra's Catalyst E2 Max has travelled in excess of 1750km on a single charge (3) and commuters travelling between Electric busses continue to exceed expectations and prove their benefits over internal combustion engine vehicles.

As to be expected with any new technology however, there have been many issues and unfavourable pilot performances covering most use cases and operational characteristics around the world. This article discusses some of the most common reasons for unsuccessful BEB trials. An unsuccessful trial or failure is defined in this article as one in which the technology behaved significantly differently to that expected by operators and promised by manufacturers. This excludes cases where costs were higher than expected or operators weren't convinced at the end. These issues will be discussed in future articles.

Rather than a critique of this promising new technology, the purpose of this article is to communicate lessons which have been learnt from less successful trials.

After studying many pilot projects around the world it became clear that most issues with BEBs fall into the following categories:

- Climate issues: the vehicle is negatively affected by extreme temperatures
- Terrain issues: the vehicle is negatively affected by topography of the route

- Breakdowns: vehicle component failure above predicted level

We'll start with examples of these failures in the category most applicable, followed by a discussion of the issues, and conclude with lessons which can be learnt from these case studies and advice on conducting a trial.

Climate Issues

Extreme temperatures, both hot and cold, commonly affect BEBs, and was a common theme in issues observed in trials. The cooling and heating of the interior of the bus to maintain a comfortable environment for passengers can be a large drain on batteries, and therefore range. Hot weather can also cause batteries to overheat, and it's understood that temperature extremes can impact the life of batteries (5).

Henning, Thomas and Smyth (2019) studied the effect of temperature on vehicle range and found that for temperature drops from 50 - 60 deg to 22 - 32 deg Fahrenheit (10 - 16 deg to -5 - 0 deg C) BEBs lost around 32.1% efficiency (6). The study also noted "The Study Team was unable to identify previous studies examining the issue of diminishing fuel efficiency for battery-electric bus fleets operating in near- or sub-freezing temperatures", which goes some way in explaining the unexpectedness of temperature issues in the pilots described below, and the importance of these discoveries.

Among the many problems that plagued the LA Metro electric bus project, the LA Times in their investigation on the trial reported that the unpredictable driving ranges were impaired by both heat and cold (7). A similarly unsuccessful trial, with multiple problems, was that of the City of Albuquerque. Amongst other issues which eventually led to the return of the twenty buses ordered, batteries overheating in the summer was reported as a major concern (8). Indianapolis also found their range greatly affected by the cold (9) as did Zhengzhou, whose BEB range are significantly limited by the cold, and demand an extra hour of charging in the winter. In Izmir it was reported that the necessity of maintaining thirteen hours of air conditioning while travelling over 150km was a difficulty for manufacturers and an electric bus trialled in Phoenix in 2019 could only achieve two thirds of its advertised range in the summer owing to the drain on the battery that the air conditioning posed (9).

In addition to temperature, rain, snow and ice can impact the range and behaviour of BEBs. In Shenzen for example, battery charge was observed to drop during heavy summer rains (9). Regenerative braking is often turned off in slippery conditions and as such when it's icy or wet the performance of BEBs can be significantly affected (6).

Battery performance variability and its associated impact on BEB ranges needs to be properly understood if vehicles are to be optimally sized (and not oversized), and range anxiety not to be a limiting factor. Oversizing batteries can have a large impact on the economics of a project as they are the single greatest cost component of the BEB, while range anxiety can severely impact decision makers' willingness to adopt BEBs.

Terrain issues

Owing to their large batteries, BEBs are significantly heavier than their diesel or hybrid equivalents. Steep terrain requires more power from their batteries to provide the torque to fight the increased gravity. As such hilly routes will drain their batteries far more rapidly than those with flatter terrains. The extra power required to navigate steep topographies has posed a challenge to multiple projects studied.

In Cape Town, South Africa, the country's first electric bus project has faced significant challenges owing to terrain. The eleven buses part of the trial were unable to make it up many of the hills in the city (11). The aforementioned LA Metro trial also had trouble with terrain, with reports of stalling on steep hills and the incapacity of the BEBs to make it up the slopes on some parts of the routes. In Campinas, Brazil, the slow speeds BEBs were limited to up hills resulted in scheduling delays (9). Sclar et al. (2019) in their comprehensive study of barriers to the adoption of electric buses around the world state that power limitations, and thus the capacity of the BEBs to handle steep terrain, remains a key barrier. They stated topography as a barrier to BEBs performance in many case studies, particularly in South American cities with hilly terrain (9).

Breakdowns

One of the main failures observed in unsuccessful pilots involved component failure, often of many components. As Sclar et al. (2019) observe "battery banks and technological components of e-buses often require different designs than the engine components of conventional buses, and these designs have not fully been standardized and real-world tested for global use." It is worth noting that much of the time the components failing in pilots had little to do with electric nature of the buses and were instead typical components of buses in general.

A three bus trial in Canberra, Australia, missed over 35% of scheduled peak services due to unscheduled technical issues, breakdowns and increased servicing requirements compared with 1.7% downtime of diesel buses (12). Germany's first long-distance BEB route between Frankfurt and Mannheim was so plagued by breakdowns and issues, with delays of up to several days resulting in cancelled trips, the BEB route was closed a year later (13). The issue plagued LA Metro project breakdowns and vehicle issues required emergency service or a return to the garage ten times worse than the rest of the fleet (7) while the Albuquerque project had many issues with vehicles, including brake malfunctions and lack of undercarriage protection (8). In Bogota and Campinas the electric buses were prototypes as they needed to be specialized to meet the requirements of the transit system. Unsurprisingly these prototype vehicles, with their lack of real-world testing and design iterations, housed defects such as ruptured air suspension valves, broken doors, structural damage to the frame etc.. To make matters worse, many of the parts which needed replacement had to be specially shipped from China, reducing the availability of the BEBs. Electric buses in Hong Kong were recalled three times in nine months owing to tyre slippage and other issues while similar buses were recalled in Shandong before ever taking the road (14).

Discussion and advice

The widely differing topographical, climactic and operational characteristics that buses are subjected to means the appropriate design specifications, operation and behaviour will differ from location to location. What worked in one location will not in somewhere else and the unsatisfactory behaviour of a bus on one route will be a resounding success on another. We can learn key lessons from the failures of trials such as those discussed earlier in this article, to ensure the success of pilot projects, and quickly progress to more extensive rollouts.

In the cases of climate extremes and terrain, much of this can be anticipated and addressed through:

- Modelling and simulation
- Analysis of data and experience of operators from similar locations
- Procurement from manufacturers who've operated in similar conditions
- Testing of vehicles before purchase

Modelling and simulation is a good way to get an idea of the energy consumption of electric buses over a route, and can determine the minimum power and battery capacity requirements of buses. Manufacturers such as Proterra and third parties such as INIT, a supplier of IT solutions for the public transport industry, will perform detailed simulations of bus routes to determine heating and cooling demands, terrain demands, temperature, passengers idle times, driver behaviour etc. (15 and 16). These insights can go a long way to providing the right vehicle for the route. It is worth noting this kind of modelling will inform other parts of the decision making and procurement process, taking into account charging options, energy tariffs, and other operational constraints, to allow planners to converge on an economically and technically optimal solution for all infrastructure. In some cases, route redesign could be a good solution.

Conclusion

Battery electric buses have many advantages over traditional internal combustion vehicles, and their huge growth around the world over the last five years and the large commitments being made for their rollout in the future are testament to their potential. None of the issues observed in this review of unsuccessful BEB trials are insurmountable, and can be avoided in the future through careful planning and design, modelling and simulation, strategic partnerships and risk management in contract formulation. By learning from both successful and unsuccessful trials and pilot projects we can ensure the ongoing success of the electrification of our bus fleets and look forward to cleaner air, quieter streets and lower carbon emissions.

References

1. *Electric Bus and Coach Travel*. (2020). *Ember.to*. Retrieved 12 March 2020, from https://www.ember.to/
2. Top 4 Factors That Influence Battery Degradation In Electric Buses & How To avoid them - ViriCiti. (2019). ViriCiti. Retrieved 13 March 2020, from https://viriciti.com/blog/top-4-factors-that-influence-battery-degradation-in-electric-buses-how-to-avoid-them/
3. Henning, Mark, Andrew R. Thomas, and Alison Smyth. "An Analysis of the Association between Changes in Ambient Temperature, Fuel Economy, and Vehicle Range for Battery Electric and Fuel Cell Electric Buses." (2019).
4. Implementing electric vehicles. (2020). Initse.com. Retrieved 13 March 2020, from https://www.initse.com/us/news-resources/blog-podcast/implementing-electric-vehicles.html
5. Feature: Chinese pure electric buses help optimize green transportation in Finland - Xinhua | https://www.linkedin.com/redir/general-malware-page?url=English%2enews%2ecn . (2020). Xinhuanet.com. Retrieved 13 March 2020, from http://www.xinhuanet.com/english/2019-10/22/c_138491275.htm
6. Paguio, J. (2019). Volgren begins its electric vehicle charge | Volgren. Volgren. Retrieved 13 March 2020, from http://volgren.com.au/volgren-begins-electric-vehicle-charge/