FINAL REPORT
APTA Study Mission to Europe

Upscaling Bus Electrification: The Road to a Zero-Emission Fleet

June 28–July 1, 2021

AMERICAN PUBLIC TRANSPORTATION ASSOCIATION

FINAL SUMMARY REPORT

Public transit agencies across North America are making commitments to roll out electric bus service with the potential to make a full-scale transition to zero emissions. Electrifying a bus fleet—whether with battery or fuel-cell—requires new approaches to planning, operations, and maintenance of your fleet.

In that context, APTA organized a virtual study mission from June 28-July 1, 2021, to learn how leading European agencies are approaching this transition. This was a unique opportunity to learn from and share insights with European decision-makers and practitioners on how to position your agency for success in the transition to zero emission fleets. Notably:

- How to approach transitioning from small-scale pilots to a large electric bus fleet and operate a mixed fleet;
- The necessary organizational management, funding and finance, and stakeholder engagement that helps ensure a successful rollout; and
- Key differences in route planning, infrastructure and depot design, operations, and maintenance of electric buses.

Participants made virtual visits to four cities: Groningen and Drenthe (the Netherlands), Paris (France), Cologne (Germany) and London (UK), that represent a diversity of bus electrification experiences and operational settings. Presentations were also be made by UITP, the International Association of Public Transport, and VDV, the German Public Transport Association, to provide global and national perspectives on the pace of bus electrification and zero-emission trends. APTA thanks UITP for its support in organizing this study mission, and the public transportation professionals of Groningen and Drenthe, Paris, Cologne and London, as well as the VDV for their time and significant contributions.

The following report serves as a summary of the key findings of the study mission.

Key Findings by City

The Public Transport Authority of Groningen and Drenthe, the Netherlands

The Public Transport Authority of Groningen and Drenthe has a goal of being 100% emission-free by 2030 and started making the transition to a zero-emission fleet in 2017. Currently, 186 of their 360-bus fleet is zero emission, operating in city and regional service. In making the transition to an all zero-emission fleet, they are experimenting with multiple technology options. They operate 164 battery-electric buses and have deployed both on-route overhead charging and depot-based charging. They are also operating 22 hydrogen fuel cell buses. The electric power needed for both the battery and fuel cell buses comes from wind energy, and fuel cell buses use green hydrogen.

- Their strategy is to match the route to the technology chosen, so they operate battery buses with overhead charging at the end of the line for the longer BRT style routes, and single and articulated battery buses with depot charging for the urban and regional services.
- They are also using hydrogen fuel cell buses for the longer regional routes; these buses are fueled with green hydrogen (both waste product from a chlorine factory and from electrolysis of green power)
- They are testing hydrogen for long distance 100 km/h buses (larger "coach-style" buses)
- Their guiding principle in this decision was to "meet the needs of the passengers," not change the routes to meet the needs of the technology. They also wanted to be able to have a 1:1 replacement of the diesel buses.
- For the depot charging buses on the BRT system, they opted for a charging opportunity at the end of the line to be combined with the depot charging, to extend range as needed.

- They used multiple vendors for their charging equipment and for their buses and recommend diversity to avoid facing delays if a single vendor or product has a problem.
- To prepare their drivers for the differences between conventional diesel and electric and hydrogen buses they started by training a small group called "ambassadors." All drivers have tablets on board, instruction videos are accessible on board and cockpits are standardized. To operate hydrogen buses, drivers must take an exam following training.
- They started very early (years ahead) in planning to deploy chargers, long before procuring the buses.
- Their primary message: don't wait for the perfect technology, just do it!

RATP – Public Transportation Operator for the Paris Region, France

RATP is planning the transition of its 4,800-bus fleet in the Parisian metropolitan area to 100% ecologically-friendly transit by 2025, with a conversion of half of its depots (13 out of 25) for electric buses and half for biogas. Two depots currently have been transformed to serve an all-electric bus fleet, with a total of 200 electric buses in service, exclusively using overnight depot charging, while two depots have been upgraded to a biogas bus fleet, with more than 250 biogas buses. 1100 hybrid buses will be in operation for years to come and most of them would still stay in the fleet after 2025. In preparation for the 2025 transition, RATP conducted a comprehensive program of piloting electric buses in real life operating conditions, experimenting with new technologies, the latest generation of batteries and the interoperability between charging station suppliers and buses manufacturers.

- RATP has 25 bus depots with 200 buses at each depot. Eventually they will have 13 electric bus depots and 12 biogas depots. As of the end of the summer 2021, there will be work in progress at all depots.
- The Lagny bus depot was transitioned to 100% electric bus depot, with mixed use/offices constructed above the depot. The depot is in a densely populated area of Paris.

- At this depot, they chose to do only overnight, plug-in charging, primarily due to the cost of electricity. They determined this would be the lowest cost way to charge an entire fleet of buses.
- They tested inverted pantograph charging but found it didn't work operationally for them, in part because it required lengthening driver breaks and partly because of the higher cost of the electricity.
- They are building out interoperable charging because they need to make sure that each bus charges with each type of charger.
- Power requirements are 10 MW per depot for 200 buses with a 2 MW transformer.
- Charging the full fleet overnight requires careful planning to ensure all buses are ready by morning.
- They are also testing hydrogen buses, with plans to start testing them in actual service.
- Training of drivers for electric vehicles required a change in mindset to ensure smooth driving and comfort for the passenger.

- One key message: When preparing for a transition to a zero-emission fleet you must be good planners and be closely aligned with the operational realities as what was planned on day 1 may be very different two months or a year later.

KVB – the Public Transportation Operator for Cologne, Germany

KVB has been operating 8 electric buses since 2016 and aims to expand their fleet to serve 6 more routes this year and an additional 7 routes by 2022 for a total of 114 electric buses. KVB has built up significant experience with operating in highly congested roads, heavy rain and summer and winter temperatures; viable options for charging infrastructure; depot configurations; and creating redundancy of the energy supply.

- KVB has a target of a fully zero emission fleet by 2030. They must build a strategy that will meet the needs of their cold winter temperatures and the need for articulated buses (which are two-thirds of their fleet).
- They looked at all greenhouse gas reducing technologies: fuel cell, trolley, synthetic fuels, battery and battery hybrid. They determined that battery would be the best option for them.
- Running a pilot of 8 articulated battery buses, started in 2016. This generation of battery buses could not meet the 200 km daily range, which drove their charging strategy of using both on-route charging by overhead pantograph and depot charging.
- The buses' charge is "topped up" throughout the day and then they are fully charged at the depot each night.
- Drivers receive one day of training, starting with theory then operational training.
- In December 2019 KVB ordered 53 battery buses. These buses will be used for the electrification of 6 bus routes in 2021.
- They purchased 51 new buses in 2021. The next generation buses will have larger batteries and will require higher charging power. Still, opportunity charging will be needed for the articulated battery buses.
- They are working to modify depots to accommodate more battery buses and bringing in more power.
- They are talking to national power suppliers about how to bring the power needed; they are also exploring energy storage options since much of the energy comes from wind power.

Transport for London (TfL), United Kingdom

TfL has over 450 electric buses in operation, one of the largest electric vehicle fleets in Europe, with a total fleet size in excess of 9,000. The current target is for the entire fleet to be zero emission by 2037, through a combination of electric and hydrogen powered vehicles. TfL is exploring initiatives to bring this date forward to 2030 to help deliver greater air quality benefits for London.

Some of these initiatives include supporting their bus operators to upgrade their garage charging infrastructure to accelerate the rate at which electric buses can be brought into the fleet. They are also investigating the role of opportunity charging for longer bus routes, where conventional big battery electric buses are unable to fulfil the distance with overnight charging alone. TfL is also taking part in the EU JIVE project to trial 20 Hydrogen powered double deck vehicles in London to identify their strengths and limitations, and what role hydrogen can play in delivering a zero-emission fleet in London.

- In developing the zero-emission bus strategy, TfL looked at biofuels but felt that would be a temporary solution and chose instead to plan for going straight to zero emission technologies.
- TfL contracts with 10 private bus operators who run the day-to-day service; these operators also have responsibility for the bus procurement.
- To date, they have mostly implemented battery buses but are open to hydrogen; one major challenge at present is the lack of suppliers. They have been working to start a pilot program of double-decker hydrogen buses, but it has been delayed and has faced multiple challenges.

- The battery bus challenges include a 50% increase in purchasing cost and the limited range; these two factors combined lead to higher costs overall.
- Regarding power demands, they spoke with the energy company, National Grid, very early in the process. TfL was told that the proposed power demand would not be a problem and they haven't had any issues yet. If any issues were to arise, it would be a local-level distribution issue, not a national level one.
- Regarding electricity rates: this is a concern for the bus operators, not TfL but they believe that most charging will happen overnight when grid power is the cheapest. They also believe some innovative solutions like power-as-a-service may evolve.

Overall Findings

- The strategy has been to match the technology to the routes. The European transit authorities often noted an internal commitment to find the technology solution that would meet the customer need, rather than modifying routes or schedules to meet the technology need. This was an important reminder that technology is not just one size fits all.

- Some transit authorities have chosen to mix the fleet with both zero and low-carbon technologies like hybrid or biofuel. Others, like London, chose to avoid any options other than zero emission.

- Charging strategies were developed around the route demands but also the cost and availability of power. Paris chose overnight depot charging at one depot so they could avoid costly power upgrades. Cologne used opportunity charging to complement depot charging due to the length.

- The transition to electric buses is a **whole system**—the infrastructure is just as important as the buses, perhaps even more, and they must be planned together. Agencies must be prepared to adjust as the operational realities become clear.

- Transit agencies need to start early on planning facilities modifications which can be substantial. They may want to look at the modifications needed for electric buses as an opportunity to do an entire facility upgrade.

- Each European agency identified elements they would not compromise on in the transition to zero emission technology, mostly focused on the customer experience: for example, the comfort of the buses or the schedule needed to provide the level of service customers want and need. These "north stars" helped drive the bus and infrastructure choices and plans.

- There have been challenges and growing pains associated with new technologies including delays in bus production and commissioning; challenges with securing replacement parts when needed; chargers that did not work, etc. An understanding that these challenges will occur with new technologies should be built into the planning process.

- Nevertheless, European transit agencies provided us this message: don't wait for the "perfect" technology solution to embark on your zero-emission journey.