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Electric busses: Who's in Charge?

Public Transport Authorities to take charge of charging infrastructure for electric busses using the triple-layered model

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Executive Summary

In this article, the sustainability of the first come- first serve-based implementation of charging infrastructure for E-busses is questioned and a new approach is put forward. In current public transport concessions in the Netherlands the site selection and operation of charging infrastructure is in the hands of the Public Transport Operator (PTO). To implement sustainable charging infrastructure, the site selection and the selection of a charging solution should represent the interests of three major stakeholders in the process: the PTO, the municipality and the Distribution System Operator (DSO). To ensure this integrated approach a separate tender procedure for charging infrastructure is suggested.

Key words: electric busses, tendering, charging infrastructure, urban planning, electricity grid

1 Introduction

The transport sector is responsible for 23% of the total global CO₂ emissions [1]. Of the transport sector emissions, 74% is attributable to road transport and in turn, 47% of the road transport emissions are emitted by heavy vehicles (busses and freight vehicles). The pursuit of reduction of these emissions and the goal to improve air quality in cities has led to large-scale developments in the electrification of busses. Electric busses (E-busses) improve conditions for both human and the environment by diminishing CO₂ emissions, (local) particulate matter emissions (PM_x) and noise pollution.

1.1 E-busses in the Netherlands

The Dutch government has the ambition to have 500 zero emission busses on the road by 2020 [2]. This means an average of over 40 zero emission busses in every Dutch province. By 2025, all new bus sales should be zero emission to reach the ultimate target of zero emission regional bus transport by 2030. For zero emission two alternatives are available: hydrogen buses or electric busses. Comparing the availability and pricing of electric busses and the infrastructure needed for hydrogen, it is expected that to obtain the goals set by the Dutch government at least a majority of the busses will be electric [3]. A trend that already

started. Currently 186 E-busses drive on Dutch roads [4]. The gradual ambition targets towards 2030 could contribute to a smooth implementation of E-busses in the Netherlands. Effectively, this means that in all upcoming public transport tender procedures zero emission busses will be included.

1.2 New stakeholders in public transport

The major difference in tender procedures of public transport including E-busses in comparison to the tendering of traditional busses and hydrogen busses is facilitating the charging infrastructure. In Europe PTOs often choose to charge their busses at high power during the operation to extend the driving range of the electric bus (next to charging at the depot during the night). This type of charging during the operation is also called ‘opportunity charging’ [5]. Opportunity charging currently occurs mostly on street, in cities, at the ‘turn-around location’ of the bus route or at nodes where multiple busses often from different lines pass by. This situation makes the municipality or city a stakeholder with new interest in public transport from an urban planning perspective. Of course, the DSO, responsible for the grid stability and energy delivery, has an interest in facilitating the transition towards electric public transport on the grid in a sustainable manner.

Because of this, this paper will address a triple layered model, including transport planning, grid planning and urban planning, to design a sustainable charging network involving all stakeholders. Next to that it is proposed that the PTA tenders the charging infrastructure in public space separate from the tendering of the public transport concessions to ensure a sustainable strategy incorporating the triple layered model.

1.3 Influencing developments

The public transportation sector is subject to major (technology) changes on the short and long term, ranging from the electrification of transport, the development of autonomous transport and the rise of mobility services. When designing a charging infrastructure network and when deciding on a sustainable governance structure for charging infrastructure, decisions are being made for at least 10 to 15 years. This being the average contracting term of a public transport concession or a concession for charging infrastructure. Below some of the developments that strengthen the need for the triple layered model and a separate tender for charging infrastructure.

1.3.1 E-bus and charging technology developments

Battery technology and chargers for E-busses are developing fast [6]. Charging power of up to 600 kW or more can be achieved towards 2025 and 2030. Depending on technology decisions of OEMs and other stakeholders, this could mean that over 10 or 15 years’ time with the growth of the number of electric busses, charging locations will scale up in power, in number of chargers, and maybe even in type of connectors. For this, enough space and grid capacity is needed on location to create a sufficient charging network, demanding involvement of the municipality and DSO.

1.3.2 Growth of (unpredictable) local energy-supply and –demand

With the growth of electric mobility energy demand rises. This co-occurs with the growth of local sustainable energy sources, increasing the impact on the low voltage grid. A reason for the DSO to look for smart solutions incorporating these energy flows on the (existing) grid. The batteries of E-busses could be used to deliver grid services to the DSO, for example as a buffer for renewable energy or to avoid peak loads on the grid [7]. Also, the use of the grid connection could be optimized distributing the available power between different chargers for E-busses (of other PTOs) or to chargers of other vehicles (e.g. cars, freight, etc.). For these types of new business models, transport nodes can be chosen as charging locations. To realize these business models, cooperation with the DSO is essential. Also, an independent Charging Infrastructure Operator (CPO) is needed to deliver charging services to the different PTOs or other users.

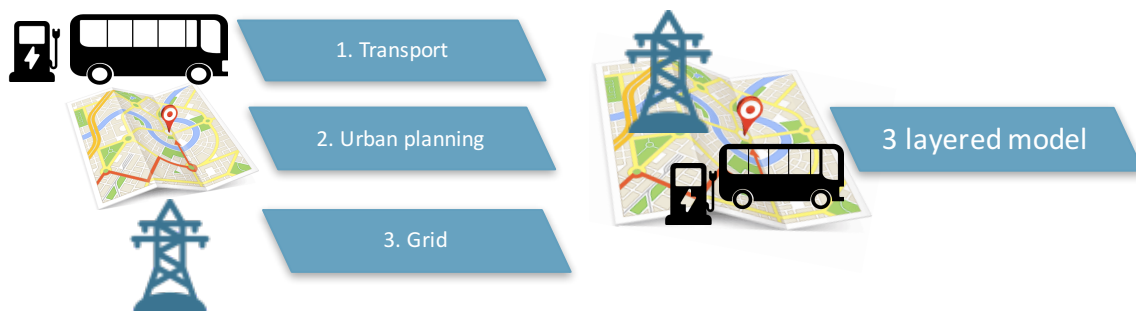
1.3.3 Autonomous transport

With the expected shift towards more autonomous vehicles, the role of public transport could possibly shift. Regardless of the scenario (e.g. less public transport because of more car sharing or private mobility services) public rapid transit lines or mass transit lines in cities will remain to play a role in transportation

[8]. From the perspective of the municipality, regardless of the scenario, in an autonomous future an even more controlled environment is necessary in public space (so no bicycles can disturb the route of the autonomous bus or car). From this perspective, strategic and integral mapping of e.g. dedicated driveways, park- and charge area's and fast charging infrastructure for bus charging can direct traffic flows, ensuring a safe, clean and accessible city.

2 Triple layered model

The triple layered model for developing a sustainable charging network entails that all aspects should be taking into account forming an integral approach on transport, the grid and urban planning. Current characteristics and future objectives concerning all three layers need to be taken into account to secure an optimized strategy. First, the characteristics per layer will be discussed.



2.1 Layer 1: Transport requirements

In layer 1 the successful operation of the E-busses is key, fulfilling the needs of customers by an ideal timetable that includes charging. The decisions on charging technology, the capacity of the battery, the power of the charger and the location of the charger depend on the following characteristics:

- The specifics of the bus lines: locations of depots, the route length and frequency of number of rides, driving speed, the type of route (i.e. inner city, regional) and waiting times during the timetable at intermediate stops and final stops (with respect to waiting of passengers);
- Environmental aspects: e.g. geology (e.g. hills, slopes or flat) and climate, since temperature has an effect on the battery use, and on top of that extra cooling, air-conditioning or heating require extra energy [9];
- The technology choice: the type of bus (number of customers, weight etc.), the type of battery (composition), the battery capacity, the type of charger (inductive or conductive with e.g. pantograph or a plug) and the capacity of the charger. The technology choice should be based on the before mentioned steps. An interdependency here exists with layer 2 (the type of charger influences the amount of impact on public space) and layer 3 (high capacity has more impact on the grid and costs for a grid connection)
- Minimization of resources: optimization in terms of number of buses, charging infrastructure and bus personnel to reduce costs

2.2 Layer 2: Urban planning

The charging infrastructure has impact on urban planning and vice versa. The decisions on the location and the type of technology chosen can have high impact on public space. Next to that, taking into account public planning can avoid replacement of chargers, avoiding high costs and operational changes in timetables. Aspects to be concerned are:

- The availability of space (in case of too few charging locations available, suboptimal routes could be necessary or additional busses might be needed which can lead to high costs);
- Optimal use of space and planning of the bus stations in terms of efficiency (e.g. driving routes) and sustainability;

- Landscaping (architecture, minimising the nuisance of sound and interrupted views etc.);
- Future upscaling of E-busses: multiple pantographs, larger charger (cabinet)-s;
- Multiple charging technologies of different PTOs: different models / colouring etc.;
- Future usage of charging infrastructure for E-buses by cars, heavy trucks, etc.;
- The opportunity to combine the charging infrastructure for instance with photovoltaic panels;
- Future area development and urban planning affecting the passenger routes.

2.3 Layer 3: The electricity grid

The charging infrastructure has an impact on the electricity grid, which needs to provide sufficient capacity to the chargers at the right moments without influencing the quality of the grid and the overall energy supply. Selecting a location while taking the existing grid layout into account (avoiding future grid reinforcements) can lead to lower costs and shorter implementation periods of placement of the chargers.

For those reasons looking at the following aspects is proposed:

- The current grid capacity and the needed capacity for charging;
- The expected need for capacity in the future: the projected electrification, i.e. the penetration of E-busses, electric vehicles etc.;
- The distance of the charging location to the grid;
- If necessary defining additional (to spread the necessary capacity) or alternative locations based on the above.

2.4 Modelling scenario's

To reach the optimal setup integrating all three layers, the modelling of different scenario's is necessary. First the boundary conditions need to be set per layer (e.g. number of customers, geography etc.) and indicating all possible locations. Combining the three layers is done by investigating different scenarios. The results exist of different scenarios with combinations of different charging locations, routes and technologies.

Based on these scenarios different decisions can be made. First of all, the feasibility of the degree of electrification can be determined including looking at scheduling, costs etc. By calculating the Total Cost of Ownership (TCO) of the different scenarios the cost-efficiency can be taken into account and the consequences of a certain site selection (e.g. more impact on architectural landscape) and decisions concerning (adaptation of) the timetable to accommodate for charging can be compared. The model is used to weigh the arguments of different stakeholders and to make informed decisions.

3 Who's in charge?

3.1 Current procurement system

In current public transport concessions, executed by the Public Transport Authority (PTA), the realization and exploitation of charging infrastructure is entirely in the hands of the public transport operator. This allocation of tasks suits conventional tender procedures. It leads to the PTO being the independent owner of the charging infrastructure, controlling most aspects of the three layers for safe and controlled public transport operation. This course of business also secures the freedom of choice of technology for the PTO. However, as we have seen within the triple layered model, multiple stakeholders are concerned with respect to the development of a charging infrastructure network; the PTA, the PTO, the municipality and the Distribution System Operator (DSO).

3.2 Current approach

3.2.1 Concession bound decisions

The PTO will base its decisions mainly on layer 1: optimizing the efficiency of the driving routes and costs. The sites chosen could not be optimal when other aspects then the ones from layer 1 (transport) would be

taken into account. Especially when upscaling takes place, or when other PTOs start needing charging infrastructure municipalities want influence on where charging infrastructure will be located. Besides choosing the type of E-bus, PTOs are responsible for choosing the charging infrastructure. Main decisions to be made concerning the charging infrastructure are the charging technology and the charging locations, so the site selection. The PTO will decide on an optimal configuration of the above mentioned, designed within the boundaries of the concession (geographical and time barriers). This might result in a configuration that is less sustainable on the long term.

3.2.2 Technology decisions

There are multiple charging technologies available and being developed for the opportunity charging of E-busses. A charger for e-busses with high power does not only exist of a pole with e.g. a pantograph attached to it, or an induction plate in the road, but also of a separate cabinet (at least 2x2x2 meters) containing the grid connection and the charger itself.

The decision for a type of charging has impact on the interoperability and compatibility of the chargers with other E-busses, which can be of use when there are multiple PTOs running in one area. The charging technology is chosen by pioneering PTOs in the current model. This results in two possible consequences for other PTOs. Either pioneering PTOs shares their charging infrastructure at transport nodes with other PTOs. In that case the second PTO that runs bus lines in the same area does not have freedom of technology choice. This could result in an inefficient E-bus solution and therewith no level playing field. An alternative is that different PTOs place different (types) of charging solutions sometimes at one location (a transport node) and the infrastructure is not shared. This results in a sub-optimal use of the necessary grid capacity (layer 3), additional land use and landscape pollution (layer 2). A risk could even be that the municipality does not agree on the instalment of extra chargers for the 2nd or 3rd PTO either because there is no additional space available or because of landscape pollution.

3.2.3 End of contract

A large proportion of the chargers will be placed during the contracting term in line with an ingrowth model of E-busses and the technological developments. This means a share of the chargers is not yet depreciated after the contracting term of the transport concession ends. Choosing a location that is reasonable according to the timetable and that is sustainable looking at urban planning, the grid- and / or the charging infrastructure could be re-used at the end of the contracting term by the next operator. Next to that sometimes multiple concessions for public transport run in the same area, all with a different contract duration. If these PTOs rely on charging infrastructure of each other this complicates the change to a new PTO with a new charging strategy.

3.3 Tendering a separate Charge Point Operator

PTOs deciding on the charging technology and location solely based on optimizing the efficiency of the transport routes of that specific concession, could unintentionally lead to a suboptimal charging infrastructure network in general. The current situation more or less excludes other stakeholders from the strategy formation of charging infrastructure for E-busses. As a consequence, the sustainability of E-busses in general could be undermined. In order to implement optimal charging infrastructure, the charging technology and site selection should represent the interests of three parties.

Therefore, a separate tender procedure is suggested, issued by the PTA. Some preconditions have to be fulfilled ensuring successful implementation:

- E-bus and charging technology are further developed and technical standards are set. This prevents market intervention by the government forcing the PTO into a wrong direction by prescribing a charging technique, with big consequences on business cases or non-feasible transport solutions. Standardization for conductive opportunity charging is expected in 2 to 3 years [10].
- Develop a strategy including all three layers and their interests: do not stick to one transport modality or concession but look at all public transport concession and the ingrowth path of electrification in a defined area. This makes it possible to design a contract for a Charge Point Operator (CPO) who is allowed to act within the boundaries set by the PTA including necessary

conditions for effective public transportation, but outside the boundaries of a single public transport concession. In this way, the CPO can offer charging services to multiple PTO's or even to other (private) transport modalities or taxi, optimizing the grid connection, energy-use and the use of public space.

- Perform a separate tender procedure for charging infrastructure, starting early. The tender is awarded (or at least the preconditions are set) before the tendering of the public transport concession(s) starts. Tenderers that bid on the public transport concession can calculate with the out comings of the infrastructure tender (e.g. a map with predefined locations, or other preconditions). The CPO is prepared to start instalment of the chargers when asked by the awarded PTO. The CPO can be held responsible for the stakeholder management with the DSO and the municipalities in the preparation phase (when forming a strategy based on the 3 layers) and in the operational phase.
- Describe the requirements on charging infrastructure including high Service Level Agreements, (SLAs) and describe clear responsibilities and liabilities for each of the parties involved.
- Develop knowledge upfront on the use of public transport and the necessary charging infrastructure to design the tender for charging infrastructure and the inclusion of the 3 layers. Demand realtime and insightful data on the infrastructure, energy use and public transport. Only in this way continuous improvements on the network can be made.

If these preconditions are taken into account, some of the advantages and opportunities of this approach for all involved stakeholders are the following:

- Preparation in advance by the PTA, CPO and municipalities becomes possible, realizing a strategic plan and mapping including interests from all three layers. This preparation also makes fast placement and instalment of the chargers possible at request of the PTO.
- The PTO(s) can calculate in advance with possibilities and limits for charging in public space and these are clear and set for all tenderers. In the current situation, it is often uncertain whether or not a charging location will be approved or not by the municipality after the tendering phase. The risks of preparing a bid on an infrastructure plan that in reality (partly) won't be accepted by the municipality lies at the tenderers (PTOs). This uncertainty makes it difficult to estimate the real costs resulting in higher bids at the tender. Removing this risk from the PTOs makes it possible to develop a more realistic bid.
- Sharing the infrastructure with other (non-public) vehicles like bus, taxi or freight, could stimulate the uptake of other electric vehicles and improve the business case of the charging infrastructure. Therewith it could also lower the electricity price for the PTO. This also means less infrastructure at other locations lowering the pressure on public space and lowering the costs on the grid connection (or it could even prevent grid reinforcements).
- CPO's can use their experience and knowledge implementing e.g. V2G, stationary storage or use of locally produced energy to optimize the energy management and lowering the energy costs for the PTOs.

In this way, it can have many advantages when the PTA takes charge of E-bus infrastructure. Using the triple layered model an integral strategy for future proof allocation and utilization of charging infrastructure for E-busses is ensured.

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