Electrification of public transport in cities
(Horizon 2020 ELIPTIC Project)

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Abstract

Public transport is one of the backbones of sustainable transport strategies in Europe. Collective transport has undisputed benefits concerning space efficiency. Today, more than 90% of buses in Europe depend on diesel, calling for better environmental and post-fossil alternatives. Further electrification of public transport (in combination with green electricity production) is a core aspect of further improving the environmental profile of public transport. Investments in electrifying public transport have a particularly high impact since urban public transport vehicles run up to 16 hours per day, compared to less than one hour for the average conventional car. A single 18 m urban bus consumes about 40,000 litres diesel annually – equivalent to more than 100 tons of CO2!

THE EU ELIPTIC project is looking at the electrification of urban buses as well as the improvement of energy performance in light rail and the multi-purpose use of infrastructure to support further electrification in transport. ELIPTIC is demonstrating technical approaches in 20 showcases with variations of electrified public transport under different operational, geographical and climate conditions. The demonstrations include new battery buses of high passenger capacity (18 m articulated) as they are increasingly in demand by public transport operators. Another concept is the combination of battery and trolley bus concepts, allowing to recharge batteries in operation (when connected to the overhead wires) and giving trolley bus cities an opportunity to extend the electric operation into areas without overhead wires. All in all, the concepts of battery volume and recharging need to be adapted to operational conditions.

There is high interest by cities and public transport operators in such concepts and related business cases. Associations of public transport operators (UITP, VDV and ASSTRA) and of cities (POLIS) play a major role in dissemination and in organising “twinnings” and exchange between the showcases and other interested cities and operators.

It is an explicit objective of the project to develop business cases by showing how costs and energy can be saved by electrifying public transport and by optimising the use of existing infrastructure and rolling stock.

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1. The role of collective transport in Sustainable Urban Mobility Plans

Sustainable Urban Mobility Plans are a tool for municipalities to develop strategies and implement related measures in an integrated understanding of mobility, transport, urban development and individual behaviour. The sustainable transport modes – walking, cycling and public transport – can and should play a specific role in providing energy-efficient, climate-friendly and space-efficient transport.

Today, in many European cities 40-60% of journeys are taken by sustainable modes. The 2015 European SUMP Award winner, the City of Bremen, shows a modal share of 60% for the sustainable modes (20% walking, 25% cycling and 15% public transport). The high share of non-motorised travel makes transport extremely space-efficient, which, in turn, leads to low congestion levels. Bremen has a congestion level (time lost in transport) of 25 hrs/citizen per year, whereas the German average is 39 hours (2014) and other cities show 65 hours and more.

A major role of collective transport is to provide space-efficient transport. Urban congestion and parking problems cannot be tackled with electric cars; a comprehensive sustainable urban mobility policy is needed. Collective transport is a cornerstone of sustainable transport strategies. And while larger cities have rail-bound transport systems (train, underground, light rail, tram) operated on separated tracks, smaller cities (as well as feeder lines in large cities) depend heavily on buses. From a global perspective, buses are the true backbone of collective transport, with bus systems accounting for 80% of all public transport passenger journeys worldwide.

Given this key role, urban buses need to be a crucial element of sustainable urban transport planning. There are about 77,000 buses in Germany alone. The lion’s share operates on diesel (estimated by UITP at about 95%). Even more than the fact that diesel is a fossil fuel, the harmful emissions of diesel engines are a problem for the local air quality in many cities world-wide.

In New York City, the emission problem of diesel buses was addressed as early as 1996 by an environmental action group.
2. Electric mobility strategies

Electrification of transport is a major strategy in many countries world-wide to reduce dependence on fossil fuels. The European Commission has set ambitious targets in that area: the White Paper on Transport 2050 (Transport 2050 Roadmap to a Single European Transport Area) sets a target of no more conventionally-fuelled cars in cities by 2050. An interim step foresees 50% of cars running on renewable sources and “essentially zero-emission” urban logistics by 2030.

Many European countries and cities have put electro-mobility in the focus of sustainable transport strategies. In conjunction with this, funding and fiscal/financial support programmes for potential consumers have been created as well as non-financial user benefits. But such a car-oriented policy approach carries negative side effects for overall sustainable transport. For example, electric cars may become the second car in many households, increasing the overall space consumption of transport.

With regard to another widely-discussed incentive, the Norwegian government recently found it necessary to withdraw a national policy on e-cars in bus lanes after finding that public transport travel was significantly slowed down6.

Strangely, the EU has no electrification targets related to public transport, although it would be logical as it is a field much easier for public authorities to influence than, for example, urban logistics.

3. “Factor 100”: a comparison of the impacts of electrification of buses and cars

An average private car is statistically in operation less than one hour daily. Cars that are generally considered for replacement by electric vehicles are small, e.g. for short urban trips due to the limited range of most electric cars. As petrol cars account for about half of all new registrations7, the share of diesel-powered cars is much lower than it is for buses. As particulates (PM10 and PM2.5) and even more, NO2 emissions, are much more significant for diesel than for petrol engines, the environmental impact of diesel engines needs to be taken into account beyond the pure consumption of fuel and related CO2 emission.

Today, an 18 m diesel bus is equipped with an engine performing with 200-300 kW8 and a fuel consumption of 50-55 litres diesel/100km. Urban buses are in daily operation up to 16 hrs. One 18 m bus in urban operation consumes about 40,000 litres of diesel annually9. Based on pure fuel consumption, an 18 m urban bus has about 80 times higher (CO2) emission than a car, but still shows a much better CO2/passenger ratio.

Looking at the overall impacts, it would take roughly 100 electric cars to achieve the same environmental relief as can be gained from one 18 m electric bus. This fact makes it difficult to understand why there is not a hundredfold financial support for e-buses and there is no target in European policy papers for the electrification of urban buses.

<table>
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<tr>
<th>Daily operation time</th>
<th>Bus</th>
<th>Car</th>
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<tr>
<td>12-16 hours</td>
<td></td>
<td>&lt; 1 hour</td>
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<tr>
<td>Engine and fuel type</td>
<td>95% diesel/5% others (CNG/trolley)</td>
<td>53% Diesel/47% petrol (new cars EU)</td>
</tr>
<tr>
<td>Size / consumption per km</td>
<td>Large engine consumption (18m) 50-55 l/100 km; (12 m) 38-43 l/100 km</td>
<td>Small engine (mainly small cars are replaced by e-cars) consumption (small/compact car) 3.5-6 l/100 km</td>
</tr>
<tr>
<td>Annual consumption</td>
<td>18 m bus: 40,000 l diesel p.a.</td>
<td>400-600 l diesel/petrol (10,000 km p.a.)</td>
</tr>
<tr>
<td>Local emissions</td>
<td>Typical diesel problems (esp. NOx)</td>
<td>For diesel: typical diesel problems (esp. NOx), For petrol: not such big problems (with catalytic converter)</td>
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6 http://www.thelocal.no/20150506/norway-strips-electric-cars-of-ke
7 53% in 2013 in Europe; European Vehicle Market Statistics Pocketbook 2014; http://eupocketbook.theicct.org
8 E.g. Evobus Citaro 18 m 220-290 kW
9 E.g. see annual report of PT operator BSAG/Bremen (2014)
The ELIPTIC project

ELIPTIC (Electrification of public transport in cities) is a European project within the Horizon 2020 programme – running from June 2015 to May 2018 (36 months).

The ELIPTIC project will show how costs and energy can be saved by electrifying public transport and optimising the use of existing infrastructure and rolling stock through developing new use concepts and business cases, especially by bringing traditionally separated domains together through developing innovative use concepts and business cases. ELIPTIC advocates for electric public transport at the political level and is helping to develop political support for the electrification of public transport across Europe.

The three thematic technology pillars of ELIPTIC are:

<table>
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<th>A</th>
<th>Safe integration of e-buses into existing electric PT infrastructure:</th>
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<td></td>
<td>• (re)charging e-buses &quot;en route&quot; (e.g. trolleybuses operated on tram infrastructure) or on the spot (battery buses/hybrids charged from trolleybus, tram or metro networks);</td>
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<td>• upgrading trolleybus networks with battery buses or trolley hybrids (diesel bus substitution);</td>
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<td>• Automatic wiring/de-wiring technology (catenary-free trolleybus operation).</td>
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| B | Energy storage / upgrading and/or regenerating electric public transport systems (flywheel, reversible substations) |

| C | Multi-purpose use of electric public transport infrastructure: safe (re)charging of non-public transport vehicles (pedelecs, electric cars/taxis, utility trucks). |

Fig. 2. The “ELIPTIC project pillars”, source: ELIPTIC project, photo: author.
ELIPTIC builds on the practical experience of 20 use cases carried out by 11 pioneering electric public transport operators and authorities with metro, light rail, tram, and trolleybus systems. They are supported by leading universities, networks and industry sector representatives.

International networks of public transport operators (UITP) and of cities (POLIS) are involved in ELIPTIC, supplemented by national networks (VDV in Germany, ASSTRA in Italy and the Low Carbon Vehicle Partnership in the UK) to broaden learning, exchange and dissemination.

The already large ‘project family’ has also added 11 “twin” organisations/cities and a 15-member ‘User Forum’. In total, 58 organisations from 21 countries are actively involved in the ELIPTIC project.

4. Technical applications in use cases

ELIPTIC has 20 cases of technical applications or feasibility studies addressing two major barriers to electrifying public transport:

1. uncertainty about the most appropriate technological path
2. lack of business case

In the field of electric urban buses, various technological paths are under development. As each path may need specific electric recharging infrastructure, the authorities and operators have to weigh the pros and cons of the various alternatives. Whereas the trolleybus represents a mature technology (with significant infrastructure needs), at the other end of the spectrum we also have battery buses, which are still at a low technology readiness level – especially when looking at buses of 18 m or more. In between, there are various combinations with different recharging technologies (conductive or inductive) and battery configurations. We also face a lack of standardisation (e.g. fast or superfast recharging with pantographs), which will be crucial to achieve a broader market application and usability by different operators and bus models.

In ELIPTIC, the technology applications range from battery-buses (including 18 m articulated) that charge overnight and have a long driving range to opportunity recharging to trolley-battery-hybrids that can operate autonomously away from the overhead wire network.

Today, apart from trolley buses, the lion’s share of electric buses is midi (< 10.5 m) to standard 12m in size. 18+ m battery-electric buses are the exception – but such buses are required by operators. In larger European cities, there is a growing share of high-capacity (18 m, 24 m and double-decker) buses. For example, 2/3 of the bus fleet of Bremen (population 550,000) is currently 18 m buses.

As public transport operators have to operate efficiently, the business case of electric buses needs to be clearly analysed. Besides the vehicle purchase cost and the fuel/energy consumption, availability and maintenance costs are also crucial. In addition, infrastructure requirements (including garages) and training staff to work with high voltage need to be analysed. Taking these needs into account, it’s not realistic to expect short-term financial viability but, apart from the pure financial aspects, there is measurable value in reducing local and global emissions and in reducing dependence on (imported) mineral oil.

ELIPTIC will further develop use cases into development schemes/business cases based on an iterative, moderated software-based planning process as a decision-making support tool for local stakeholders (e.g. authorities, energy suppliers).

5. More political and financial support required

Besides the technical and financial analyses of the ELIPTIC use cases, the project partners are working on gaining political and related financial support. Looking at the “factor 100”, the partners are calling for a stronger commitment by local, national and European authorities. Looking at air quality and noise problems on the local level, electric buses can both reduce local emission problems and support a modal shift from the car to collective transport. Some incentives for increased electric car use (e.g. free parking or access to bus lanes) send the wrong message in the overall transport context.
In terms of financial support for research and development at the national and European levels, billions of euros have been committed to electric cars, but a comparatively small amount is going into the electrification of public transport, indicating that we are following industrial policy rather than transport policy. It is necessary to strengthen the focus on transport policy when developing e-mobility strategies. One element must be the enhanced development of electric buses and testing them in real operation.

The European targets on sustainable and climate friendly transport need to include clear targets for electrification of public transport: the 2030 targets of the White Paper on Transport should integrate a goal of 80% of urban buses running on sustainable energy sources. It is also necessary to enhance the promotion the electrification of urban public transport in European and national RTD programmes. Focussing investment in electric buses and related infrastructure as part of a wider sustainable transport strategy would be significantly more efficient than focussing on individual private cars: ‘factor 100’.

References

UITP: Buses today and tomorrow, media background, Brussels (2010)

10 The overall financial support can be counted in billions. Germany alone has spent about €1 billion (KOPA2 and follow-ups). On the European level, there is RTD and infrastructural support (e.g. EFRE)