FIVE KEY STEPS FOR ELECTRIC BUS SUCCESS

A Report for Transport & Environment

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December 2020

Executive Summary

In recent years, ambitious targets have been established by the EU and Member States in order to tackle the issues of air pollution and climate change. Building on the Paris Agreement objective to keep global temperature rise to well below 2°C, the European Commission has proposed to achieve climate neutrality by 2050 as part of the European Green Deal. As cities across Europe implement measures to achieve ambitious environmental strategies, there is pressure on the transport sector to decarbonise as fast as possible. The use of clean zero-emission mass transit solutions, such as electric buses (e-buses), is key to sustainable transport, and is a solution widely adopted by numerous authorities. While this shift is not without challenges, our research has identified a number of common factors evident in successful e-bus schemes.

Eunomia Research and Consulting was commissioned by Transport & Environment to identify key success factors for e-bus deployment. These factors are intended to guide municipalities and operators in the effective implementation of e-buses in their jurisdictions.

Approach

Eunomia researched 13 case studies of e-bus implementation from across Europe, including the UK. The locations were selected in order to demonstrate a variety of contexts, thus providing guidance relevant to a pan-European audience.

Through an extensive desk-based literature review, supplemented with stakeholder engagement, and internal review, the team produced a longlist of factors, derived from problem drivers, which influenced success. These factors were compared and cross-checked between case studies in order to identify shared points and prevailing themes. By grouping and categorising similar findings, this longlist was refined into a shortlist of five criteria. The case studies were then mapped against the criteria in the format of a matrix, in order to illustrate which criteria were most prominent in each example.

Findings

Based on the research and analysis, the following five key success criteria emerged:

1) **Political leadership** often with an e-bus champion, or champion, is vital. This in turn leads to the knowledge-sharing, collaboration and alliance-building needed to put e-buses on the road;
2) **Financial support** is central to e-bus roll-out, noting that analysis of total costs of ownership (TCO) increasingly shows that e-buses can have lower lifetime costs than comparable fossil fuel vehicles.
3) **Trialling, monitoring and evaluation** in order to ensure the technology performs optimally over its lifetime and achieves desired outcomes;
4) **Proactive and innovative procurement** to set the foundations for successful and cost-effective e-bus implementation; and
5) **A considered and integrated design of e-bus services**, which is complete, practical and user-centric.

The next section examines these factors in more detail, followed by summaries of each case study and a technical appendix containing expanded versions of the 13 examples.

Contents

1.0 Key Success Criteria

1.1 Political Leadership

Electric buses require the development of extensive infrastructure and systems. Political leadership which establishes strong cooperative and collaborative relationships between stakeholders at an early stage delivers greater economic and social benefits to e-bus schemes. Strong political leadership supports effective communication and cooperation between manufacturers, operators, the transport authority, and energy network operators and providers, crucial for the successful design and deployment of e-bus services. Such relationships allow knowledge sharing and valuable experience to be passed on.

Strong leadership also helps to clearly define the roles and responsibilities of each key stakeholder. Indeed, early and ongoing stakeholder engagement was found to be vital (e.g. France and Netherlands), particularly with manufacturers to deliver and maintain the vehicles and charging infrastructure. Training and upskilling drivers and operators also stood out as a priority, such as in the Netherlands.

Political support, often with a single champion, is vital. This should be supported by a clear vision and set of strategies, such as Zero or Ultra Low Emission Zones, or making the procurement of zero- emission buses mandatory. Crucially, as demonstrated in Cluj-Napoca in Romania and examples from Italy, political alliances can unlock funding opportunities and reduce procurement costs.

1.2 Financial support, including TCO evaluation

Transitioning to e-bus fleets typically requires substantial financial investment. While innovative financial solutions have emerged, financial support from municipalities, national governments and the EU remains crucial to the successful deployment of most e-bus schemes. Such funding is often facilitated by a clear political mandate set out in national and municipal level plans and targets to tackle air pollution and carbon dioxide.

At the same time, however, financial modelling for Rotterdam showed that e-buses deliver a 10.8% saving over diesel buses.[1] An important factor here was signing a 10-year contract with the electricity supplier (Eneco). As TCO calculations play an ever-increasing role, more cities and regions are likely to realise that the higher upfront costs of procuring e-buses must be weighed against their lower operating costs.

1.3 Trialling, Monitoring and Evaluation

The majority of the cases reviewed had run pilot programmes, phasing in e-buses over a number of years. Despite the maturity of e-bus technologies there is still value in assessing the suitability of e-bus solutions according to the routes for deployment, and siting of charging infrastructure.

[1] F.G., R. (2014) *e-Busz Rotterdam*, https://clean-fleets.eu/fileadmin/files/e-Busz_Rotterdam_final_Ecomobiel-Bremen_-_Rieck_small_.pdf

Fully understanding the performance of the buses, especially their range, helps ensure the chosen technology is reliable, and aids stakeholder buy-in.

From trials to full service operation, ongoing monitoring and evaluation was also shown to be critical to continually improving and upgrading the service. Notably, in Warsaw, testing provided practical insights and data, which allowed the operator to negotiate requirements with the manufacturer. In Sweden meanwhile, smoother procurement was attributed to the evaluation and assessment conducted through the ElectriCity partnership. Overall, trials can reduce the risks associated with implementing new technology, while monitoring and evaluation enables lessons to be learned and services to be improved.

1.4 Proactive and Innovative Procurement

A well-planned procurement of sufficient length is key to transitioning to an electric fleet in line with ambitious targets to achieve zero emissions on-road and improve air quality, which are in some cases within a ten-year period. Extending both the length of the procurement stage and the length of the contracts themselves is beneficial. For instance, the Swedish transport authority, Västtraffik, reported that early dialogue, especially during procurement, is important to address any uncertainty, allowing time for operators to purchase vehicles and charging infrastructure. Longer contracts of around 10 years were noted in a number of cases as more appropriate for the rollout and continuous upgrade of e-bus technology.

Cost-effective contracts involved service agreements with the manufacturer, and longer warranties/guarantees on vehicle batteries. Joint procurement can also reduce technology costs. Moreover, considering the total cost of ownership (TCO) at the procurement stage is crucial in establishing a financial plan that informs procurement. As demonstrated in the Netherlands, provision of the whole system by the manufacturer was seen to result in optimum TCO. Ultimately, procurement defines the terms of an agreement, the scope of the scheme and sets parameters/requirements for the service. Taking certain steps at this stage can ensure strong foundations for successful deployment.

1.5 Considered and Integrated Service Design

Effective planning which considers how the service is designed and integrated underpins all of these success factors. Fully understanding the requirements of the location and the users supports a successful service, e.g. Keolis in Orléans. Other cases also signalled the importance of integrating e-buses with other transport modes, providing en-route charging and ensuring inter-operability of charging infrastructure between vehicle manufacturers.

What is more, as demonstrated in Groningen, a well-designed service which seeks to maximise user satisfaction and awareness can support objectives to increase public transport patronage, which in turn will raise profits, thus boosting the viability of the scheme. As also displayed in Milan, a plan which goes beyond the simple route-based replacement of diesel buses and which instead considers the whole mobility network of an area, can lead to optimal, more cost-effective and future proofed developments.

2.0 Case Studies

This section provides short summaries of the 13 selected case studies, outlining the key success factors for each example. The matrix below indicates the factors which were present in each case study. The majority of cases exemplify nearly all of the criteria, thus highlighting the ubiquity and relevance of these success factors.

Table 1 Case Studies Mapped Against the 5 Key Success Criteria

Country	Case study	Key criteria				
		Trialling, evaluation & monitoring	Political Leadership	Financial Support	Considered & integrated design of services	Innovative Procurement
DK	Copenhagen and Roskilde	✓	✓	✓	✓	✓
FR	Orléans	✓	✓	✓	✓	✓
DE	Hamburg	✓	✓	✓		
IT	Turin	✓	✓	✓		✓
IT	Milan	✓	✓	✓	✓	✓
NL	Amstelland Meerlanden		✓	✓	✓	✓
NL	North Brabant	✓	✓	✓	✓	✓
NL	Rotterdam		✓	✓	✓	✓
NL	Groningen	✓	✓	✓	✓	✓
PL	Warsaw	✓	✓	✓	✓	
RO	Cluj-Napoca and Turda		✓	✓	✓	
SE	Gothenburg	✓	✓	✓	✓	✓
UK	London	✓	✓	✓		

2.1 Denmark: Copenhagen and Roskilde

Key Success Factors: Copenhagen and Roskilde

- Longer contracts between transport authorities and providers reduced financial risk for the operator.
- Cooperation between owners and operators, and effective communication with the manufacturer.
- Political support from ambitious zero emission targets set by the City of Copenhagen.
- Multiple trials over a number of years to determine reliable e-bus technology.

From 2014 to 2015, trials were conducted in Copenhagen through a partnership of stakeholders, including the city authority, DONG Energy and the transport agency Movia, all of whom financed the scheme. Funding was also provided by the Danish Transport and Construction Agency, Keolis and Arriva, with the whole pilot costing over DKK8.3 million.[2] Since the trial, 38 electric buses were introduced across two city routes.

Key to the rollout of e-buses is the supportive political context. Copenhagen is a signatory of the C40 Clean Air and Fossil Fuel Free Streets Declarations, committing to procure only zero emission buses from 2025 and ensuring a major area of the city is zero emission by 2030. The city aims to be carbon neutral by 2025, and from 2020 the minimum standard for the city's Low Emission Zone (LEZ) will be Euro 5 for vans, trucks and buses, increasing to Euro 6 in 2022. E-buses are key to achieving these targets. To mitigate the negative effects of the LEZ, Copenhagen negotiated with the national government to give private bus operators access to low interest rate loans for e-bus purchases.

In Roskilde, 20 e-buses are operated by Umove East. Umove was contracted in 2018 to deliver the electric fleet as well as the charging and service centre. The scheme has had a phased implementation in order to allow personnel time to upskill. Cost-efficiency was key to the scheme and is especially pertinent, given Denmark's high electricity taxes. The municipality reduced costs by allowing Umove to continue using some diesel buses in the first two years in order to cover breakdowns. They also issued a 10-year contract, rather than the typical six years, allowing the bus company more time to write off investments.

[2] Movia (2016) Forsøg med store elbusser. Available at https://www.moviatrafik.dk/media/6124/slutrapport-forsoeg-med-store-elbusser.pdf

2.2 France: Orléans Metropolitan Region

Key Success Factors: Orléans

- An operator with an in-depth understanding of transport requirements for the region allowed for specific demands to the manufacturer and planning of infrastructure.
- Collaboration with stakeholders – transport authority and energy supplier.
- National policy – cities of over 250,000 inhabitants or with more than 20 diesel buses must operate only low-emissions buses by 2025.

In France, national policy requires that, by 2025, cities with over 250,000 inhabitants, and bus fleets of over 20, diesel buses must be replaced with low emission buses. In Orléans, between 2017 and 2019, the transport operator Keolis tested six e-buses in the region for energy consumption, vehicle reliability, maintenance and customer satisfaction. Trialling and collaborating equipped Keolis with experience of which e-bus would be the most suitable. As the incumbent operator, Keolis understood the transport requirements for Orléans. Their understanding helped to develop software (Neolis) which modelled the region's 'ideal' transport network, including trains, trams and subways. In November 2019, Keolis signed a partnership with energy supplier Enedis to share expertise on the impacts of electric fleet transitions on the grid to help ensure that there will be sufficient energy provision for the fleet.

An overall investment of €110 million from the city of Orléans will be used to replace the whole fleet comprising 112 vehicles (supplied by Irizar) and the infrastructure. [3] The first 29 e-buses will be commissioned in the first half of 2021. [4] Irizar was selected through a competitive tender process for their 15-year guarantee on the vehicle performance, at little extra cost compared to other manufacturers.

2.3 Germany: Hamburg

Key Success Factors: Hamburg

- Reliable vehicles with infrastructure and equipment designed to be upgraded by the manufacturer.
- The Hamburg Senate requires transport operators to purchase only zero-emission buses from 2020.
- EU and national government funding.
- Training of drivers with regards to bus maintenance and operation.

In 2019, Hamburger Hochbahn, the operator of most of Hamburg's bus routes, launched plans for 530 e-buses to be delivered from 2021-2025. The EU-wide tender, launched in September 2019, follows the three year HELD pilot and the subsequent introduction of 30 e-buses in the city in 2019. To date, the transport authority Hamburger Verkehrsverbund has invested around €10

[3] Orléans Métropole (2019) *Orléans Métropole Sur La Voie Du Zéro Carbone*, http://www.orleans-metropole.fr/351-7460/fiche/orleans-metropole-sur-la-voie-du-zero-carbone.htm
[4] *Ibid*

million in e-bus infrastructure, alongside Hochbahn investments of €73 million for a new storage depot at Alsterdorf in the north of the city.

Cooperation and partnerships between operators, authorities and manufacturers has been key. For instance, during the HELD trial Volvo made continuous technological updates, and there is ongoing collaboration between Hochbahn, Volvo and Siemens, who have provided the charging infrastructure.

Furthermore, there has been much political and financial support for the roll-out of e-buses in order to achieve sustainable urban travel. The Hamburg Senate requires transport operators to only purchase zero-emission buses from 2020. This is supported by: amendments to the energy and electricity tax act by the German Government to provide relief for electric buses;[5] and, a €300 million increase in Germany's State aid, to a total of €650 million, granted by the European Commission, for the purchase of electric buses and charging infrastructure. The total state funding now amounts to €650 million, with the Federal Environment Ministry subsidising up to 80% of the additional costs to purchase e-buses (against diesel purchase price) and up to 40% for e-bus infrastructure.[6]

2.4 Italy

2.4.1 Alessandria, Cuneo, Asti and Turin

Key Success Factors: Alessandira, Cuneo, Asti and Turin

- Joint procurement resulted in lower administration costs related to e-bus procurement and implementation, and better pricing for Piedmont region's operators.
- Funding from national government covered 90% of total cost of vehicles in the trial.
- Funding from national government from 2019-2033 to put towards electric, methane or hydrogen buses.

After being allocated funds cascaded down to Piedmont from the Ministry of Environment to cover 90% of the purchase of electric buses, in 2014, the region of Piedmont launched a programme to promote the introduction of e-buses. They called upon all transport operators to submit requirements for the number of buses, routes and charging infrastructure required. Together they launched a joint procurement, saving administration costs and enabling them to access better prices. The procurement was for 19 e-buses, with Torinese Trasporti (GTT), who had already operated urban electric minibuses in the region since 2003, selected to act on behalf of all operators. GTT published a market survey which enabled them to identify the types of electric bus available. This enabled the identification of six manufacturers who could meet the defined technical and financial requirements, of 10 who presented an offer. The contract was

[5] https://www.bdo.org/presse/pressemeldungen/busbranche-begrusst-absenkung-der-eeg-umlage-fur-linienbusse

[6] Randall, C. (2020) *EU Commission approves electric bus funding for Germany*, https://www.electrive.com/2020/01/31/eu-commission-approves-electric-bus-funding-for-germany/; see also https://www.erneuerbar-mobil.de/foerderprogramme/foerderprogramm-fuer-die-anschaffung-von-elektrobussen-im-oeffentlichen

awarded to BYD in 2016, and operators were required to fund the extra 10% of the vehicle purchase cost, plus infrastructure costs.[7]

In January 2020, GTT began the process for the €72 million procurement of 100 e-buses for Piedmont, complete with a 10-year service period.[8] The closing date for submissions was May 2020, with the first 50 buses arriving in the second half of 2020. As with the first procurement exercise, each operator will sign their own agreement with the manufacturer. Directly prior to the commencement of the procurement process, the Ministry of Infrastructure and Transport announced that €149 million would be provided for Piedmont to invest in e-buses for the period 2019-2033, as part of the National Strategic Plan for Sustainable Mobility. €10 million is available to put toward the 2020 procurement.[9]

2.4.2 Milan

Key Success Factors: Milan

- Collaboration with the Municipality of Milan, the manufacturer (Solaris), and the Polytechnic University of Milan to better understand service and infrastructure requirements for a successful e-bus network.
- Transport solutions implemented to ensure customer satisfaction and patronage.
- Operator (ATM) launched a 'Full Electric Plan' in 2018 to see the city's entire public transport network powered by electricity by 2030.

Situated in the Po Valley, Milan's air pollution often exceeds EU standards. At present, 70% of Milan's public transport network is powered electrically[10]; replacing the 1,200-strong bus fleet with e-buses will help the entire system become electric by 2030.[11] Azienda Trasporti Milanesi (ATM) is the municipal public transport company of Milan. ATM trialled 25 e-buses from Solaris before awarding them a €192 million framework contract for 250 e-buses, 40 of which will arrive by June 2020.[12] It was announced in January 2020 that €310 million has been made available to the Lombardy region between 2019-2033 from the Ministry of Infrastructure and Transport for

[7] SPP Regions (2016) *Electric Buses: Joint Procurement of 19 Urban Electric Buses in Piedmont*, https://sppregions.eu/fileadmin/user_upload/Tenders/APE/spp-regions-tender-model-GTT-eng_Final.pdf
[8] electrive.com (2020) *Turin transit operator tenders for 100 electric buses*, https://www.electrive.com/2020/02/04/turin-transit-operator-tenders-for-100-electric-buses/
[9] Ministero, and delle Infrastrutture e dei Trasporti (2020) *Tpl, alle Regioni 2,2 miliardi per l'acquisto di bus ecologici*, https://irp-cdn.multiscreensite.com/0d79c62c/files/uploaded/Report%20Full%20Electric_sito.pdf
[10] Associazione Interessi Metropolitani (2019) *Milano Full Electric: L'Evoluzione del Trasporto Pubblico*, https://irp-cdn.multiscreensite.com/0d79c62c/files/uploaded/Report%20Full%20Electric_sito.pdf
[11] Sustainable Bus *ATM Milano: electric buses are the present - Sustainable Bus*, https://www.sustainable-bus.com/interview/atm-milano-electric-buses-are-the-present/
[12] Electrek (2019) *Milan to receive 250 electric buses from Solaris in one of Europe's largest e-bus orders yet*, https://electrek.co/2019/07/10/milan-250-electric-buses-solaris/

the procurement of e-buses, some of which will be allocated to Milan for the purchase of future e-buses and infrastructure.[13]

ATM has worked with the Municipality of Milan and the Polytechnic University of Milan in order to ensure the effective implementation of the e-bus fleet, rather than simply replacing diesel buses. The focus of this collaboration considered the city's requirements for public transport, to which charging infrastructure and routes were matched. ATM foresees that public transport requirements will increase in Milan, and providing a service which contributes to positive environmental outcomes will, as well as a convenient and comfortable service, increase patronage, and therefore revenue.

2.5 The Netherlands

In the Netherlands funds for public transport stock and infrastructure are allocated by the Ministry of Transport. The procurement process gives a single operator sole rights to the entire public transport network in each concession, usually for a period of ten years. The Green Deal Zero Emission Bus Transport (2012) was confirmed in 2016 by national government, ensuring that: from 2025, all new buses must be zero emissions, and, from 2030, all buses in use must be zero emissions. Concessions in each of the Netherlands' case studies have been awarded to operators who seek to exceed these targets.

2.5.1 Amstelland Meerlanden

Key Success Factors: Amstelland Meerlanden

- Effective collaboration with key stakeholders, such as VDL (the e-bus manufacturer) and Schiphol Airport.
- Emphasis on good data collection to optimise the operation of the network.
- Manufacturer supplied complete system offering solutions with an optimum TCO.
- Operator (Connexxion) exceeded national targets in their tender package for the uptake of e-buses, winning them the concession.

Connexxion successfully tendered alongside manufacturer VDL for the operation of Amstelland Meerlanden's €100 million per year public transport contract running from 2017-2027, which prioritised e-buses over other bus types.[14] By 2021, 258 e-buses will be rolled out, meaning that 90% of the fleet will be electrically powered.[15] This is well ahead of national targets which helped them to secure the contract. 100 e-buses were deployed in April 2018, 49 of which were distributed on six routes in the R-net (the intra-urban area), and 51 on routes at Schiphol Airport. The airport funded its own vehicles, but worked with Connexxion and VDL to enable knowledge sharing. The airport also conducted a joint study with Amsterdam Transport Region to assess the requirements for implementing a zero-emissions bus fleet.

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[13] Ministero, and delle Infrastrutture e dei Trasporti (2020) *Tpl, alle Regioni 2,2 miliardi per l'acquisto di bus ecologici*, https://irp-cdn.multiscreensite.com/0d79c62c/files/uploaded/Report%20Full%20Electric_sito.pdf

[14] Schiphol (2018) *Europe's largest electric bus fleet operates at and around Schiphol*, https://news.schiphol.com/biggest-electric-bus-fleet-in-europe-at-and-around-schiphol/

[15] *Ibid*

Transdev, Connexxion's parent company, place technology and the collection of robust data at the centre of their operations. Drivers are provided in-depth training, ensuring that they operate e-buses at maximum efficiency and keep energy usage to a minimum. Using route data from trials ensured they could effectively plan for the number of buses and charging infrastructure.

2.5.2 North-Brabant incl. Eindhoven

Key Success Factors: North-Brabant incl. Eindhoven

- Collaboration between key stakeholders, including Brabant Development Agency, the Foundation for Zero Emission Bus Transport, and business in the community, in pilots and planning phases.
- Operator (Hermes) exceeded national targets for e-buses in tendering, strengthening their proposal over their competitors.
- Manufacturer supplied complete system offering solutions with an optimum total cost of ownership (TCO).
- Staged deployment over ten years, allowing technology to advance.

Three pilots were carried out in North-Brabant from 2015-2018 using funding from national, regional and local governments. The pilots tested both e-buses and hydrogen buses to develop a model for total cost of ownership (TCO). After Hermes was awarded the concession, the country's first electric fleet of 43 buses was rolled out on eight high-frequency lines in 2017. The buses are scheduled to drive 71,000 km/year, equivalent to operating for 20 hours per day and an average daily distance of 200km.[16] A further 130 e-buses are scheduled for deployment between 2019-2024, replacing all diesel buses.[17] The manufacturer VDL, and the provider of charging infrastructure Heliox, worked closely with Hermes during the planning phase, after pilot studies proved that extra infrastructure was required to charge the vehicles, including transformers and a 10,000 MVA network.

So far, Hermes are reporting that the buses are performing well and with less wear than diesel buses. The e-buses are also reported to be running effectively to schedule; this was an important criterion in the tender. Drivers have been upskilled to optimise operations and offer help to passengers, improving their experience of using e-buses.

[16] Pourbaix, J. *Deployment of electric buses in Europe*, https://www.busworldacademy.org/download/PRESENTATIONS/a7e9eb953413e824382bb1b266cc1d8f/b497a44c66e28d5987039ab3f5e2e018

[17] Zeeus *Eindhoven*, https://zeeus.eu/uploads/publications/documents/zeeus-city-sheet-eindhoven-en-final.pdf

2.5.3 Rotterdam

Key Success Factors: Rotterdam

- Guarantee of electricity supply by signing 10-year contract with supplier Eneco.
- Use of simulation and modelling software for testing and optimization, enabling a greater understanding of risks and challenges.
- TCO exercise demonstrated a 10.8% saving on e-buses over conventional buses.
- Knowledge sharing with other cities rolling out e-buses through schemes such as RUGGEDISED.

In 2019, Rotterdamse Elektrische Tram (RET), launched 55 e-buses to be used on shorter routes, and 100 hybrid buses for longer routes. By the end of their concession in 2027, they plan to have replaced 270 buses with zero-emission technology.[18] The 55 e-buses were procured through a tender which was awarded to VDL, who also provided charging infrastructure. RET have spread their investment across the concession period to allow for changing technology.

TCO calculations have shown e-buses be 10.8% cheaper than conventional city buses.[19] RET have sought to ensure the optimisation of e-buses through a partnership with Erasmus University Rotterdam, who developed a discrete-event simulation model integrated with an optimisation model that is responsible for the charging schedule, as well as optimising CO_2 benefits by coordinating with renewable energy production. Furthermore, Rotterdam is taking part in RUGGEDISED, an EU smart city project, with Eneco and RET, part of which looks into optimising the e-bus fleet using e-mobility software.

2.5.4 Groningen

Key Success Factors: Groningen

- Competitive tender to stimulate the market and obtain best prices for e-buses.
- Engaging different manufacturers for different types of buses which are best-suited to different types of route.
- Collaboration with infrastructure providers to ensure interoperability, and use of ViriCiti software to monitor entire fleet.
- Ambitious e-bus commitment in tender helped win concession, exceeding national targets.

Qbuzz, the incumbent operator in Groningen, was awarded their second consecutive concession for the period 2019-2029, and will keep well ahead of the 2025 and 2030 national targets for the

[18] RUGGEDISED *Optimising the Electric Bus Fleet: Rotterdam Factsheet*, https://ruggedised.eu/fileadmin/repository/Factsheets/Ruggedised-factsheet-R7-Rotterdam.pdf
[19] F.G., R. (2014) *e-Busz Rotterdam*, https://clean-fleets.eu/fileadmin/files/e-Busz_Rotterdam_final_Ecomobiel-Bremen_-_Rieck_small_.pdf

roll-out of e-buses.[20] Qbuzz engaged charging infrastructure provider Heliox in an e-bus trial with 10 vehicles on two routes, and developed a system of slow- and fast- chargers which would allow e-buses to drive around 350-400km per day. 164 e-buses were rolled-out in 2019 with 20 additional hydrogen buses for longer routes, at a total cost of €100 million.[21] Qbuzz's procurement strategy was to stimulate the market and boost competition, and purchased buses from three different manufacturers. Qbuzz use ViriCiti software to monitor the fleet and charging stations to ensure that the schedule is maintained. They also prioritise customer satisfaction, providing a Mobility-as-a-Service promise through the TURNN app which sends travellers real-time notifications on their mode of transport. Cooperation with all stakeholders ensured that charging infrastructure was optimised for interoperability.

At the same time, this region of the Netherlands has been selected to receive a 'Hydrogen Valley' subsidy through the Fuel Cells and Hydrogen Joint Undertaking, which has contributed to the procurement of hydrogen buses.

2.6 Poland: Warsaw

Key Success Factors: Warsaw

- €42 million of EU funding specifically allocated to zero-emissions buses.
- Early dialogues with manufacturers and energy providers ensured vehicle requirements and sufficient electricity could be delivered.
- Consideration of the existing network and infrastructure, and how this could support an electric bus fleet, by testing charging of e-buses using tram power supplies.

Poland has been the recipient of large amount of funding from the EU Cohesion Fund for the development of infrastructure in the country. Notably, €42 million of the €94 million contract with e-bus manufacturer Solaris, was provided by this fund. Miejskie Zakłady Autobusowe (MZA), Warsaw's transport operator, will roll out 130 Solaris e-buses by the end of 2020 along the Royal Route bus lines in the city centre.[22] The ZeEUS project, which is co-funded by the European Commission, helped to finance the purchase of 21 Solaris e-buses, and construction of the charging infrastructure in Warsaw. Solaris and MZA have a long working history. Solaris' experience of e-bus manufacturing since 2011 provided extensive data, enabling them to advise MZA on the most suitable vehicle.[23] The city was involved in the ELIPTIC Project, which seeks to

[20] Top Dutch *The Race to Zero Emission Public Transport*, https://www.topdutch.com/uploads/fckconnector/e75339a7-1641-5319-983c-84ee8939620b/3164711659/topdutch-the-race-to-zero-emission-public-transport-print.pdf

[21] Mario (2019) *Qbuzz to Launch 164 Electric Buses in Groningen Drenthe Concession, Charged by Heliox*, https://www.sustainable-bus.com/news/qbuzz-to-launch-164-electric-buses-in-groningen-drenthe-concession-charged-by-heliox/

[22] Sustainable Bus (2020) *First of 130 Solaris e-buses for Warsaw is in operation*, https://www.sustainable-bus.com/electric-bus/first-of-130-solaris-e-buses-for-warsaw-is-in-operation/

[23] Green Car Congress (2020) *First of 130 Solaris electric buses deployed in Warsaw*, https://www.greencarcongress.com/2020/03/20200328-solaris.html

optimise existing charging infrastructure across Europe. The trial phase included testing whether the city's electric tram infrastructure could be used to charge e-buses, therefore reducing the requirement for construction of further charging infrastructure. This provided operational data, and demonstrated the requirement for pantograph infrastructure. Working with Warsaw University of Technology provided insights into the impacts on the grid network, and software from Solaris is enabling the optimisation of the fleet.[24]

Warsaw has not committed to an all-electric bus fleet at this stage partly because energy storage is considered a challenge according to the Warsaw Public Transport Authority. By 2022, around 400 vehicles will be electric, hybrid or gas-powered.

Two important developments came in the second half of 2020, with the Polish government setting the objective that all public transport will be fully electric by 2030 in cities with populations of 100,000 or more, and its government allocating €290m to support zero emission bus procurement.[25]

2.7 Romania: Cluj-Napoca

Key Success Factors: Cluj-Napoca

- Political alliance of municipalities in order to secure European funding.
- Knowledge and information sharing through political alliances, particularly regarding Sustainable Urban Development Plans.

Cluj-Napoca began the process of electrifying the city's bus fleet in 2016. In 2018 the city had 10 e-buses, and in September 2019, implementation began for another 20. The scheme was part of the city's efforts to modernise the public transport fleet, aiming to have 100% environmentally friendly public transport by 2026.

Crucially, Cluj was part of an alliance with three other cities in western Romania: Timisoara, Arad and Oradea. The purpose of the institutional initiative was to access EU funds for economic development, one of the aims being to increase environmental mobility by electric buses. The alliance enabled autonomy as well as information sharing for the development of urban mobility plans. In addition, Cluj acquired 11 electric buses though the Swiss-Romanian Cooperation Programme and 30 through EU funds (Regional Operational Program 2014 - 2020), with a total cost of around €15.9 million. [26,27] Up to 50 articulated trolleybuses have also been contracted.

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[24] *Zagrajek, K. et al, (2020) Impact of electric bus charging on distribution substation and local grid in Warsaw,* https://www.mdpi.com/1996-1073/13/5/1210/pdf

[25] See the 2040 energy strategy from Poland's Climate Ministry: https://www.gov.pl/web/klimat/minister-kurtyka-polityka-energetyczna-polski-do-2040-r-udziela-odpowiedzi-na-najwazniejsze-wyzwania-stojace-przed-polska-energetyka-w-najblizszych-dziesiecioleciach; see also https://www.dw.com/en/polish-built-electric-buses-take-over-the-european-market/a-55778652

[26] UITP (2014) *Cluj-Napoca: First Romanian city with electric buses*, https://ceec.uitp.org/cluj-napoca-first-romanian-city-electric-buses

[27] Sustainable Bus (2018) *Other 18 Solaris Urbino Electric to Cluj Napoca (Romania). They'll be 41*, https://www.sustainable-bus.com/electric-bus/electric-bus-solaris-urbino-12-order-cluj-napoca-romania/

The technology choice was a balance between battery weight/power, vehicle capacity and the length of route needed. The buses have a 105km range based on new batteries capacities and a 5-year warranty.

2.8 Sweden: Gothenburg

Key Success Factors: Gothenburg

- Efficient and integrated charging, accessible to multiple e-bus manufacturers.
- Testing and evaluation of e-bus schemes was crucial to improving future procurement processes.
- Cooperation, collaboration and early dialogue during the procurement process, especially with regards to charging infrastructure. Developing knowledge of e-bus deployment across all relevant stakeholders.
- Entrepreneurial approach to risk-taking.

Since 2015, three Volvo e-buses have operated on route 55 in Gothenburg under the ElectriCity pilot programme which brings together stakeholders from industry, academia and wider society with the aim to develop and demonstrate electric transport. More recently, in 2018, two all-electric buses have operated on part of route 16, one of the most heavily trafficked routes in the city, with 30 new e-buses ordered. In 2019, Transdev won a 10-year contract worth around €757 million from Västtraffik for 160 e-buses starting in December 2020. [28] Some of the newly planned e-buses are being delivered within the framework of existing agreements, whilst others have been procured through new agreements. Volvo is responsible for the delivery of the stations and provides all maintenance for both the vehicles and their batteries at a fixed monthly cost.

Strong political support for electric buses has been key. In 2017, Sweden introduced a climate policy framework, aiming to reach net-zero by 2045. Västtraffik meanwhile, aims to electrify all city traffic in Västra Götaland by 2030, with all city buses in Gothenburg electric by 2023. [29] Not only are e-buses central to meeting these targets, but they also meet aims to reduce noise pollution. In addition, the unique partnerships between key stakeholders, as well as the processes of testing and evaluation facilitated by the ElectriCity cooperation has been vital. The results from ElectriCity have made it easier for new procurement, with experience indicating that early dialogue between stakeholders, particularly regarding charging, is important and helps to address the uncertainty of introducing new technology. The authority aims to start procurement earlier in order to allow bus operators the time to procure new vehicles as well as charging infrastructure.

[28] Sustainable Bus (2019) *Gothenburg to have further 130 Volvo electric buses in operation*, https://www.sustainable-bus.com/news/gothenburg-to-have-further-130-volvo-electric-buses-in-operation/

[29] Mehmet, S. (2020) *157 electric buses to be rolled out in Gothenburg*, https://www.intelligenttransport.com/transport-news/94918/157-electric-buses-to-be-rolled-out-in-gothenburg/

2.9 UK

Key Success Factors: London

- Effective collaboration between the transport authority, manufacturers, energy companies and the distribution system operators helped to reduce costs and risks.
- Grid upgrades for charging and reliable vehicles, combined with upskilled drivers and operators.
- A strong business case.
- Coordination between boroughs and knowledge sharing.

2.9.1 London

Since the first trials in 2013, London's electric bus network has grown steadily to over 200 vehicles. This has been driven primarily by the Mayor of London's Transport Strategy which sets an objective for zero emission buses, pledging that by 2037 at the latest, Transport for London (TfL) will have a 100% zero emission fleet. Low and Ultra Low Emission Zones operate across the city. From 2020, all new single-decker buses procured in new contracts will be zero emission.

Operators are also playing a key role in bus electrification. Notably, Abellio and Zenobe Energy have formed a new financing scheme in which Abellio owns the buses while Zenobe owns the batteries and charging infrastructure and has also funded the remainder of the buses for Abellio. This has reduced infrastructure issues for the operator and the collaboration aims to operate 34 vehicles in 2020. [30] The e-buses predominantly use charging terminals at depots, of which the newer models are fast-charging. A number of bus depot upgrades have been carried out. For instance, at Waterloo two new electricity substations were installed by Go Ahead London and SSE, costing over £1 million in TfL funds and taking a year to complete. Moreover, in a review of the Arriva Croydon depot, it was noted that a significant amount of support was needed with batteries, the charging technology and optimising the vehicles after purchase. Partnerships were considered important for cost-effective solutions.

2.9.2 Wider Lessons Learned

The Low Carbon Vehicle Partnership (LowCVP)[31] has reported the findings and lessons learned from a number of UK e-bus trails. These include:

- Communication and collaboration between organisations in order to align priorities. Specifically:
- Having a well-developed vehicle supply chain and after-market support from the manufacturers, particularly for replacement or fixing of bus parts;

[30] Zenobe Energy (2019) *Abellio and Zenobe Energy to bring 34 electric buses to London*, https://zenobe.co.uk/abellio-and-zenobe-energy-to-bring-34-electric-buses-to-london/

[31] LowCVP is a public-private partnership and has been engaged in ultra-low emissions bus schemes deployed across the UK as part of the UK Department for Transport's ambitions to achieve a low emission vehicle fleet.

- Strong engagement with the District Network Operator (DNO), the company which owns and operates the electricity network infrastructure. Good communication with the DNO is essential in negotiating the cost of charging infrastructure and making complex upgrades and connections to the energy grid.
- Securing a holistic transport solution with the manufacturer. This requires early discussions with operators regarding the bus routes and charging strategy, the TCO and longer-term plans for battery upgrades and residual value of e-buses; and
- One project owner for the scheme, as well as a project champion. This ensures roles and responsibilities are clearly defined, and that there is strong support and leadership for the project.

3.0 Conclusion

In summary, the 13 selected case studies highlight five key factors for the successful deployment of electric buses. **Political leadership** which fosters **cooperation and collaboration** between multiple stakeholders enable communication, learning and knowledge sharing. **Financial support** and maintaining commitment from all relevant stakeholders are crucial for delivering a **considered and integrated design of electric bus services**, which is complete, practical and most importantly user-centric to encourage increases in bus patronage.

This can be supported by **running trials, monitoring and evaluation** to not only ensure that the technology performs optimally over its lifetime and achieves the desired outcomes, but to also inform the **procurement** process, thereby setting the foundations for successful and cost-effective deployment.

It is intended that these five key factors for successful e-bus deployment provide guidance for municipalities and operators seeking to roll out electric buses. As the technology improves, and the pressure to tackle air pollution and climate change heightens, the successful roll-out of e-buses across Europe will be a crucial component of transitioning to a more sustainable future.