# How to make a smooth transition to electric mobility

MOBILITY INSIGHTS BY VOLVO BUSES

APRIL 2021

Many cities around the world have already taken important steps towards more sustainable public transport. But to reach the climate goals set for 2030 and 2050 to meet the Paris Agreement, a much higher pace is needed. So, how do you prepare for a smooth transition to an electric bus system? What are the biggest challenges and success factors? Volvo Buses' Head of Public Affairs – Lars Johansson – answers the most important questions.

**LARS JOHANSSON**

Lars Johansson is responsible for Public Affairs & Government Relations at Volvo Buses. For many years, he has been active in several international committees within industry NGOs such as ACEA, UITP and IRU – organisations that cover all kinds of bus-related issues for both the European and global markets.

In addition, Lars Johansson has been a representative in prominent sustainability committees within the European Commission, focusing on electromobility and environmental issues. He regularly attends meetings with relevant EU representatives for various matters regarding future development of the bus industry.

# 5 questions and answers about going electric

# 1 When is the right time for a city to make the transition to an electric bus system?

The answer to that question is really yesterday. To meet the Paris Agreement's climate goals of completely fossil-free transport by 2050 to slow down global warming, it is urgent.

For instance, in Europe there are clear goals that all countries have committed themselves to. As recently as mid-December 2020, EU countries agreed on a new climate goal: a 55 per cent reduction in carbon dioxide emissions by 2030 compared to 1990 levels. The increase from 40 to 55 per cent is a clear indication that more measures are needed, and quickly.

The approach to implementing electrified public transport differs a lot in various parts of the world. For example, China has today about 90 per cent of all electric buses in the world, mainly due to large subsidies for manufacturers and operators in recent years. This development has primarily been driven by the need to improve the air quality in large cities.

In the US and Canada, there is usually a very high portion of federal funding for the purchase of new buses. This model supports the transition towards electrification, which is taking off. On the contrary, in Europe, a traditional tender process applies with few ad hoc state subven-

tions for the purchase of electrified buses. Despite this, many cities have taken important steps towards electrification, and the EU's Clean Vehicle Directive will accelerate the transition.

Recently, the same electromobility trend can be observed in Latin America, mainly in progressive cities like Santiago in Chile and Bogotá in Colombia.

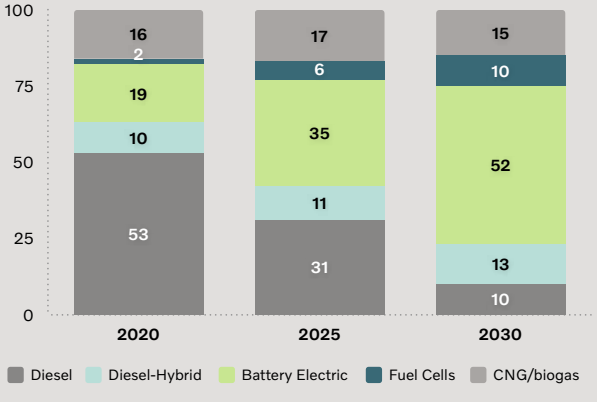
An important aspect for us in the transport industry is that there is a long lag because the buses purchased today will normally run for around ten years. This means that if you do not quickly phase out buses that run on fossil fuels, it will take a long time before $CO_2$ emissions can be reduced. You must also take into account the differences between city, regional and long-distance buses – it is primarily city operations where electrification must start and happen very quickly.

One initiative that will drive the development of electrified public transport in Europe – and probably later in other regions - is the EU Commission's Clean Vehicle Directive. It will take effect in 2021 and will affect all procurements that include city buses. For all EU countries, this means that a certain proportion of buses procured must meet the definition of a 'clean vehicle' according to a set quota per member country. For example, in Sweden 45 per cent of all buses purchased before 2025 must be in the categories "zero emission" or "low emission", of which at least half must be "zero emission" buses, i.e. electric buses.

The proportion differs among the member countries, but for most the quota will be the same as it is in Sweden, i.e. 45 per cent from 2021. The levels will then be raised to 65 per cent from 2026 until 2030. Beyond that, no decision has been made.

**ELECTRIFICATION OF THE BUS MARKET**

The Clean Vehicle Directive will accelerate the electrification of city buses in Europe. The industry predicts that electromobility products will gradually take over and that diesel buses will fade out towards 2030. (Source: UITP)




In addition to the Paris Agreement's ambition to minimise greenhouse gas emissions, every country has its own target for carbon dioxide emissions, as well as nitrogen oxides and particles. The transition to electrified vehicles will play a very important role here too.

According to the World Health Organization (WHO), air pollution has become the world's single largest environmental health risk and it is the fourth highest cause of death among all health risks.

Today, 90 per cent of the world's population live in areas that do not meet the WHO's minimum standards for air quality.

For example, in Europe, more than half of nitrogen oxide emissions and a significant proportion of other pollutants come from transport. Some cities have such major problems with air quality that they have banned older diesel vehicles from entering central zones. More and more cities are planning to implement similar restrictions.

Minimising traffic noise is another challenge that is high on the agenda for many cities, and where we can see requirements becoming increasingly stricter.

The WHO estimates that every fifth inhabitant of Europe is regularly exposed to noise levels that are so high that they can adversely affect their health. Excessive noise can result in, among other things, an increased risk of disturbed sleep, cardiovascular disease and damaged hearing.

Both the negative health effects of noise and the construction of noise barriers can be costly. For cities, there is therefore much to be gained from reducing noise where it occurs. In city traffic, heavy vehicles with diesel or gas engines are among the dominant sources of noise.

In addition to the fact that electrified public transport is necessary for achieving climate goals and reducing hazardous emissions and harmful noise, there are several other arguments in favour of electrified buses.

With growing populations and urbanisation, demands for functional and sustainable public transport increases. Traffic jams are already a very big challenge for cities around the world. For cities to be attractive in the future, they must be able to offer their residents efficient, sustainable, quiet and convenient transport options.

Electrified public transport also creates new and exciting opportunities for mobility and urban development. Without exhaust fumes and high noise levels, buses can operate in more areas and you can build in areas of cities that were previously unavailable. Public transport can take people closer to where they need to be, and you can even build bus stops indoors. All of this allows cities to become denser, but also more attractive for their inhabitants.

# 2 How long does it take to implement electric bus systems on a large scale?

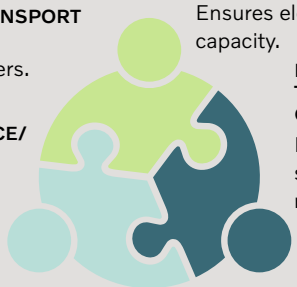
The conditions for implementing electrified bus systems on a larger scale vary hugely between cities. How long it takes depends on, among other things, local conditions for electrification and what the procurement procedure looks like. In most cases, you have to count on at least 18 months from the start of the process to when the buses can be put into service.

One of the biggest differences between the procurement of electric buses and conventional buses, is that there are many more stakeholders involved. In addition to the public transport authority (PTA), the bus operator and the manufacturers of the buses and charging infrastructure, the city municipality, the electricity providers and other relevant stakeholders, must also be involved at an early stage.

Careful planning and close cooperation between the various stakeholders are prerequisites for being able to take the step to large-scale implementation.

**COLLABORATION IS KEY**

The main stakeholders involved in the transition to electric public transport:



**ENERGY PROVIDER**
Ensures electricity capacity.

**PUBLIC TRANSPORT AUTHORITY**
Issues tenders.

**PUBLIC TRANSPORT OPERATOR**
Purchases system solution, manages bus operations.

**MAYOR OFFICE/ POLITICIANS**
Set the high-level targets.

**CITY MUNICIPALITY**
Responsible for issues related to urban planning, building permits etcetera.

**BUS SYSTEM PROVIDER**
Provides electromobility system solutions (buses and charging infrastructure).

> **"Careful planning and close cooperation between the various stakeholders are prerequisites for being able to take the step to large-scale implementation."**

Several cities have conducted test projects with electric buses on a smaller scale and the lessons from those projects have been important when implementing larger electrified bus fleets. What we can see is that there is a lot of interest from cities in Europe to learn from each other and share knowledge.

At Volvo Buses we were very early in investing in electromobility. Thanks to our long and broad experience in delivering complete solutions to different cities, we are also ready to be a partner and sounding board for cities that are looking into the electrification of their city bus traffic in a sustainable way.

When it comes to successful collaborative projects, ElectriCity in Gothenburg, Sweden, is a very good example. The city's first electric buses were put into service as early as 2015 and the project has attracted tens of thousands of visitors from all over the world. The municipality, the PTA Västtrafik, the local energy supplier Göteborg Energi, the bus operator Keolis, Chalmers University of Technology, Volvo Buses and other stakeholders have been involved in running the project.

With the experiences and lessons learned from ElectriCity, Gothenburg has now taken the step towards large-scale implementation. In December 2020, one of northern Europe's largest electric bus fleets – 145 Volvo 7900 Electric Articulated – were put into service. The goal for the region is to electrify all its city bus traffic by 2030.

Finally, to implement an electric bus fleet like Gothenburg needs careful planning and successful collaboration between stakeholders from the beginning. Depending on local conditions and scale of operation, time to implementation will differ a lot between cities.

Another crucial issue is the availability of electricity. Regardless of which charging infrastructure a city chooses, electric buses place great demands on electricity capacity. It is therefore important to have an early dialogue with energy providers and the city about building permits and permits to rebuild and lay new cables to depots and charging stations.

### THE ENERGY REQUIRED BY ELECTRIC BUSES

Securing enough energy capacity is crucial when implementing electric buses. During 12 years, the total energy usage for 100 electric buses (12 metre) is **97,200 MWh**. That is equal to 400 private houses during the same period. But compared to conventional buses, the energy saving is huge.

# 3 How do you ensure an optimal charging infrastructure?

Implementing a complete system is a complex task. Different route lengths, topography, frequency, capacity and local rules and regulations mean that different e-mobility solutions are required for each city.

Ensuring an optimal charging infrastructure requires careful analysis and simulations of each individual route on which the electric buses will run. It is an extensive preparatory project that Volvo Buses as a system supplier does in close collaboration with the PTA, the operator, the energy suppliers and other stakeholders. These calculations then form the basis for our suggestions for buses, energy storage systems (batteries and supporting devices), charging strategy and charging infrastructure.

In many cases, a combination of depot charging and fast charging on route can be the best solution from an operational point of view. On routes with a lot of traffic, charging stations on route give buses unlimited range and more driving hours. Another aspect to consider is the local grid capacity, as with charging on-route the grid capacity need is distributed geographically.

Charging infrastructure is crucial for determining how many batteries and what capacity each bus needs. The batteries in an electric bus are still very expensive and resource-intensive to produce. It is therefore extremely important to make sure that the batteries are utilised in an optimal way to ensure the longest life-time possible.

When a battery is taken out of service from the bus, it still has capacity left. Instead of sending the battery for recycling, the battery can serve in second life applications, e.g. housing energy storage, UPS (uninterrupted power supply) and peak shaving. From a Life Cycle Analysis (LCA) perspective, the second life usage of batteries

means that the “in-use” phase of the product lifecycle is significantly extended and thereby reduces the overall environmental footprint.

A key question in the long-term transition to electrified public transport is having industry standards with open interfaces for charging infrastructure. All buses, regardless of brand, must be able to use the same charging stations. International organisations have been working on this topic for many years, and in Europe the bus industry has agreed on which standards should apply.

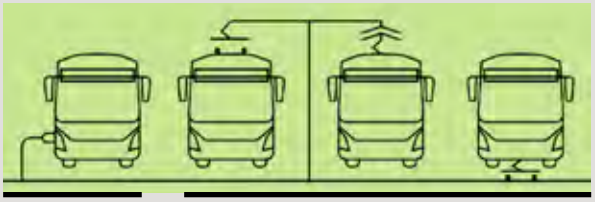
An important bridge has been the EU’s ASSURED project, which aims to encourage electrification of vehicles in urban traffic through interoperability between different manufacturers of vehicles and charging stations.

The International Association of Public Transport (UITP) was commissioned by CenCenelec (European Committee of Electrotechnical Standardization) to submit a proposal to the EU Commission. This was done in 2019.

Four standards have been proposed: depot charging via CCS cable, opportunity charging via roof mounted pantograph (panto up), opportunity charging via station-mounted pantograph (panto down) and charging via an electric contact on the road, which is likely to be used only in rare cases.

**FOUR WAYS OF CHARGING**

Industry standards with open interfaces for charging infrastructure will be crucial. These are the four standards suggested by UITP:



**MANUAL CONNECTION**

Depot charging via CCS cable.

**AUTOMATED CONNECTION**

Opportunity charging via station-mounted pantograph (panto down, left) and roof mounted pantograph (panto up, right).

Charging via an electric contact on the road.

Finalisation of the various standards will be decided late 2021. The EU Commission will publish the final charging standards at the end of the year. It will of course be hugely advantageous if markets outside Europe choose to follow these standards.

# 4 What's the true environmental impact of going electric?

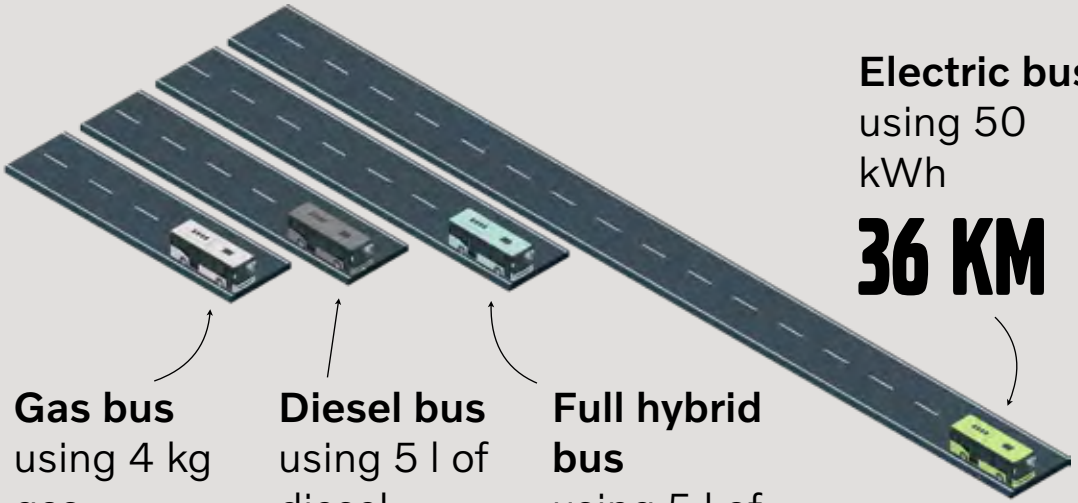
Electrified public transport is hugely beneficial to the environment, primarily in terms of the reduction of greenhouse gas emissions, nitrogen oxides, particles and noise.

A concrete example is Gothenburg, which at the end of 2020 implemented the Nordic region's largest electric bus fleet to date. By replacing the cleanest diesel buses on the market with 145 new Volvo 7900 Electric Articulated, the city will reduce its $CO_2$ emissions by 14,500 tonnes per year. This is about the same as the $CO_2$ from around 5,000 cars. Simultaneously, emissions of nitrogen oxides will decrease by approximately 8,000 kg per year. Emissions of soot and other hazardous particles will be reduced by 200 kg.

An electric bus also consumes 80 per cent less energy than a diesel bus. The energy savings for the fleet of 145 Volvo 7900 Electric Articulated, which drive a total of 60,000 km per year at an average speed of 18 km/h, is 32,200 MWh per year. This corresponds to the yearly energy need for 1,600 private households.

**"Electrified public transport is hugely beneficial, primarily in terms of the reduction of greenhouse gas emissions, nitrogen oxides, particles and noise."**

## How far can you go on the same amount of energy?



**Gas bus** using 4 kg gas
**10 KM**

**Diesel bus** using 5 l of diesel
**12 KM**

**Full hybrid bus** using 5 l of diesel
**16 KM**

**Electric bus** using 50 kWh
**36 KM**

The calculation is based on tank-to-wheel energy consumption. Energy value of different types of fuel has been converted to kWh, where 4kg CNG = 5l diesel = 50 kWh electricity. Conventional diesel is used as a benchmark (100%) to compare results.


One question that often comes up in the debates around electric vehicles is how clean the electricity is from a $CO_2$ point of view. Depending on whether the electricity is produced from renewable or fossil sources, the carbon footprint – from well to tank – can vary from as little as 10g to over 1,000g of $CO_2$ per kWh.

In addition to the environmental benefits of electric buses, it is very important that all countries are involved in driving the development towards electrified transport. If we do not start the transition now, we will not achieve the climate goals that are necessary for reducing global warming.

Even though many countries globally still produce a relatively high proportion of their electricity from fossil sources, a positive trend is observed. A very large proportion of new European energy plants will produce renewable energy. This is also the case for certain countries outside Europe.

Electric buses also have a positive effect on a city's noise levels. In one year, the 145 buses in Gothenburg will take off 17,640,000 times. Each bus's noise level is reduced by 7dB, halving its perceived noise emissions compared with a conventional bus. In homes nearby, the noise level is reduced even more, with 15dB.

A study on noise was carried out within the framework of the ElectriCity project in Gothenburg, which compared differences in the sound from electric buses, diesel buses and gas buses. The study showed large differences in noise levels at speeds of up to 40–50 km/h, with the electric buses being clearly quieter than the others. The differences were greatest when it came to low-frequency noise, which is more difficult to mitigate with noise protection, facade materials and windows.

According to recent studies, the indirect costs of noise pollution are substantial.

**LESS NOISE EMISSIONS**

**-7dB** With an electric bus, the noise level at take-off is reduced by 7dB. This means the perceived noise is cut by half compared with a conventional bus.

# 5 What are the most important success factors for implementation of electric buses?

### Political will

This is where it all begins. Making the transition to an electric bus system requires political will, vision and a political decision. It also requires a long-term system approach and knowledge of what electrification actually means, its effects, and the opportunities it creates.

### Collaborative approach

Implementing an electrified bus system is completely different to buying diesel buses. Being successful requires close collaboration between various stakeholders and all partners must be involved in the process as early as possible. Otherwise, the risk is that the whole project fails because of a missing building permit or other authorization.

At Volvo Buses, we have extensive experience in delivering complete solutions to cities around Europe. Good collaboration and a common vision, both in terms of environmental goals and creating an attractive city for residents, is something that everyone involved in large-scale implementations highlights as the most important success factors.

### Thorough analysis

As a system supplier, we undertake meticulous analysis before every offer. Route distances, topography, climate, passenger numbers, traffic density, bus types, battery capacity – all of these factors affect which charging infrastructure is most optimal. Where and when will the buses be charged? Is it better to have three smaller de-

**“Electrification requires new thinking, a lot of commitment, and a common vision.”**

Hanna Björk, Sustainability Manager at Västtrafik in Gothenburg, Sweden. Last year Västtrafik added 145 new Volvo 7900 Electric Articulated to its fleet.

pots rather than one large one? By undertaking analysis early on, we can ensure the city gets the best solution that suits them.

### Ensure energy supply

To charge electric buses, large amounts of electricity are required and the power supply to depots and charging stations must be secured at an early stage. A close dialogue with the city’s electricity suppliers is therefore absolutely crucial.

### Plan for implementation

Apart from a collaborative approach, a common plan for how the actual implementation is to take place is also required. This includes planning for the construction and rebuilding of depots, charging stations and stops, as well as applying for building permits and other authorizations. Again, it is important to ensure that all parties are involved early on in the process and that everyone is striving towards the same goal.

For cities that already have some experience with electric buses, this is a simpler process. For those starting from scratch, more holistic planning will enable their electromobility journey to be successful.

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