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Implementation Guides November 2020

How to shift your bus fleet to zero emission by procuring only electric buses

Finance and Economics | Transport

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Cities can lead the shift to electric vehicles (EV) by focusing on the vehicles they have most influence over, particularly buses. Electric buses are an attractive option for cities: they deliver improved air quality, noise reduction and their total cost of ownership can be cheaper than polluting alternatives. Cities such as Shenzhen, Santiago, Moscow and Seattle are already making, or have completed, this shift.

Transitioning to a full electric bus fleet requires a rethink of the bus system. Cities need to thoroughly plan the shift and pilot new buses to ensure a successful transition. This article explains how.[1]

Set a goal to *only* procure electric buses from 2025, or earlier

Procuring only zero emission buses from 2025 is ambitious but achievable, allowing time to plan and pilot the deployment of electric buses (e-buses). Cities including Los Angeles, Seattle, Copenhagen, Amsterdam, Guangzhou and Nanjing have already set targets to fully transition their fleets to electric by 2030 or sooner, and have started the procurement and operation of e-buses. The Chinese cities of Shenzhen, Guangzhou and Dalian have already completed the transition to fully electric, with fleets of over 16,000, 11,000 and 4,600 buses respectively.

Explore the map below to see which cities are already building zero-emission bus fleets and/or have adopted zero-emission bus targets.[2]

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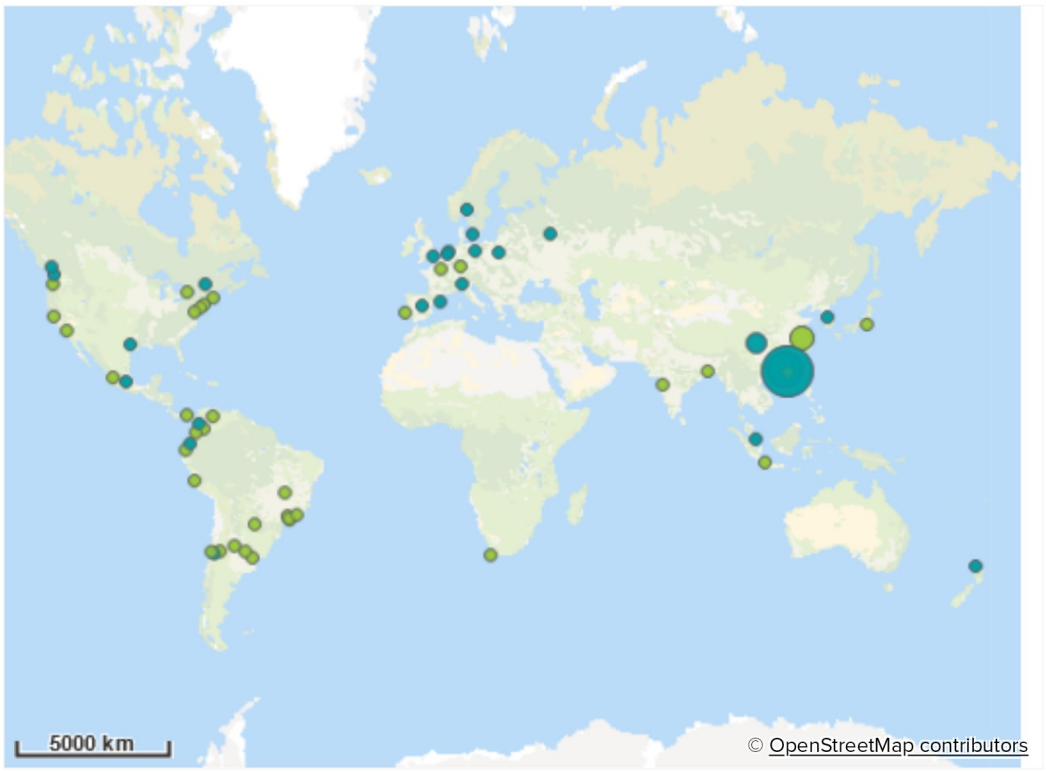
Use the filters above to narrow down the cities displayed in the map.

Zero-emissions bus fleets and targets



Hover over each city to see the size of their zero-emissions bus fleet size and the targets that cities have set to accelerate the transition. In teal, cities with zero-emissions buses targets.
GHS: "Green & Healthy Streets Declaration". Data source: see references section.

Setting a target year will drive the city's action and also signal demand to bus suppliers, operators and capital providers. This will spur on their investment in developing zero emission bus models and technology.

Cities that are planning to renew their fleets, or that are developing their first bus system, are particularly well positioned.

Develop a project framework to plan the transition

Shifting to a purely zero-emission bus system is about much more than purchasing new buses. Electrification typically requires a rethink of the whole bus operation. This includes procurement, charging, maintenance and driver training.

Cities should treat this transition as a major and multi-year project. It should incorporate: in-depth feasibility studies of technology and financing options; a pilot; staggered introduction of buses and infrastructure upgrades; and continued performance analysis to ensure a smooth and affordable transition. All this is outlined below.

Cities will need to engage new stakeholders – particularly utility companies – and negotiate new models

of working with bus suppliers.

Conduct analysis to understand technical and operational requirements

Ahead of procurement, conduct a detailed analysis of your service. Identify technology and vehicle specifications that match your requirements. This knowledge is critical for successful procurement; it enables you to narrow down the list of potential manufacturers and evaluate the suitability of tenders.

Consider in your analysis:

- **Vehicle range.** The maximum range for depot-charged buses is currently limited to around 350 miles. For operations with greater mileage, on-route (opportunity) charging is an option (see box on charging options below). Effective range can vary greatly depending on local conditions; this has to be evaluated in the pilot.

- **Route prioritisation.** Evaluate different routes to identify those best suited for electrification during the pilot stage and later. This analysis must consider: local grid capacity (see grid impact analysis below); the route length and implications for the total cost of ownership; areas of high pollution; and local priorities, such as access for low-income communities.

- **Total cost of ownership.** Find solutions that will deliver competitiveness locally (see box below). For example, a fleet-wide analysis in Sao Paulo which assessed slow-charging battery electric, diesel and CNG buses found that electric buses to be the cheapest option, with lifetime costs 9% lower than the existing diesel fleet.[3] Mexico City found that using opportunity-charging electric buses could reduce costs by 12% compared with Euro VI diesel, and even greater savings by utilising existing trolleybus infrastructure.

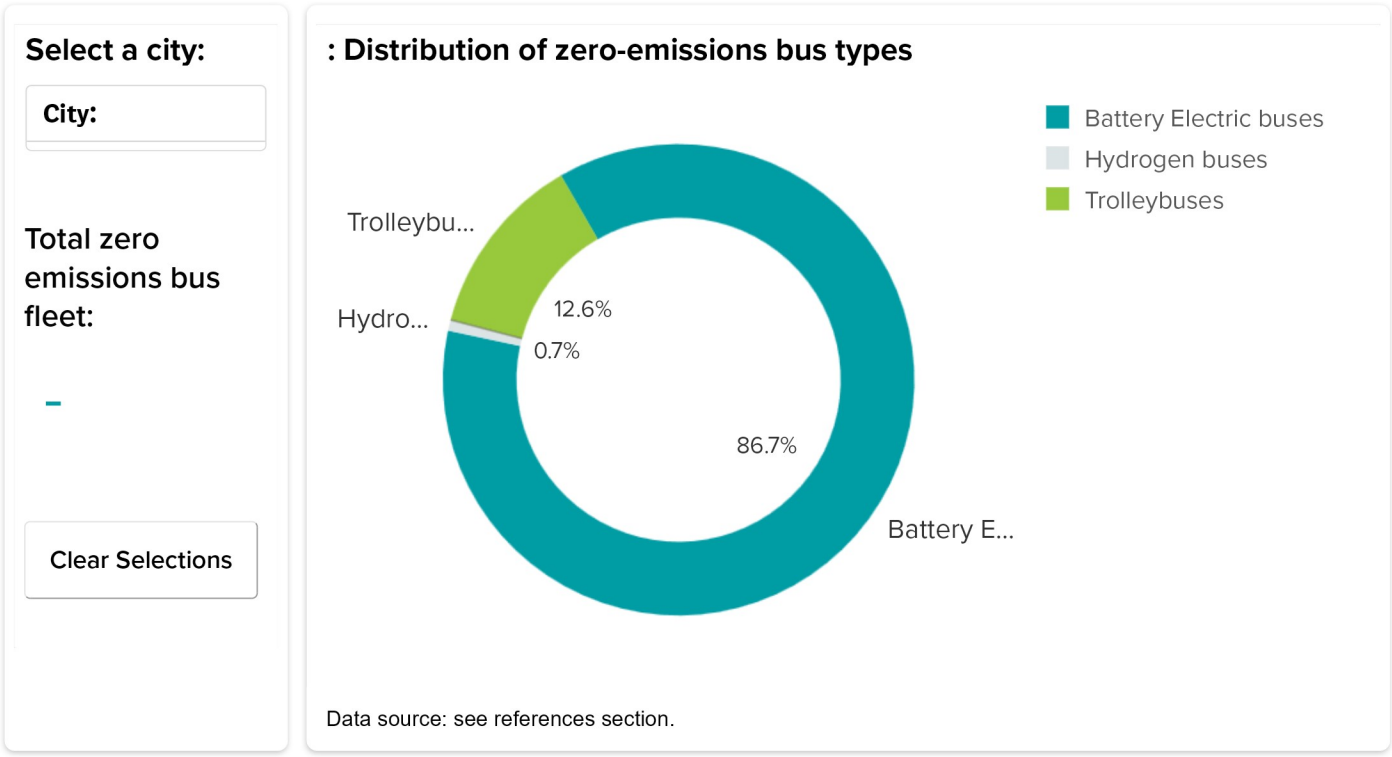
- **Procurement model.** There are a number of options to procure buses, especially at the pilot stage. This includes outright purchase, lease, loans and joint purchasing. These are explained in more detail below.

- **Product availability.** There has been an explosion in the variety of zero emission bus technologies available in the market in many countries. These include, but are not limited to, overnight-charging battery electric buses, hydrogen (H2), trolleybuses, inductive plate charging and on-route opportunity charging. Not all vehicles and manufacturers will be available in your country. Early engagement with manufacturers is highly recommended.

There has been exponential growth in the availability of battery electric buses. Hydrogen buses are lagging behind, but as the technology matures and governments implement more favourable policy

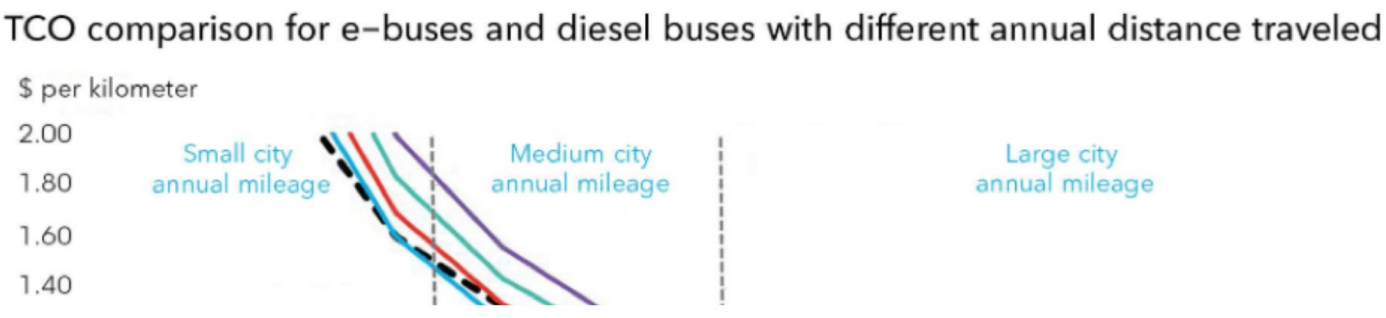
environments it is likely that hydrogen buses will increasingly play part in the transition to net-zero transportation. Hydrogen-fuelled buses are typically lighter, making this technology especially well-suited for long-distance city routes, inter-city travel and for regions our countries with poor electricity access or stability.

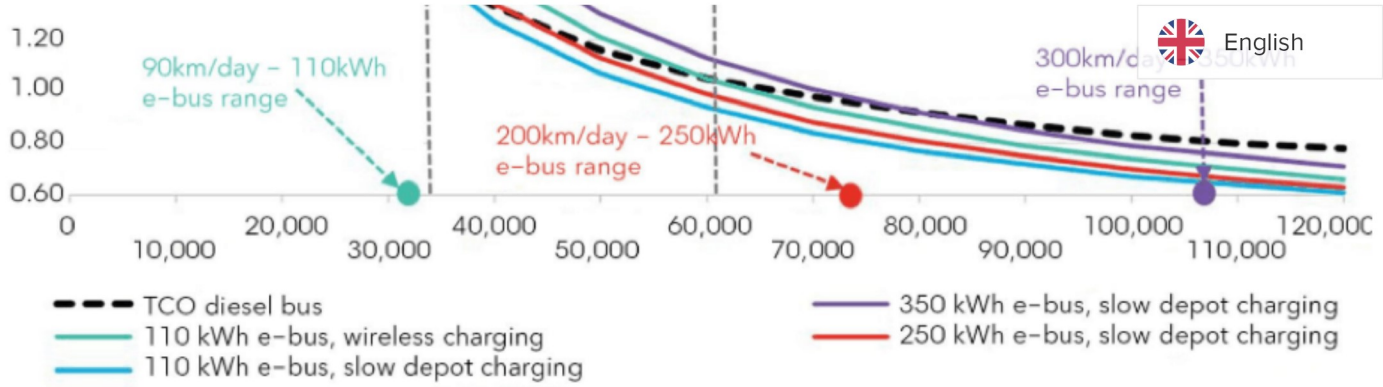
You can explore the distribution of different technologies in the cities with the largest zero-emission bus fleets below.



Total cost of ownership for electric buses can be cheaper than diesel and compressed natural gas buses

While the initial purchase cost of electric buses remains higher, the cost over the vehicle's lifetime can be lower due to operating cost savings.[4] The total cost of ownership (TCO) (in cost/km) of electric buses varies depending on factors such as mileage, fuel and electricity cost, climate, average speed and vehicle cost. The graphic below shows the TCO improvement rate with mileage for different bus configurations – this needs to be evaluated thoroughly at a local level.





Source: Bloomberg New Energy Finance. Note: Diesel price at $0.66/liter ($2.5/gallon), electricity price at $0.10/kWh, annual kilometers traveled – variable. Bus route length will not always correspond with city size.

Cities need to conduct in-depth TCO analysis based on local parameters to choose an electric bus system that can achieve TCO competitiveness in their location. For more information on TCO and how to evaluate this locally, cities can consult *Electric Buses in Cities: Driving Towards Cleaner Air and Lower CO2*.[5]

Design and implement a pilot

Small-scale pilots minimise risk. They allow cities to test bus performance in local operating conditions; evaluate their suitability for new and existing bus routes; assess reliability; and quantify operating costs, including energy and maintenance.

Gathering real world data is critical. This will inform future procurement and help you to build viable operating and financing models. Cities should mandate the collection of data as part of any bus pilot and provide specific data collection requirements.

A carefully-prepared pilot is also important for managing financial and political risk. It builds and maintains public trust and interest in electric buses, political will for their deployment and bus driver support. If the bus fleet is owned or managed by a private company, it will help maintain their interest in participating in future trials.

Core questions that a pilot should aim to answer are:

- **Bus reliability.** Like all new products, e-buses can present reliability issues that must be solved before starting passenger operation and full-scale deployment.
- **Effective range.** Range can vary significantly depending on climate, terrain, average speed, passenger load and local driving habits. Other factors, such as heat and hills can also lead to faster battery drawdown. As such, buses may not perform to their advertised range in your city environment. For example, testing in California found that air conditioning can use up to 25% of the battery energy. The buses need to be tested on multiple routes, at different times of day and in different seasons, to ensure they are performing to your satisfaction.

- **Driver feedback.** It is vital to engage drivers in the pilot. Framing the pilot positively with drivers, for instance as an opportunity to test new technology or as a reward for good service, will have an impact on how the shift to electric buses is perceived. Drivers typically report that e-buses are enjoyable to drive.

- **Charging time.** Test how long the buses take to charge in your depots. If they take longer to charge than expected it may affect your service. You may need to either upgrade the substations, procure additional buses or amend the service.

- **How passengers respond.** This should be the last aspect tested – only introduce passengers to trial buses that have passed the above requirements.

A trial using 2-10 buses is usually sufficient to evaluate different technologies and understand real-life performance. Pilots should first be run without passengers, then gradually incorporated into passenger service *in addition* to existing buses until the pilot is complete and they are performing reliably. This will mitigate operational risks associated with a new technology and improve public perception of the project.

Los Angeles' transition to electric buses

In 2010, the Foothill Transit Agency in Los Angeles, United States, began the transition of its Pomona Transit Center (PTC) with three electric buses on a 16-mile round-trip bus route.

The pilot fleet of Proterra short-range buses used a fast-charging station with two overhead chargers at the PTC in the middle of the route. Usually, buses arrive at 60-70% charge and charge to 100% in around 7 minutes.

The fleet now has 14 extended-range electric buses on longer bus routes charging at nearby Azusa, 16 fast-charge on-route electric buses charging at PTC, and the city plans for the fleet to be fully electric (300 vehicles) by 2030.[6]

Shift to total cost of ownership procurement, and use innovative and longer-term financing models

With higher upfront costs and lower operating costs (compared to diesel and CNG) e-buses require a new procurement approach. Shifting to a TCO approach enables owners to leverage operating cost savings and potentially save money over the vehicle's lifetime.

Cities can amend procurement processes to evaluate tenders based on TCO and alter contracting models to

secure longer-term and innovative partnerships with bus suppliers, as well as financing arrangements that maximise value and mitigate operational and financial risk.

Leading cities have developed and trialled new and innovative models to reduce upfront costs:

Ways to lower piloting costs

- **Negotiate a loan of buses from the suppliers to test during the pilot.** For example, Buenos Aires negotiated a free loan of eight buses for their pilot in 2018 – two from four manufacturers. The city only paid for the infrastructure upgrade.

Ways to lower upfront costs

- **Battery leasing.** This was first offered by Proterra in the United States as a way to reduce the high upfront costs and lower risks for operators. It is also the approach used in Shenzhen in China.[7] Maintenance and repair costs for the battery are covered by the leasing company. This also provides a way to avoid being locked into aging battery technology.

- **Joint purchasing.** Joint purchasing by two or more bus operators increases their purchasing power and reduces upfront costs. For instance, several transit authorities in the Los Angeles region collaborated with the State of California to develop a state-wide joint procurement schedule and maximise economies of scale. A similar approach was taken by Washington State and the Indian Government.

Ways to lower upfront costs and add flexibility

- **Separate bus ownership from operation and maintenance.** This business model has enabled Santiago de Chile to grow (as at November 2020) the biggest electric bus fleet outside of China, and has the potential to accelerate the transition to zero emission buses elsewhere. The Executive Director of Santiago's Metropolitan Public Transport Authority, Fernando Saka, has shared his advice for his peers around the world. More detail about the city's experience and business model are given in *From Pilots to Scale: Lessons from Electric Bus Deployments in Santiago de Chile* and *Metbus pioneering e-bus deployments in Santiago* respectively.

- **Operating or capital lease.** By leasing vehicles, cities can free up capital and let the private sector bear the financial and technological risks. Any operational savings can be funnelled towards lease payments. With a strong lease agreement, this model also lets cities procure a service based on performance requirements, thereby shifting much of the operational risk to the operator and vehicle supplier. The manufacturer will usually be responsible for maintaining (and sometimes operating) the buses, at a fixed cost during the contract. This is a relatively new approach, but is already used by a

bus operator in Warsaw and the New York Metropolitan Transportation Authority (MTA), and companies such as Proterra offer this option to its customers.

Cities should also lobby their national government for loans or tax-based incentives to support the purchase and operation of e-buses. For example, Copenhagen negotiated an agreement with the national government to grant private bus operators access to low interest rate loans for bus purchases, and agreed a guaranteed contract length of 10-12 years (instead of the usual six years).[8]

> Innovation and trial and error has shown that reforms to existing models, concessions, contracts and payment structures are often needed to ensure that electric bus projects are viable. Drawing lessons from cities leading the electric bus transition, *Six tips for your electric bus project's financial viability in the green recovery* explains ways to make these projects financially viable and attractive for municipalities, operators and investors.

Evaluate electricity grid capacity and plan e-bus routes and infrastructure upgrades accordingly

Building charging infrastructure to support bus fleet electrification is a major cost for cities making this transition. Evaluating spare capacity of the local electricity grid and the impact of e-bus charging at different locations can determine where an electrified bus depot, terminal or bus stop would carry the lowest upgrade costs. Other important considerations for electrifying bus depots include space for transformers and charging points, infrastructure compatibility, and integration of renewables. *Depot electrification for zero-emission bus systems* explains more.

The Auckland Grid Impact Study[9] is a good example of the analysis required, showing that upgrades to local substations may be required, even for small-scale pilots. Gaining knowledge of local grid capacity will inform route prioritisation and help cities plan the necessary infrastructure improvement works. You can also learn about Jakarta's experience with designing an appropriate and cost-effective charging system for TransJakarta's expanding zero-emission bus fleet in *Zero-emission bus charging systems: Insights from Jakarta*.

Work with the utility company to do analysis. Utilities will need to review energy demand and invest to ensure they can provide sufficient and reliable power to charge buses. Bus electrification is a huge business opportunity for utility companies, and they will usually develop their own plans to support electrification in the medium to longer term. In Vancouver, for example, BC Hydro has helped to incentivise electrification by designing an inexpensive rate and demand charge exception for Translink, Metro Vancouver's public transit agency. If the utility company uses complex pricing models that complicate and increase the cost of bus electrification, early discussions will be needed to negotiate more

favourable models. You may also need to work with the relevant local authority to obtain planning permission for on-route charging, depending on which authority owns the land.

The problem with California's dual energy charge payment model

E-bus charging in Pomona, California is subject to a dual charge payment model that adds a 'demand charge', based on the highest energy use within a 15-minute interval to the standard electricity charge.

The demand charge can be anything from 25% of the utility bill to multiple times the cost paid for electricity usage. The city has needed to plan carefully to minimise this cost by charging buses at every opportunity using on-route charging. The utility company is now looking at a fixed rate that would eliminate the demand charge for the next five years.

Two main charging infrastructure options

At depot. Overnight charging, usually slow plug-in charging, but fast plug-in charging or wireless charging is also an option. Using overhead, rather than on-ground, chargers will save valuable space in the depot.

On-route. Opportunity charging at the terminal or at bus stops. This requires fast- or super-fast-charging technology, usually pantograph or induction (more rarely plug-in). It allows the procurement of cheaper short-range buses and the flexibility to cover longer routes, but also requires construction of charging points in the city, which may carry cost and planning issues.

Cities can use one of these options, or a combination. On-route charging extends the range of buses and helps to spread charging throughout the day, but reliance on it restricts the routes the buses can drive.

Build inter-operability into charging infrastructure procurement to avoid being locked-in to one bus provider

It is absolutely critical to use a standardised system that enables cities to procure vehicles from different bus manufacturers while continuing to use the existing infrastructure. A non-standardised system that uses technology proprietary to one manufacturer will preclude any future opportunity for a competitive procurement and present tremendous financial and technological risk for cities.

This is becoming easier; as more transit agencies are acquiring electric buses there is increasing pressure to standardise charging systems. To avoid this problem, include a paragraph in procurement documents requiring the inter-operability of charging technology, and avoid procuring proprietary charging systems that can only be used by one manufacturer.

Vancouver's Translink has run the world's first pilot project for interoperability of bus and charger manufacturers. Hear from senior Translink staff in *Vancouver and Toronto: Our e-bus transition advice*.

Longer term considerations for a fully electric fleet

Negotiate a contract with bus suppliers that batteries are guaranteed for a minimum of eight years at 70% capacity, requiring replacement if they fall below 70% capacity in that time under the warranty.

When batteries become worn down outside of warranty, and the bus range reduces, those buses can be put on shorter routes, or the batteries taken out and used for energy storage.

Rooftop solar at the charging station can also help to reduce the cost of charging your vehicles, and contribute to the greening of your city's energy supply.

Where next?

For more details of the above actions and the cities that are implementing them, browse the linked resources in the article and related resources below. For guidance on shifting private vehicles to electric, read *How to drive electric vehicle uptake in your city* and *How to build an electric vehicle city*.

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