ARTICLE

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ENERGY INSIGHTS

City Bus Electrification: The Business Case in Selected Developed and Developing Countries

Electric buses promise a cleaner, quieter and less carbon intensive mode of travel in cities. This article explores the trend to electrify urban bus routes in a selection of developed and developing countries and how falling electric bus costs and increased performance are making the business case for electric buses more attractive in many markets.

There may be a business case today to switch from diesel to electric city buses in 6 out of 20 developed countries and 18 out of 22 developing countries analysed by FTI Consulting, without accounting for environmental externalities.

When externalities are priced in, this increases to half of the developed countries and all of the developing countries.

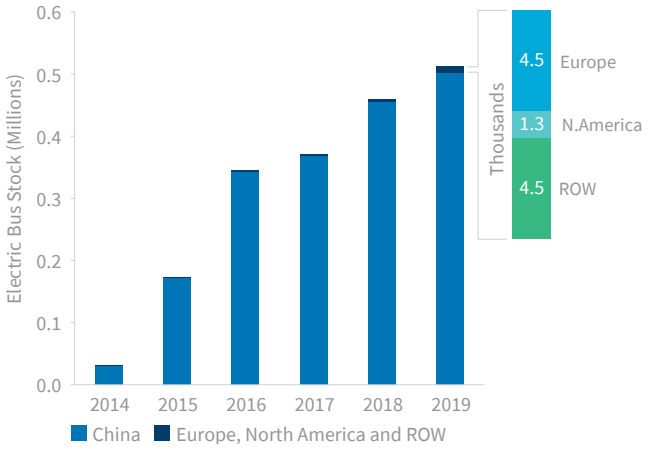
Electric bus development

The number of electric buses on our roads is increasing. The global electric bus stock in 2019 was approximately 513,000 vehicles, up from 30,000 in 2014, a compound annual growth rate of 77% (see figure 1). China has 98% of the worldwide fleet, or just under 503,000 vehicles. Sales outside China are however accelerating rapidly. Europe had 4,500 electric buses on its roads in 2019, up from 2,600 in 2018, and new registrations in 2019 (1,900) increased more than 100% on 2018[1]. The US electric bus stock approached 700 in 2019, more than double the 2018 figure. Battery electric technology is dominant, and accounts for more than 90% of stock, with plug-in hybrid and fuel cell electric buses making up the remainder.

From a country perspective, China dominates electric bus deployment as well as manufacturing. About 95% of the electric buses registered in 2019 were made and sold in China[1].

1 Source: IEA (2020) Global EV Outlook, as modified by FTI Consulting, Inc, www.iea.org/reports/global-ev-outlook-2020.

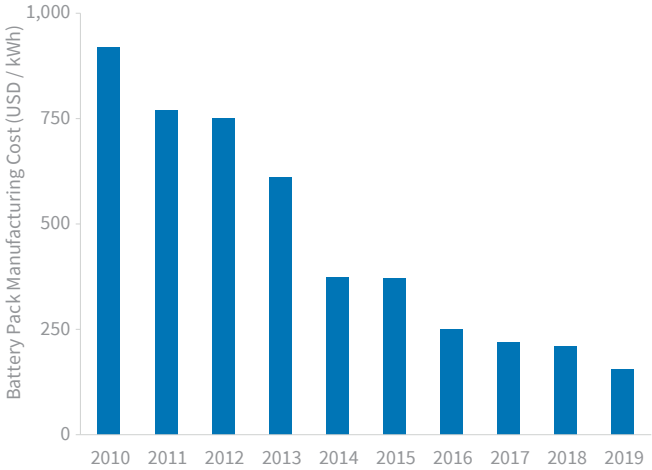
FIGURE 1: GLOBAL ELECTRIC BUS STOCK[2] (MILLIONS)



Adoption drivers for electric bus deployment

The profile of city buses as a transport mode suits electrification because typically they follow fixed routes so that batteries may be recharged once a day, usually overnight at depots. Battery pack costs, a key driver of the business case, fell more than 80% from 2010 to 2019 (see figure 2) and battery energy density has increased significantly over the same period. Battery performance has now developed so that the range on a single charge can exceed 250 kilometres. Policy is favouring electrification, driven by action on climate change and increasing concerns about the health impacts of urban air pollution. Policy measures include financial incentives for electric vehicle purchase and charger deployment, and the establishment of pilot cities and emissions zones.

FIGURE 2: BATTERY PACK MANUFACTURING COST ESTIMATES (USD / KWH)



Source: FTI Consulting analysis

FTI Consulting's analysis and findings

FTI Intelligence has analysed the total cost of ownership ("TCO") of a battery electric city bus at a typical annual driving distance of 60,000 kilometres and compared it to the TCO of a diesel city bus, for selected developed and developing countries globally. We have undertaken this analysis excluding and including environmental externalities; for the latter we have applied shadow prices to emissions of pollutants (carbon dioxide, nitrogen oxides, sulphur oxides, particulate matter and non-methane volatile organic compounds).

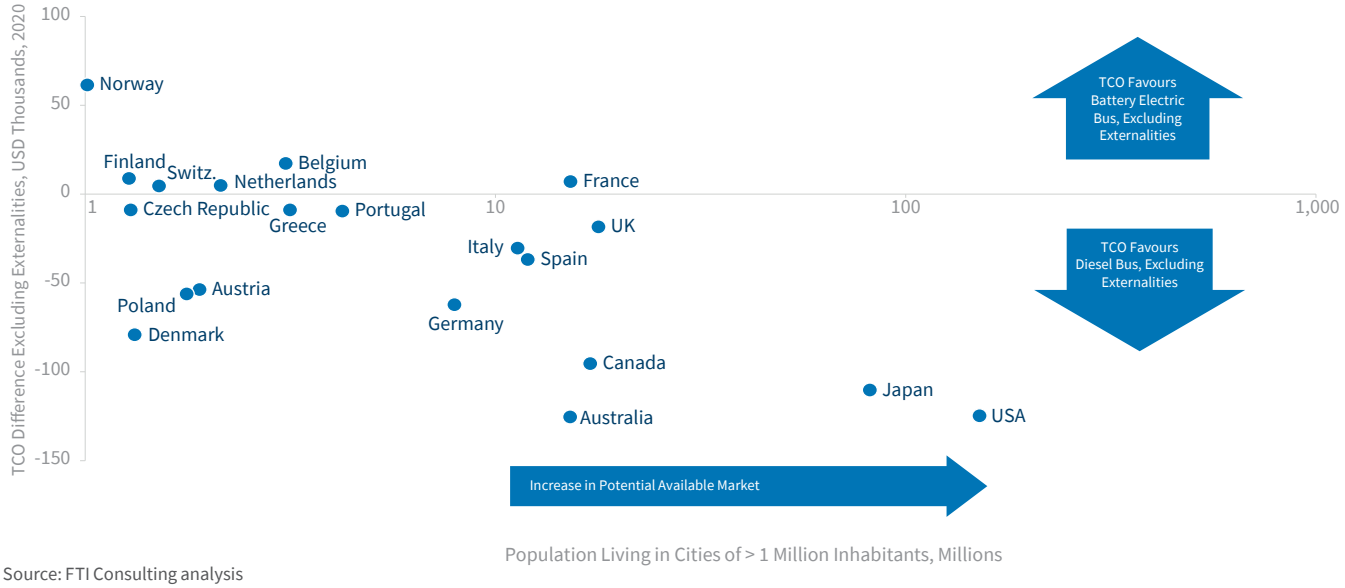
Emissions of sulphur oxides are caused by sulphur in road diesel. High levels of sulphur in some developing countries prevent the pollution control devices of modern diesel buses working, so a Euro 5 or Euro 6 diesel bus would emit much more air pollution than it is designed to do. In countries with high sulphur levels, there is no advantage in buying a Euro 5 or Euro 6 diesel bus with sophisticated pollution control devices and so in those countries we have used a Euro 2 bus in the TCO analysis.

The analysis uses low yet commercially-available battery electric bus purchase prices, with one price for developed countries and another lower price for developing countries. We have assumed that trade tariffs are zero, supposing that national governments have the ability to remove import and other tariffs if they wish. For the diesel bus purchase price in developed countries we have used an average price for a Euro 6 bus, whilst in developing countries two commercially available diesel bus purchase prices are used: one for a Euro 2 city bus and the other for a Euro 5 bus, depending on the level of sulphur in each country's road diesel. Again, for diesel buses, we have chosen to ignore import and other tariffs. It is worth noting that bus prices will vary significantly in each country, largely depending on the fit-out of each bus.

Our modelling shows that for 6 out of the 20 developed countries and for 18 of the selected 22 developing countries a business case to switch to battery electric city buses may already exist, even excluding environmental externalities. This is shown graphically in figures 3 to 5 below. The analysis behind these charts calculates the 10-year TCO difference between a diesel city bus and a battery electric city bus by country. This is plotted against the population of each country living in cities of greater than one or five million inhabitants (on a log scale), which has been used as a proxy for market size. A positive TCO difference means that there is a business case to switch from diesel to electric.

2 Sources: IEA (2016, 2017, 2018, 2019 & 2020) Global EV Outlook, as modified by FTI Consulting, Inc, www.iea.org/reports/global-ev-outlook-2016; www.iea.org/reports/global-ev-outlook-2017; www.iea.org/gevo2018; www.iea.org/reports/global-ev-outlook-2019; www.iea.org/reports/global-ev-outlook-2020. All rights reserved.

FIGURE 3: ESTIMATED CITY BUS 10-YEAR TCO DIFFERENCE (DIESEL TCO – BATTERY ELECTRIC TCO) EXCLUDING EXTERNALITIES VERSUS CITY POPULATION, SELECTED DEVELOPED COUNTRIES, 2020

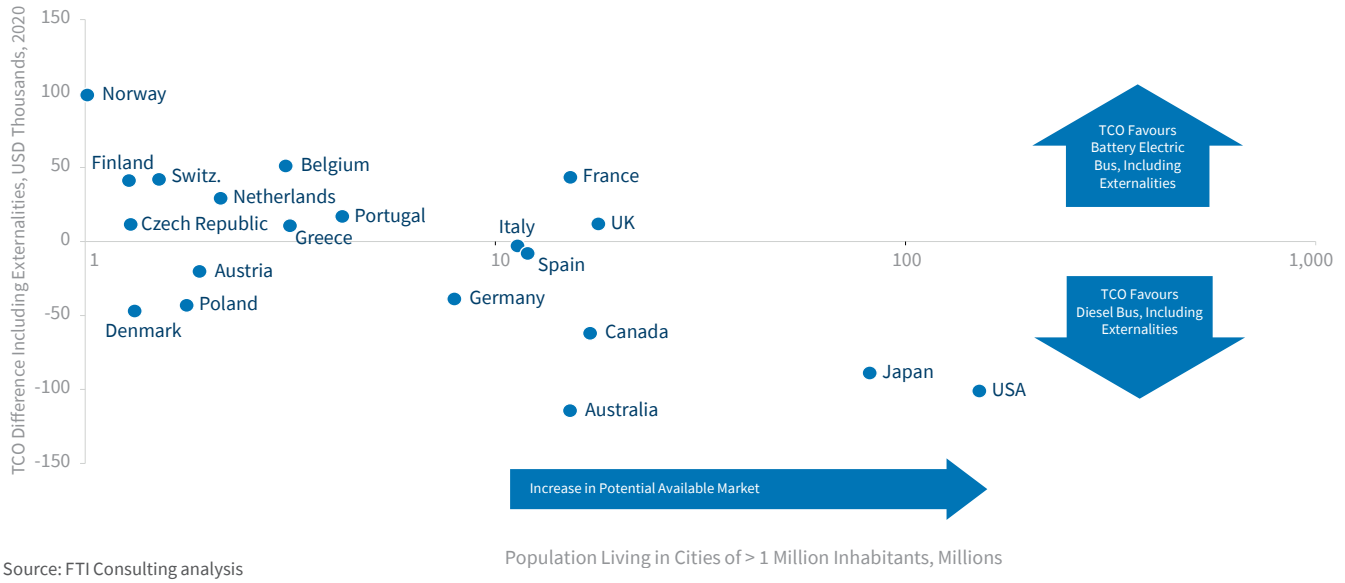


Source: FTI Consulting analysis

Developed countries

For developed countries, figure 3 shows that the strongest business case exists for Norway, excluding environmental externalities[3], with an estimated USD 60,000 saving per bus at 2020 prices, over a 10-year ownership period. France, Belgium, the Netherlands, Switzerland and Finland also show favourable business cases for electrification. In Portugal, Greece and the Czech Republic the business cases are slightly unfavourable. The USA, Australia and Japan have the most unfavourable business cases for electrification, yet the USA has the largest market potential, with approximately 150 million people who live in cities of more than one million inhabitants. TCO variances between developed countries are largely due to differences in national diesel and electricity prices, which can vary widely depending on their base prices and local tax treatment.

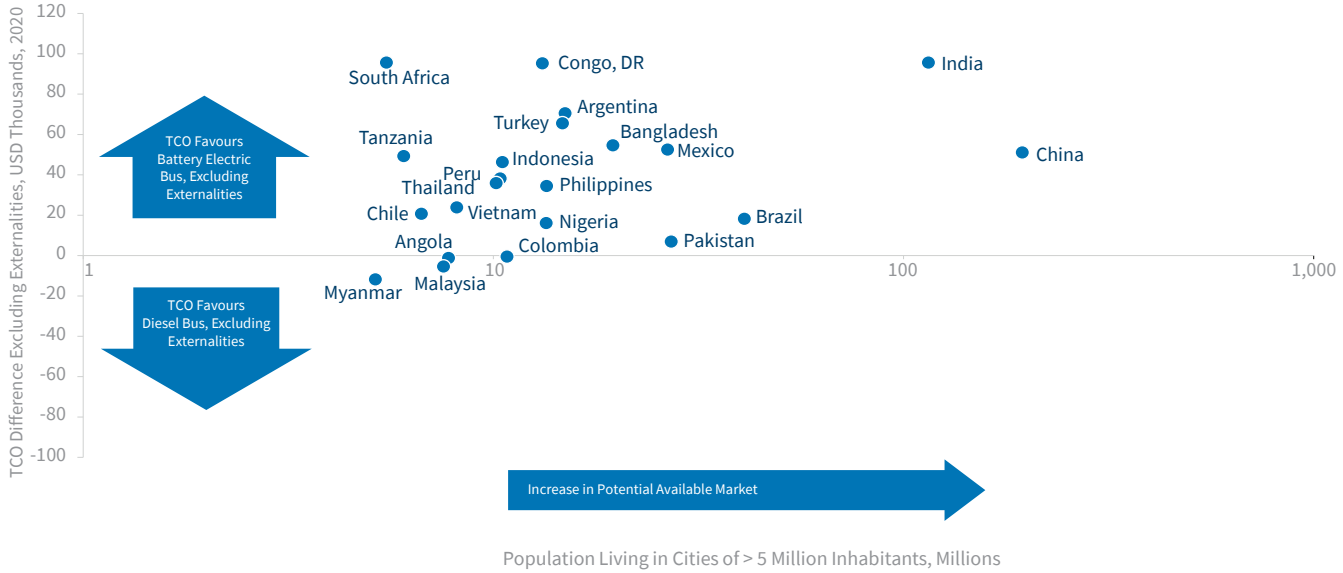
FIGURE 4: ESTIMATED CITY BUS 10-YEAR TCO DIFFERENCE (DIESEL TCO – BATTERY ELECTRIC TCO) INCLUDING EXTERNALITIES VERSUS CITY POPULATION, SELECTED DEVELOPED COUNTRIES, 2020



Source: FTI Consulting analysis

3 Note that the exclusion of externalities means that the TCO analysis is based purely on the actual capital and operating costs of electric versus diesel buses, over a 10 year ownership period and discounted back to 2020.

FIGURE 5: ESTIMATED CITY BUS 10-YEAR TCO DIFFERENCE (DIESEL TCO – BATTERY ELECTRIC TCO) EXCLUDING EXTERNALITIES VERSUS CITY POPULATION, SELECTED DEVELOPING COUNTRIES, 2020



Source: FTI Consulting analysis

When externalities are included[4], half of the developed countries show a favourable business case to electrify (see figure 4). The TCO benefit each developed country receives by including externalities depends largely on its electricity grid carbon emissions factor. Countries with higher carbon emissions factors benefit less. Poland, for example, has a relatively high grid emissions factor because it relies heavily on coal-fired power plants, and so it receives less benefit when externalities are included, compared with Austria for example.

In terms of the current market situation, close to 60% of the electric buses on Europe's roads in 2019 are in four countries, with 800 in the UK, 800 in the Netherlands, 600 in France and 450 in Germany[1].

Developing countries

For developing countries, figure 5 shows that the strongest business cases exist for India, South Africa and the Democratic Republic of Congo. Of the 18 countries with a favourable business case, the majority (nine) are in Asia, with five in Latin America and four in Africa. TCO variances between developing countries are largely due to differences in national diesel and electricity prices.

With the inclusion of externalities, FTI Intelligence modelling shows that all 22 developing countries have a positive TCO, so a business case to switch to battery electric city buses may already exist. The TCO benefit each developing country receives by including externalities depends on its electricity grid carbon emissions factor, as well as the sulphur content of its road diesel and whether a Euro 2 or Euro 5 diesel bus is analysed. Countries with lower sulphur content in their diesel benefit less.

Although the Chinese market dominates, other developing markets are growing too. New electric bus registrations in India were 450 in 2019, a doubling of 2018's figure, and India's electric bus fleet exceeded 800 vehicles in 2019[1]. Electric bus registrations in South America were more than 450 in 2019, up 250% compared with 2018[1].

Local variances

Each country and city has its own local characteristics that would need accounting for in more detailed modelling. In addition to tariffs, two local factors can significantly impact the economics. These are the cost of connecting charging infrastructure to the local electricity grid and the use of in-vehicle air-conditioning and heating, which can substantially shorten the range on a single charge. The cost of connecting chargers to the local grid can vary widely; in some cases, local grid strengthening may be required, which can significantly increase costs.

4 Note that the inclusion of environmental externalities means that the TCO analysis is based on the actual capital and operating costs of electric versus diesel buses, in addition to the costs from the emission of the pollutants listed earlier, over a 10 year ownership period and discounted back to 2020. The costs deriving from the emission of pollutants are calculated by estimating the emitted weight of each pollutant and multiplying by a shadow price (or notional market price) for the pollutant.

Other factors that affect the economics are the way the buses are driven and recharged, how fast they are driven, local weather conditions, and the battery age and performance over time. In certain least developed countries, security of electricity supply could be an issue, although charging at night will avoid peak periods of electricity use which should increase availability and reliability.

Conclusion

Battery electric bus fleets could make attractive investments in some of the developed countries and in the majority of the developing countries FTI Intelligence has analysed, even without pricing in externalities, if tariffs were removed. If externalities are included, the business case may be attractive in half of the developed countries analysed and in all 22 developing countries.

Governments could consider the removal of existing tariffs on electric buses and may wish to look at refreshing their national electrification strategies and plans, as well as introducing other incentives to increase electric bus adoption. If city buses are franchised to private companies, authorities should ensure that franchise lengths do not disincentivise electrification or alternatively structure electric bus ownership so that it is separate from operations.

Opportunities for investors and corporates exist to accelerate electric bus deployment and the associated charging infrastructure. To properly assess these opportunities, it will be essential to examine local market conditions to refine the economics. The business model chosen will also need careful consideration. For example, whilst upfront payment is the most common way to purchase electric buses and the associated infrastructure, leasing options are being increasingly offered to offset capital requirements, such as creating a financing structure where the extra upfront cost of an electric bus is eliminated. Creative financing may provide additional opportunities for market participants, whether they are bus and charging infrastructure manufacturers, utilities, asset owners, operators, or providers of financing. As battery prices and other electric bus costs are likely to fall further over the coming years, we expect that the business case will favour electric over diesel buses in increasing numbers of markets.

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