



ELECTRIC VEHICLES 101

A series of transport notes on electric vehicle trends and opportunities from IFC

E-Bus Economics: Fuzzy Math?

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Electrifying the global urban vehicle fleet depends on the convergence of several economic, technological, and political factors. However, the big shift to electric vehicles will likely take place only when the economics of owning and operating electric becomes a “no-brainer.” Using the example of electric buses, two factors must fall into place before the electric option can take off:

- **First, the upfront cost needs to come down.** Electric buses are prohibitively expensive in some markets as compared to their diesel and hybrid counterparts. (This is also the case with other electric vehicles, which tend to be pricier upfront.) The price differential is bigger in markets where there are no domestic manufacturers and equipment must be imported. A large 12–15-meter diesel bus generally costs between \$200,000–\$300,000, depending on jurisdiction, while electric equivalents can cost anywhere from \$400,000–\$800,000 (note: all dollar figures here are U.S. dollars). While China and some OECD countries provide generous subsidies to municipalities for bus acquisitions, this largesse is generally not available in developing markets. This means that the economics have to stand on their own.
- **Second, there needs to be a change in procurement culture towards lifecycle cost or Total Cost of Ownership, or TCO.** For decades city transit officials have acquired buses based on the lowest cost, which is simple, verifiable, and easy to defend in the court of public opinion. Unfortunately, the upfront purchase price is a poor determinant of the overall lifecycle cost of a vehicle, which includes operations, maintenance, financing, and insurance, among others. A shift to procurement based on total costs would provide an “apples-to-apples” comparison, which would give electrics a fighting chance.

BREAKING DOWN TCO

TCO refers to the total cost to acquire, operate, and maintain a vehicle, as well as the associated fueling infrastructure. TCO is usually reflected on a cost-per-

kilometer basis and generally includes some combination of the following (again, sticking with the example of urban buses):

Table 1. Components of Total Cost of Ownership

Item	Description
Bus acquisition: Down payment	Initial cash outlay for bus and/or infrastructure purchase. It is assumed that the remaining payments are embedded in the loan.
Bus acquisition: Loan installments	Principal and interest on the loan to purchase the vehicle. For leasing structures, a greater proportion of the payments could be considered vis-à-vis a loan purchase.
Bus retirement: Resale Value	Any positive cash resale value of the depreciated vehicle. Battery resale will also become a more prominent source of resale value as the “second life” market for batteries expands.
Fuel/Power Cost	Annual cost to power the vehicle, which is driven by vehicle efficiency, distance traveled, and source of power/fuel.
Routine Maintenance	Tires, parts, fluids, and other required maintenance of the bus in question. This also includes the cost of insurance.
Major Maintenance (Bus Overhaul)	For bus purchases that do not include a warranty for the life of the vehicle, a major mid-life overhaul would include the cost of battery replacement for electric buses and engine overhaul for conventional buses.
Infrastructure Maintenance	Where not already included in the retail fuel price, this includes the cost of infrastructure maintenance and operations.

Source: *Financing the Transition to Soot-Free Urban Bus Fleets in 20 Megacities*. International Council on Clean Transportation, 2017.

Depending on location, the distribution of costs of these items can be quite different. The key factors are generally the business acquisition and financing costs. Fortunately, the upfront cost and cost of financing are relatively predictable. The trickier elements are items such as electricity costs, fuel costs, and maintenance of the buses (and batteries in the case of e-buses). These items fluctuate over time and are devilishly difficult to forecast. Discounting these costs back to the present value to make the side-by-side TCO calculation is complicated, which can discourage city officials from relying on this analysis. This is one of the key reasons why lower-cost procurement is still the name of the game.

We know that electric buses are expensive, but what does the research on TCO add to the mix?

World Bank

In a January 2019 study by the World Bank, *Green Your Bus Ride*, the authors analyzed five municipalities in Latin America where e-bus business models may stand on their own (meaning without heavy subsidies). The TCO review focused on Buenos Aires, Mexico City, Montevideo, São Paulo, and Santiago, where the World Bank assessed local, national, and international factors that affect TCO, including technical literature and manufacturer information. The study looked at electric buses, but also cleaner diesel technologies, biofuels, and compressed natural gas.

The data from Latin America is useful. In Buenos Aires, the TCO (cost/kilometer basis) for battery electrics is higher due to a combination of higher financing costs and taxes. On the other hand, battery electrics in Santiago are already cost-competitive on a TCO basis (10 percent less than diesel) due to lower electricity costs and cheaper financing costs.

Figure 1. World Bank TCO Buenos Aires Estimates (\$/km)

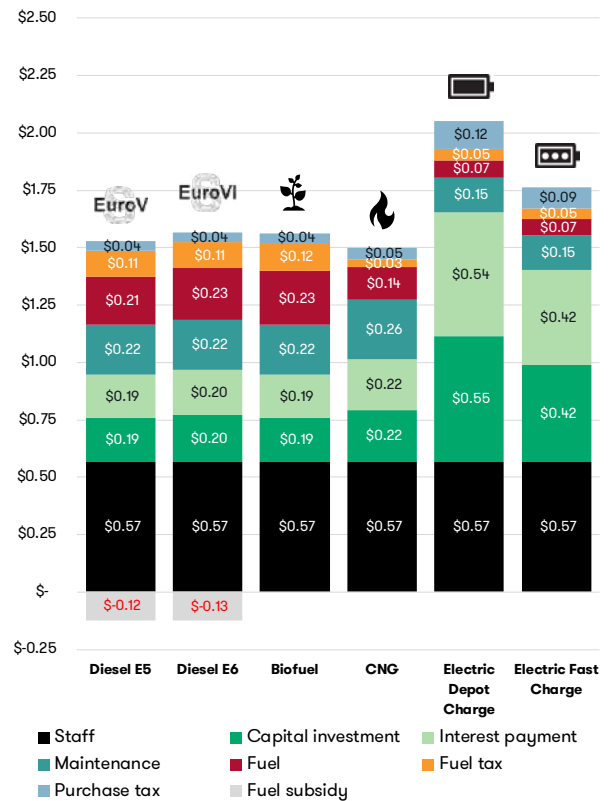
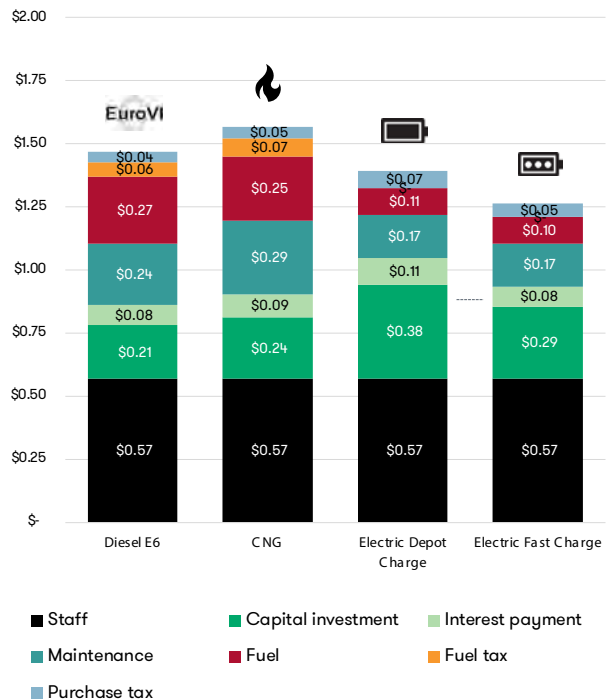


Figure 2. World Bank TCO Santiago Estimates (\$/km)



Source: 2019. World Bank. *Green Your Bus Ride. Clean Buses in Latin America.*

The other cities fall somewhere in the middle, depending on capital investment, maintenance forecasts, fuel, and energy costs and taxes. The document also provides a note of caution about forecasts and discount rates in that small swings in the variables can paint a very different picture.

Bloomberg New Energy Finance

According to BNEF, battery electrics generally remain more expensive on both upfront *and* TCO basis at the moment. There are a few outliers like Santiago, where competitive energy and low financing costs have already driven TCO to parity. However, Bloomberg New Energy Finance predicts that electrics will start to reach TCO parity in most locations in the next two to three years, while upfront cost parity will probably take another decade (currently estimated at around 2030).

TCO TAKEAWAYS

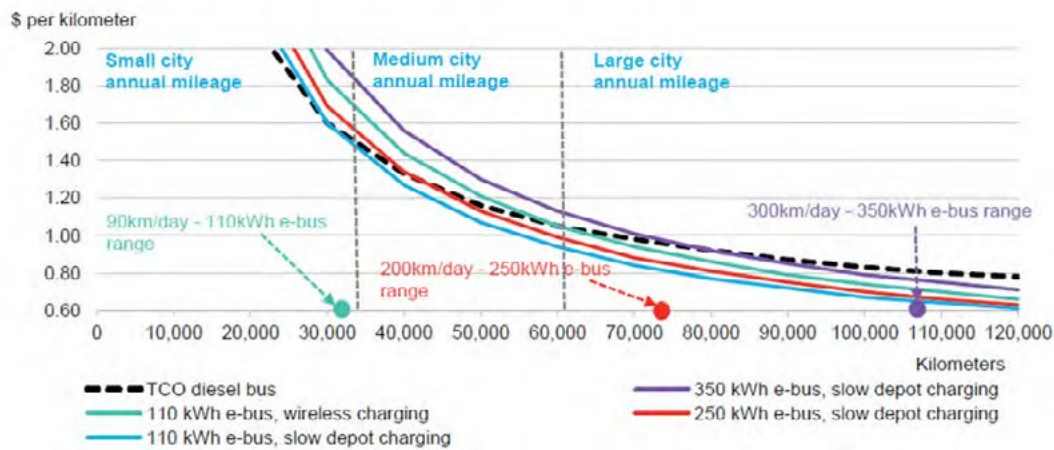
Based on this analysis of the literature, we can arrive at a few conclusions about e-bus economics:

- First, in the short run, e-buses are still quite expensive at this stage of development, particularly outside of China. This can be seen in the substantial premium

paid for e-buses, sometimes reaching as much as double the upfront procurement cost. For city transit officials who do not consider TCO, this is a no-go.

- Second, there is a powerful and inverse relationship between TCO and the annual distance driven that favors the lower operations and maintenance costs of electric buses when the savings can be spread over longer distances. (This also applies to other high use fleet applications such as intra-city delivery trucks and taxis.) To amortize the higher purchase price and financing costs of e-vehicles, such as buses, it is necessary to put this equipment to work on longer routes with high annual mileage. For medium-sized buses with overnight depot charging, the crossover point with diesel is recognized to be between 30,000 and 40,000 kilometers annually. Put differently, you need to “sweat” this equipment to make it work.
- Finally, electric vehicles may only be TCO-competitive in a few select places like Santiago, which have lower electricity costs. Once the social and environmental costs of local air pollution and GHG emissions (which are generally ignored in TCO calculations) are factored in, parity is much closer than you might think.

Figure 3. Total Cost of Ownership over Distance Traveled



Source: Bloomberg New Energy Finance, AFLEET, Advanced Clean Transit Notes: Diesel price at \$0.66/litre (\$2.5/gallon). Electricity price at \$0.10 kWh, annual km. traveled-variable. Bus route length will not always correspond.

FUZZY MATH?

Regardless of which set of numbers you consult, the argument for electric vehicles is built on forecasted savings that reach positive internal rates of return and payback periods only over the medium term. This is a tough sell for transit authorities that have immediate needs and limited budgets to cover the cost. The inertia towards the status quo is powerful.

At the same time, there are huge global forces behind the e-vehicle phenomenon, including commercial interests, air quality demands, climate concerns, and even geopolitics (when you consider the magnitude of state resources being channeled into the industry). Whether or not it takes a decade to get there, it is just a matter of time before electric vehicles such as e-buses are acquisition-cost-competitive while performance

data accumulation reduces the uncertainty of projected numbers. Further, if utilities can structure out fluctuations in power costs (through PPAs) and the marketplace moves to leasing and other fixed-price operations and maintenance arrangements, these calculations could standardize across the board quickly. This is when the math starts to get a lot less fuzzy.

ADDITIONAL TRANSPORT NOTES IN THE ELECTRIC VEHICLES 101 SERIES

[An EV Playbook for Electric Buses](#)

[Bumps in the Road: Challenges to E-bus Implementation](#)

[Electric Buses: Why Now?](#)

[Twists and Turns: New Business Models](#)

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