Executive Summary

The Case for All New City Buses in India to be Electric

Summary: We illustrate that when the benefits of recent dramatic declines in Lithium battery prices are fully realized, the total cost of ownership of urban (intra-city) electric buses is lower than that for diesel buses in India even without subsidies. Factoring in the air quality benefits, projected reductions in the cost of batteries and solar electricity, it becomes evident that transitioning to an all-electric bus fleet presents an enormous opportunity for India to reduce urban air pollution while improving the finances of urban bus transit agencies. Applying relevant lessons from the policy ecosystem that delivered substantial price reductions and large-scale rapid deployment of solar PV and LEDs could achieve similar outcomes for battery electric buses. Well-designed high volume auctions and clear long term ambitious targets could achieve rapid electrification with little net public subsidy in the long-run.

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Indian cities are struggling to keep the air breathable for inhabitants, due in part to emissions from diesel buses. While the case for electric buses, and more generally, zero emission buses, has always been clear from an urban air pollution perspective, the economic case depended strongly on their environmental benefits. However, the situation seems different today.

By the end of 2017, lithium-ion battery costs had fallen more than 80%—to less than $175 per kilowatt-hour (kWh)—relative to their cost in 2010. Consequently, the cost of producing electric buses have fallen steeply, and electric buses are gaining market share worldwide. For example, electric bus sales in China have increased tenfold over the last five years, to 100,000 units per year.

Given these recent developments, we develop a model to estimate the total (or lifecycle) cost of ownership (TCO) of both electric and diesel buses from the bottom-up (i.e., using cost of individual major components and sub-systems in a bus) while taking into account the cost of charging infrastructure, and battery replacement. We use this model to analyze the sensitivity of the difference in the TCO of electric and diesel bus to different future scenarios of battery cost, bus utilization rates, and lastly, to different policy interventions (subsidies, tariffs, and electricity rates). We do this analysis for four different bus configurations - 9 meter (m) non-air-conditioned (AC), 9m AC, 12m Non-AC, 12m AC.

Across a broad range of average daily utilization rates from 150 to 250 kilometers, and at the current unsubsidized cost of electricity supply, we find that electric buses have a lower TCO relative to diesel buses not only in the absence of EV subsidies but even after factoring in the 30% tariff on import of EV batteries into India (see Figure A). A few other recent studies have compared the TCO of both electric and diesel buses. However, because those studies assume battery cost that are 2X to 4X the cost in 2017, they result in greater TCO for EVs.

We also compare our bottom-up estimates with actual bids received by various Indian cities under the Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) policy which provides generous subsidies for procuring EV buses. This data suggests that while TCO of the electric bus to the buyer (i.e., city bus agency) is comparable to that for diesel buses in most cases[1],

[1] To be clear, there is variability in how the bids compare to our bottom-up estimates for each of the four different bus specifications – 9 metre AC and non-AC, 12 metre AC and non-AC and for each specification depending on whether

the total price received by the manufacturers, which is the price paid by the buyer plus the subsidy, translates into a higher TCO relative to diesel bus, which appears to contradict the bottom-up estimate.

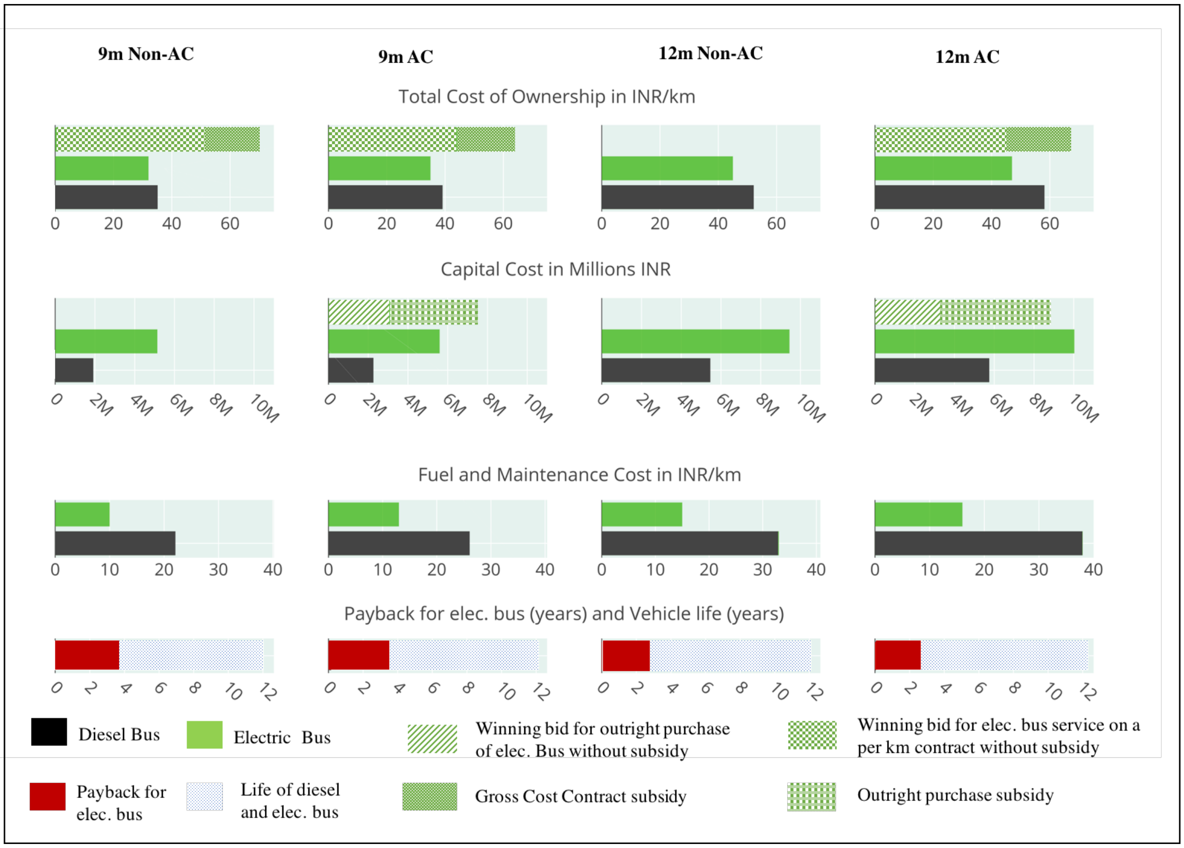

Figure A: Comparison of TCO, capital cost, fuel and maintenance cost for four different classes. Comparison – 9 metre (m) non-air-conditioned (AC), 9m AC, 12m Non-AC, 12m AC -- of buses for average operation of 200 km/day. Figure also shows how the TCO derived from bottom up cost estimates of vehicle production cost (solid green bars) compares to the winning bids for electric bus service on a per km contract basis (green checkered bars). All diesel bus metrics are based on bottom-up estimation of vehicle production cost. It also shows how the bottom up estimate of electric vehicle production cost (solid green bars) compares to winning bids for outright procurement of electric buses (hashed green bars). It also depicts the payback to electric buses relative to an assumed common useful life of 12-year life for both diesel and electric buses. Note that for 9m Non-AC bus, the bids for electric bus service exceeds our bottom up estimate.

Plausible reasons as to why the bid data suggest a higher TCO relative to the bottom-up estimates include imperfect competition (most cities had one or two bidders)[2], information asymmetry, and battery prices that are out-of-date with recent trends. At the same time, it is plausible that our bottom-up estimates are biased downward due to hidden costs including transaction costs and higher actual cost of capital.

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bid was for outright purchase of the bus or a bid for bus operations on a cost-per-km basis. More details are in the full report.

[2] When there is imperfect competition, bidders might set their price to the buyer at or close to the TCO of diesel bus, which is easy to estimate, so as to capture the full benefit of the subsidy.

Notwithstanding the higher total cost (i.e., with the subsidy) revealed by the bids as well as the estimates in the literature, our bottom-up analysis is aimed at illustrating how in the long-run the difference in costs fundamentally ought to reflect the incremental cost of the battery, the savings in engine cost, and savings in fuel and maintenance costs. Viewed from this perspective, given the projected future decline in battery prices (from $200 to $100 per kilowatthour (kWh)), the reduction in the cost of solar electricity (from INR 6/kWh to INR 4/kWh), and the air quality benefits, the case for embarking on a transition to an all-electric future for city bus transportation today is evident.

Furthermore, unlike diesel prices which are volatile, EV buses are poised to take advantage of low and 20-year nominally fixed solar electricity prices which are substantially lower than today's average cost of electricity supply (see Figure B).

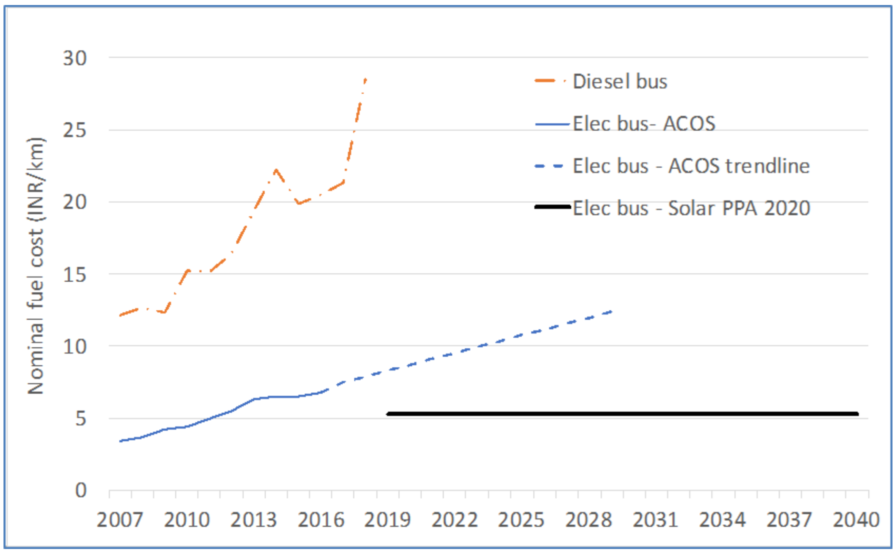

Figure B: Nominal fuel cost per kilometer for diesel buses (orange and dashed dot) and for electric buses under for two different scenarios for electricity prices – average cost of supply for state-owned utilities in India (ACOS) (solid blue and dashed trend line) and under 25-year nominally fixed solar power-purchase agreements (PPAs) effective from 2020 (solid black line). Diesel bus fuel cost is based on average annual diesel price and a fuel economy of 2.5 km/liter of diesel. Electric bus fuel cost is based on a fuel economy of 0.8 km/kWh for electricity and solar PPAs at INR 5.3/kWh (which is inclusive of a transmission and distribution cost of INR 1.5/kWh).

Most publicly owned bus systems in large Indian cities generally recover only about 70 to 90 percent of operating costs. Complete electrification of publicly owned fleets would more than offset the current net loss incurred by these agencies, which could enable these agencies to improve their finances without raising fares and then spur increased ridership in a virtuous cycle of performance and growth. Electrifying all 160,000 buses owned by state and city road-transport corporations across India would increase national electricity consumption by only about 1%.

India has significant experience in bringing down the prices of key clean energy technologies such as solar PV and LEDs with a robust policy ecosystem and well-designed large scale auctions. Relevant lessons from this experience can potentially be applied to bring down the electric bus prices in India including the use of large volume reverse auctions enabled by aggregation of demand, clearly defined uniform technical specification, clear long term policy target, and provision of supporting infrastructure.

India’s Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) policy facilitates electric bus deployment, but our analysis suggests the need to improve the allocation of funds and address other shortcomings in the current scheme. For instance, despite FAME’s generous per-vehicle subsidies, allocating the entire budget of INR 3,500 Crores set aside for electrification of buses and cabs would electrify less than 1% of the national stock of public and private buses combined. Low- or zero-interest loans to finance bus procurement, lowering the cap on maximum subsidy per bus, differentiating subsidies for AC and non-AC buses, adopting ambitious overarching goals such as ensuring all new public buses are electric, selecting a few major cities for demonstrating the feasibility of this idea, facilitating bus procurement on a large scale to exploit scale economies, and removing informational asymmetries and barriers would represent steps in this direction.