Electric Bus Operation in Kolkata City

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Questions	Answers
1. Bus numbers and targets	
1.1 How many total intra-city buses are owned and operated by WBTC and the private sector?	9700
1.1.1 How many intra-city buses are run and owned by WBTC only?	1300
1.1.2 How many intra-city buses are run and owned by private sector only?	8400
1.1.3 How many intra-city buses are electric and are owned and run by WBTC?	75
1.1.4 How many intra-city buses are electric and are owned and run by private sector?	None
1.2 What is the WBTC's goal in terms of future deployment of number of electric buses and time frame?	In the first phase WBTC procured 80 electric buses, of which 75 buses are in operation. Procurement of another 50 (12M) buses is under process.
2. Technical specifications	
2.1 Are all e-buses air-conditioned? If not, what percent are air conditioned?	All electric buses are air conditioned
2.1.1 Given Kolkata's hot climate (especially in summer months), it would be illustrative if you can give some figures on auxiliary consumption with and without use of air conditioning and how this affects choice of battery.	Though time since the introduction of the buses is not enough to draw any conclusion regarding choice of battery in the context of AC and non-AC buses, there are still some issues to be considered: 1. If WBTC continues to increase AC buses in the city, further analysis to be done related to what extent AC buses will contribute to pollution 2. The electricity consumption for electric buses is roughly around 200 units per day (20 ton AC capacity with a hourly consumption of 20/unit, with 10 hours of operation it comes to 200 per unit). There is a resulting increase of operational cost and reduction of battery life as well with ACs. The impact of AC on battery life needs to be calculated.
2.2 Please provide cost or investment figures of electric buses and their cost comparison with 9- and 12-meter diesel buses (actual figures for Kolkata)?	The difference of CAPEX between AC electric buses already procured and existing AC diesel buses is not significant enough. In the procurement of the buses, the difference between the lowest bidder and the 2nd lowest bidder was around 50 lakh (cost of 9 meter EV bus was Rs.72,00000 & 12m was Rs. 82,00000 compared to Rs. 70,00000 for a diesel

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	bus). But operating cost varies significantly. Presently comparison may be done for fuel cost only as maintenance cost is very low in the initial 1-2 years for any bus. Electricity cost for EV is roughly INR14.00/km while diesel cost for diesel operated bus is INR35.00/km
2.3 What is the range in km of a 9-m and 12-m electric bus in single full charge of 125 kWh and 188 kWh battery capacity respectively?	70 and 95 km respectively, with full charge
2.4 What is the battery chemistry? Are all buses using NMP batteries or something else (pl. specify)? And, what is the reason for choosing the battery chemistry?	NMC (Nickel, Manganese, cobalt) batteries are being used. NMC batteries have longer life, high energy density and have low cost. Their high density permits compact and light weight designs.
2.5 What is the average electricity consumption in a 9-m and a 12-m electric buses in km/kWh?	Average electricity consumption for 12M bus is 1.06 km/kWh and for 9M bus it is 0.95 km/kWh. Total average km/kWh is 1.05
2.6 What would be the impact on bus capital cost if the battery capacity is increased due to increase in price of battery? Pl. provide actual figures to illustrate how big the impact is?	In general, battery comprises of almost 40% of the cost of the vehicle so it will increase accordingly. Battery pack price is around USD 230/kWh
3. Charging model and deployment of charging infrastructure	
3.1 Any plans for upgrades of charging infrastructure and impacts on the distribution grid? Please elaborate.	Without the implementation of proper algorithm for charging / opportunity charging and replacement of EV with diesel buses to maintain normal route service, it is not possible to justify upgrades of the existing infrastructure. A study is required to estimate maximum number vehicles / routes which can be catered with the existing infrastructure.
3.2 What's the distribution of each charging infrastructure – slow (60 kW) and fast (120 kW) chargers (e.g. 90% overnight charging, 10% opportunity charging). Planned versus reality?	The number of fast chargers went up in the actual operation by 10% for 80 buses. Total fast charger under the initial estimate was 25, now it is 30. 60% slow chargers, 40% fast chargers
3.3 How many chargers/guns per bus?	82 chargers and 75 buses
3.4 Time taken from 0 to full charge in 9-m and 12-m bus in slow and fast chargers?	Battery will be charged in 2-3 hours using fast charge, 3-4 hours slow charge Fast charger for 9m charges at 80 ampere Avg 2 to 2.5 hours 12 m – 3.0 hours Approximately (this is being calculated) From 94% to 100% takes 30 to 40 mins From 0-90 SOC it is 1.2 mins/unit. Once it crosses the 92% SOC the current rate at which it is charging it goes down

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3.5 What is the reason for choosing the Chinese standard – GB/T? Is it the same for all 80 Tata e-buses, or was it a requirement by WBTC?	Standard is same for all the 80 electric buses, as Bharat charger specification also followed GB/T. At that time GB/T was the most prevailing standard
3.6 What is the cost of charging in Rs/kWh? Is this a flat rate?	Commercial tariff applicable for charging the buses. Flat rate INR14.00 / kWh including average installation cost.
3.7 Does the charging cost include demand and energy charges?	Yes
4. Total cost of ownership and energy cost comparison - diesel vs electric bus	
4.1 What is a comparative TCO for diesel and electric bus, both fully air-conditioned?	INR35.00/ km for diesel INR14.00 / km for EV Capex: Diesel AC 12 meter: 74 lakh EV 12 meter: 82 lakh Going forward: 12m EV buses will cost 1.4 crore which makes EV buses double the cost of diesel. The operational cost of future EV buses at 1.5 crore will go up because the interest cost on the bus capital cost will be included in the operating cost. Future operating cost will include fuel + interest on the capex. This model is the future opex model for the additional 50 buses that have been procured where the cost is Rs. 75/km, revenue is Rs. 62/km.
4.2 What is the energy cost of operating a diesel bus compared to electric? Is this true that energy cost of operating electric buses is half that of diesel? Can you give some numbers in Rs/km and in Rs/kWh for both bus categories?	INR 14/km for electric buses, INR 35/km for diesel buses
5. Institutional implementation	
5.1 Please elaborate on the business model and the partnership established among bus manufacturer, WBTC, charging infrastructure provider, utility, relevant regulatory authorities, financing institutions for daily bus operation. Describe the institutional arrangement and roles and responsibilities of each stakeholder.	The 80 buses under FAME I have been procured under CAPEX model where WBTC is taking care of both operation and maintenance of buses. Subsidy received under FAME I. Under FAME II buses are procured under OPEX model where operator will be paid fixed rate (Rs. 75) per km and will take care of both operation and maintenance of electric buses and depots and terminus
5.2 What are the key lessons learned including key successes, innovative financing, associated risk?	Key lessons:

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	1. The implementation of EV project is in the preliminary state now. Therefore, success story lies only with the launching process. There is a long way to go to get the tangible benefits out of it. 2. Currently, the buses are being underutilized due to a minimum range anxiety. Although drivers have an incentive to complete 3 to 4 full trips, buses are returning to the depot with 40-50% SOC, due to range anxiety. These are dead SOCs. An automatic monitoring and planning tool will be created for better utilization of the buses. Right now it is left to the driver's discretion when to bring the bus back. Confidence to be built up amongst the drivers to run the EV with SOC below 30-40%. The operation needs to be improved at least to run it up to the SOC level of 15%. With operational data analysis, this can be done. 3. Detailed study and analysis is required before going for further procurement. 4. If the estimated period for complete replacement of diesel vehicles with EV is say 8 years, then separate study is required for the crucial transition period because to get maximum benefit of EVs there is a need for mixed operation with both diesel and EV and this requires dedicated controlling of operation through dedicated team and proper planning. 5. Average SOC before starting the charging operation is 50%. This is too high to get the actual benefit. This is to be reduced at the earliest. 6. Decision on battery size for future bus procurement cannot be taken as of now due to under-utilization of existing buses. 7. Driver dependency on decision making process for opportunity charging to be automated with software algorithm to increase per day km run. 8. Innovative OPEX model has been chosen for next phase of procurement. The risk involved in the same will have to be analyzed after the implementation. 9. Extensive planning is required in implementing dispatch priority of EVs.

Questions	Answers
	Operational insights: Approximately, $316,000 saved in operating cost in 9 months. Total EV km in 9 months: 1,800,000 km =1,300,000*14 = Rs. 25,200,000 = $360,0000 @ Rs 70 exchange rate Projected operating cost diesel+ Rs. 1,800,000*35= Rs. 63,000,000 = $900,000 Profit = $900,000-$360,000=$540,0000
5.3 What is the current thinking on optimizing electrical connectivity requirement to reduce the connectivity cost, demand charges, etc.?	Utilization of available capacity of existing transformers. Optimization of route and planning of operation of buses to optimize charging time which will subsequently reduce the number/time of charging sessions in the depots
6. Positive and negative impacts	
6.1 Reliability of bus operation: Electric buses have priority over diesel buses vis a vis dispatch. Can you expand a bit on reliability? Any operational data comparing reliability of diesel vs e-bus (to make it fairer, new diesel vs new e-bus, as there isn't much history yet)? Any impact on operations, for example, that you need more frequent charging than modelled, and thus you are requiring a larger fleet size? Was it a 1:1 replacement?	A diesel bus does 6 roundtrips per day which is double the trip done by a EV, because of EV charging optimization issues. EVs are underutilized and deployed in a limited way in the evenings.
6.2 Cost of bus operation: How does the cost compare between a diesel and electric bus in a common unit?	Energy cost – e-bus- INR14/km – diesel bus –INR30/km Diesel (INR) Capex: 70,00000 Maintenance cost/km: Rs 4-5 Operating cost/km: Rs. 35 Salary cost per km: Rs. 40 EV (INR) Capex: 82,00000 (current); 14,000,000 (future) Maintenance cost/km: Rs 8-10 Operating cost/km: Rs. 14 Salary cost per km: Rs. 40
6.3 Ridership issue: Has there been any survey conducted to capture passenger's preference? If so, is there	The question of preference does not arise at all. The percentage of EV is less than 1% as of now.

Questions	Answers
any preference? Or, are we assuming because of high demand, passengers take whichever type of bus comes first?	
6.4 Local pollution versus GHG emissions: What is the perception? Is there any analysis to substantiate this?	Currently the figures are not available
6.5 Distribution grid: Can you put some numbers on need for additional transformers based on available analysis and the results? I imagine there is no impact in terms of energy, but there is in terms of increased power loads.	In all the depots and terminus additional transformers have been installed except for Nonapukur depot where existing capacity is being utilized. Of the 10 depots, 9 depots needed new transformers. One depot had a relatively new transformer. WBTC paid for the transformer.
6.6 New transformers installed: WBTC has acquired three connections in each depot from the utility which enables them to charge three buses simultaneously. Power level? Only three buses at a time in each depot? Considering charging time, is this enough to charge the whole fleet so it will be fully ready by the start of operations in the morning?	Three connections of 105 kW have been acquired by WBTC. Route optimization and opportunity charging help the buses to get ready for operation next day with three connections for overnight charging. The current infrastructure of 10 depots and 10 transformers can support more than 80 buses. However, the determination of the optimal number of buses this infrastructure can support, has not been done. The real test is pending until procurement of significant number of EVs is done.
6.7 Availability of charging infrastructure for other EVs - taxis/cars/trucks: Are there charging infrastructure available for e-taxi or e-truck fleets? How about private 2-, 3-, and 4-wheelers? Also, are there shared EV operators such as Lithium in Kolkata? If so, where do they charge?	Kolkata Municipal Corporation has planned to install EV charging stations for vehicles other than buses in and around the city. Presently there is no question to share EV infrastructure to other vehicles due to the absence of other EVs in Kolkata.
7. Challenges	
7.1 What are the critical challenges for electrification of buses and other EVs?	• Cost of setting up of public charging station which is very high (municipal charges for cabling, dedicated 11kV line, transformer etc.) and considering the number of EVs on the road negative ROI is expected. • High battery cost • Space will be a major constraint as with increase in number of buses, depots to be renovated with infrastructure up-gradation and few depots need to be extended. Terminus for opportunity charging need to be developed as spaces in terminus will be an issue with increase in number of buses.

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	• Centralized control room is required for charging operation monitoring particularly for opportunity charging as opportunity charging is the key to achieve the desired target.
7.2 What is the current thinking on greening the power grid given India's heavy reliance on coal-fired power generation?	Currently in India RE constitutes 37% of the total installed capacity which is more than one third of the capacity. Considering India's target of 175 GW of RE by 2022, greening the grid is on track and public charging stations can use solar for catering the charge load. WBTC has already taken the initiative to run the charging stations with solar power. The first project for this will be implemented at Kasba Depot. This will certainly reduce dependency on coal-fired power generation and will achieve 100% pollution free bus operation.
7.3 What are the other transportation challenges beyond electrification?	Vast number of private bus operators running on old diesel buses, under-utilization of trams, inefficient and polluting diesel boats, streamlining e-rickshaw operations, use of engine vans in Sundarbans which are major source of pollution.
8. Excel Data Sheet on Hourly Bus Operation over say last 4 months	
8.1 Please arrange and supply data for each electric separately bus hourly data over time with respect to (i) cumulative distance traveled, (ii) SOC distribution with % of time dedicated for opportunity charging, and (iii) electricity use pattern (km/kWh) at different levels of SOC %.	**Not available with us. WBTC is having the data. It will be good if you can request them to share the available data. However, it will be difficult to assess 4-month data as most of the data is captured on hard copy.**