TATA Motors Electric Bus

Date: 23rd Sept 2019
Challenges in Metro and similar cities
- Shortage of buses – gap of 4000 buses
- Pollution > 300 PM
- Congestion – Avg speed 10 kmph

Way Forward
- Zero Emission buses
- Connected - to improve efficiency and enable modal shift
- Economical – to enable movement of masses
In 2018, We have developed widest range of electric buses (5 different models)
Advance Preparation by Tata Motors

- Head start in testing & validation for 9m/12m
- 8 Prototypes successfully demonstrated

<table>
<thead>
<tr>
<th>Trial City</th>
<th>Shimla</th>
<th>Chandigarh</th>
<th>Guwahati</th>
<th>Nagpur</th>
<th>Manali</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle</td>
<td>9m Bus</td>
<td>9m Bus</td>
<td>9m Bus</td>
<td>12m Bus</td>
<td>9m Bus</td>
</tr>
<tr>
<td>Ambient Temperature (deg C)</td>
<td>Max / Min -34/-19</td>
<td>Max / Min -41/26</td>
<td>Max / Min -35/24</td>
<td>Max / Min -50.8/30</td>
<td>Max / Min -34/27</td>
</tr>
<tr>
<td>Month of Testing</td>
<td>March</td>
<td>June</td>
<td>November</td>
<td>May</td>
<td>August</td>
</tr>
<tr>
<td>Testing Duration</td>
<td>5 day</td>
<td>10 days</td>
<td>7 days</td>
<td>5 days</td>
<td>3 days</td>
</tr>
<tr>
<td>Total Distance Traveled</td>
<td>840 kms</td>
<td>1715</td>
<td>440</td>
<td>540 kms</td>
<td>312</td>
</tr>
<tr>
<td>Consumption (kWhr/km)</td>
<td>0.53</td>
<td>0.55</td>
<td>0.6</td>
<td>0.75</td>
<td>0.55</td>
</tr>
</tbody>
</table>
We have orders of 250+ electric buses from various cities across India and the number is growing.

<table>
<thead>
<tr>
<th>City</th>
<th>No. of buses required</th>
<th>Bus length</th>
<th>Floor height</th>
<th>Bus Type</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AC</td>
<td>Non-AC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indore</td>
<td>40</td>
<td>-</td>
<td>9m</td>
<td>900 mm</td>
</tr>
<tr>
<td>Kolkata</td>
<td>80</td>
<td>-</td>
<td>40 -9m; 40 -12m</td>
<td>900 mm</td>
</tr>
<tr>
<td>Lucknow</td>
<td>40</td>
<td>-</td>
<td>9m</td>
<td>900 mm</td>
</tr>
<tr>
<td>Guwahati</td>
<td>-</td>
<td>15</td>
<td>9m</td>
<td>900 mm</td>
</tr>
<tr>
<td>Jammu/Srinagar</td>
<td>-</td>
<td>40</td>
<td>9m</td>
<td>900 mm</td>
</tr>
<tr>
<td>Jaipur</td>
<td>40</td>
<td>-</td>
<td>9m</td>
<td>650 mm</td>
</tr>
</tbody>
</table>
Features of our Electric buses with proven advanced technology

- These are built on existing proven platforms of Starbus Ultra
- TATA Motors has designed the buses in house with critical EV aggregates sourced from internationally known best in class suppliers, from USA, Germany and China.
- The entire vehicle architecture and Software strategy designed, tested and validated in house.
- Best Energy consumption performance due to direct drive and system optimization – **20% better energy consumption as compared to competition buses.** This allows to use most optimum size of battery to use the desired range.
- Li-ion batteries with NMC are best suited for Electric Vehicles as they have good specific energy and power density.
- Li-ion batteries with NMC are best suited for **fast charging** (120Kwh pack can be fully charged in 2 hrs.)
- **Batteries on roof top to prevent breakdowns due to water logging.**
- Batteries are liquid cooled to keep temperature within an optimum range to ensure longer life and better performance in tropical conditions as in India.
- Most of the models have been Type Approved and registered under FAME scheme.
- Annual Maintenance Contract, extended warranty, finance etc. is available if required.
- **Extensive trials have been done** in Himachal, Chandigarh, Assam and Maharashtra to establish performance in different geographies of the country.
E-Buses can run on all routes and get charged during shift break at mid-day

1. **Start of day**
   (All buses start at respective depots with full charges)

2. **Daily Operation**
   (Vehicle operated on designated route till shift-end)

3. **Shift changeover**
   (Vehicles come back to depot for shift change, top-up charging to be carried out)

4. **End of Day**
   (All batteries recharged at respective depot)

- **Full charge** ~ 2 hours
- **60 km top-up** ~ 1 hr

Routes will be optimized to enable 5 minute service levels and e-Bus utilization

1. Average number; different for every route
Tata Group is taking the lead in electrifying transportation in India

**Tata Group has laid out a strong vision to shape EV adoption in India**

- Achieve 1 million Tata EVs on the road by FY25
- Proactively build the EV market in India & drive breakthrough adoption
- Provide unique value proposition of our EV offerings through a Tata e-Mobility ecosystem

**Tata Group companies are working together to create an EV ecosystem**

- **Data Platform/BMS**
- **Charging Infra**
- **Financing**
- **Buses**
- **Insurance**
- **Mobility Services**
- **Battery**

**Key Achievements in Electric Buses**

- Supplying majority of electric buses in India – won 250+ buses via tenders
- Supplied Electric Buses to 5 cities across India
- We received “ICV People Mover of the year” and “CV of the year” award for Ultra 9m Electric Bus at Apollo CV Awards
- Tata Motors received “Best solution Provider for Electric Vehicles” at Smart, Livable and Resilient City Conclave, Pune
Requirement

E-Bus
Chargers
Charging Infra

Considering Depot/Dedicated Space as Charging hub

Charging to be done at Depot during Night time – 2.5 hrs per bus for full charge
Installation of charging systems at the depot would be part of the service.

**DC Charger specifications**

- Power: 120 kW
- Concurrent charging: 2 vehicles

**Charger solution offered**

Installation offered with AMC, including warranty period.
TML can provide chargers and buses along with setting-up charging infrastructure for 11 KV input

<table>
<thead>
<tr>
<th>Infra requirement</th>
<th>TML’s Scope- TML will provide Chargers after studying the routes – approx. 1 charger for 2 buses</th>
</tr>
</thead>
<tbody>
<tr>
<td># Fast Chargers proposed (120 KW)</td>
<td></td>
</tr>
<tr>
<td>Civil / Electrical Infra set-up required from Tata?</td>
<td>Depot is expected to have 11 KV Line which is required for charging of buses</td>
</tr>
<tr>
<td>Note: 11KV line supply will be in scope of client</td>
<td></td>
</tr>
<tr>
<td>Civil structure (Transformer platform)</td>
<td>Assumed to be available</td>
</tr>
<tr>
<td>Statutory approvals</td>
<td>Assumed to be available</td>
</tr>
<tr>
<td>Parking</td>
<td>Assumed to be available</td>
</tr>
<tr>
<td>Substation for 33 KVA to 11 KVA</td>
<td>Assumed to be available</td>
</tr>
<tr>
<td>HT Cables</td>
<td>Can be Part of TML/User scope (optional)</td>
</tr>
<tr>
<td>RMU – Ring Main Unit</td>
<td>Can be Part of TML scope (optional)</td>
</tr>
<tr>
<td>Metering (CT, PT)</td>
<td>Can be Part of TML scope (optional)</td>
</tr>
<tr>
<td>Sub-Transformer (11 KV / 415 V)</td>
<td></td>
</tr>
<tr>
<td>LT Cabling</td>
<td></td>
</tr>
<tr>
<td>Feeder Pillars</td>
<td></td>
</tr>
<tr>
<td>Assumed to be available</td>
<td></td>
</tr>
</tbody>
</table>
TML has the widest range of pure Electric buses

<table>
<thead>
<tr>
<th>Floor Height</th>
<th>7metre</th>
<th>9 to 9.5metre</th>
<th>12 metre</th>
</tr>
</thead>
<tbody>
<tr>
<td>900mm</td>
<td>![Bus Image]</td>
<td>![Bus Image]</td>
<td>![Bus Image]</td>
</tr>
<tr>
<td>650mm</td>
<td>![Bus Image]</td>
<td>![Bus Image]</td>
<td>![Bus Image]</td>
</tr>
<tr>
<td>400mm</td>
<td>![Bus Image]</td>
<td>![Bus Image]</td>
<td>![Bus Image]</td>
</tr>
</tbody>
</table>
SMART FEATURES: Connected Vehicle

- Fleet management and location based information
- Vehicle Health monitoring and early warning of failures
- Driver identification and profiling
- Quick breakdown assistance

Data Analytics and Knowledge base
- Wi-Fi based Diagnostics
- Android based applications for complete Fleet & Service Management
- Workshop Management

Vehicle Data over GPRS
- Media Streaming for Driver
- Navigation
- Driver Entertainment

Safety Application Development
- Intersection Assistance
- Sudden Halt warning
- Reporting Accidents

Next Generation Telematics – 2015-16

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## Summary Certain parameters

<table>
<thead>
<tr>
<th>Parameters / Models</th>
<th>4/12m Low Floor Full Electric</th>
<th>9/12m Full Electric</th>
<th>Ultra Electric 6/9m</th>
<th>Ultra Electric 9/9m</th>
<th>7m Electric Bus (Planned)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Length</strong></td>
<td>12 m</td>
<td>12 m</td>
<td>9 m</td>
<td>9 m</td>
<td>Upto 7 m</td>
</tr>
<tr>
<td><strong>Floor Height</strong></td>
<td>400 mm</td>
<td>900 mm</td>
<td>650 mm</td>
<td>900 mm</td>
<td>900 mm</td>
</tr>
<tr>
<td><strong>Lead on Single Charge</strong></td>
<td><em>(Depends on drive and traffic conditions)</em></td>
<td><em>(Depends on drive and traffic conditions)</em></td>
<td><em>(Depends on drive and traffic conditions)</em></td>
<td><em>(Depends on drive and traffic conditions)</em></td>
<td><em>(Depends on drive and traffic conditions)</em></td>
</tr>
<tr>
<td></td>
<td>*100 - 150 km (Extendable)</td>
<td>*100 - 150 km</td>
<td>*150 - 170 km</td>
<td>*150 - 170 km</td>
<td>*100 - 150 km</td>
</tr>
<tr>
<td><strong>Charging Time</strong></td>
<td>Normal: 4-6 Hr</td>
<td>Normal: 4-6 Hr</td>
<td>Normal: 4-6 Hr</td>
<td>Normal: 4-6 Hr</td>
<td>Normal: 4-6 Hr</td>
</tr>
<tr>
<td></td>
<td>Fast Charging: 2 Hr</td>
<td>Fast Charging: 2 Hr</td>
<td>Fast Charging: 2 Hr</td>
<td>Fast Charging: 2 Hr</td>
<td>Fast Charging: 2 Hr</td>
</tr>
<tr>
<td><strong>Charging Infrastructure Reqd.</strong></td>
<td>60 -120 KW charger</td>
<td>60 -120 KW charger</td>
<td>60 -120 KW charger</td>
<td>60 -120 KW charger</td>
<td>60 -120 KW charger</td>
</tr>
<tr>
<td><strong>Power Consumption</strong></td>
<td>0.9 to 1.2 KW/Hr</td>
<td>0.9 to 1.2 KW/Hr</td>
<td>0.7 to 0.9 KW/Hr</td>
<td>0.7 to 0.9 KW/Hr</td>
<td>0.5 to 0.7 KW/Hr</td>
</tr>
<tr>
<td><strong>Scope of warranties</strong></td>
<td>Standard - 2 Years, Batteries &amp; Motors - 4 Years (AMC as an option can be provided for the life cycle of the bus)</td>
<td>Standard - 2 Years, Batteries &amp; Motors - 4 Years (AMC as an option can be provided for the life cycle of the bus)</td>
<td>Standard - 2 Years, Batteries &amp; Motors - 4 Years (AMC as an option can be provided for the life cycle of the bus)</td>
<td>Standard - 2 Years, Batteries &amp; Motors - 4 Years (AMC as an option can be provided for the life cycle of the bus)</td>
<td>Standard - 2 Years, Batteries &amp; Motors - 4 Years (AMC as an option can be provided for the life cycle of the bus)</td>
</tr>
<tr>
<td><strong>Seating Capacity</strong></td>
<td>31+1D &amp; Standees</td>
<td>40 + 1D &amp; Standees</td>
<td>26 +1D &amp; Standees</td>
<td>31 + 1D &amp; Standees</td>
<td>&gt;15 + 1D &amp; Standees</td>
</tr>
</tbody>
</table>
Our e-Bus mobility solutions offers several advantages, while addressing the typical challenges in acquiring e-Buses

Advantages of e-Buses

- Zero Tailpipe emissions – improves air quality
- 40-50% lower fuel costs compared to diesel buses
- Reduces diesel cost burden (~52% of overall cost)
- Lower maintenance downtime and costs compared to diesel buses

Additional advantages through an end-to-end mobility solution

- One stop solution – no coordination hassles between suppliers to integrate different parts of the e-mobility ecosystem
- Savings from day 1 – lower net cost / km to NMC
- Greater control of vehicle operations – ensure service delivery to employees
- Potential to drive greater ridership and better user satisfaction
- Potential to optimize vehicle routes and operating costs, increase efficiency through digital solutions including fleet management and monitoring, Bus Stop Monitoring and Management.
- Potential for additional revenue from monetization of vehicle data
Tata Motors starts supply of 40 electric buses for Lucknow city transport

Tata Motors said on Sunday that it will be supplying 40 air-conditioned electric buses to the Lucknow City Transport Services Ltd (LCTL) in a phased manner within the next four months.

40 electric buses soon to hit J&K Roads

Jammu, Mar 3 (UNI) Giving a major boost to the government’s vision of electrification in transport sector, as many as 40 electric buses would soon hit the roads of Jammu and Kashmir.

"The Jammu and Kashmir State Road Transport Corporation is soon going to introduce 40 electric buses in both Jammu and Srinagar regions, likely from the month of May," officials sources here said.

They said that air and noise pollution-free, electric buses will run on separate routes in both Jammu and Srinagar regions and added, "these lower floor buses will be added to the State Road Transport Corporation next month but will be made functional in May."
E-Bus Inauguration Pics in several states
Lucknow inspection Pics at various stages. Jammu customers were also shown Electric buses
Key Points related to charger installation:

- Approx 66 chargers are installed at various depots of Kolkata (Nonapkur, Salt lake depot, Kasba Depot, Howrah Depot)

- 1 chargers each is also installed in Lucknow Alambagh Depot and Indore. More chargers will be installed within 31st March at various locations in India
<table>
<thead>
<tr>
<th>Cities</th>
<th>9 m</th>
<th>12 m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kolkatta</td>
<td>40</td>
<td>40 Nos Expected in July</td>
</tr>
<tr>
<td>Lucknow</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>Indore</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>Jammu</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Kashmir</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Guwahati</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>175</td>
<td></td>
</tr>
</tbody>
</table>

TATA Buses have covered more than 5 Lakh kms of operation.
Alternate technology-
HYBRID
Starbus Hybrid

- Power Train - Series Electric Hybrid with 5 Litre Diesel Engine
- Transmission – Automatic
- Suspension – Electronically Controlled Air Suspension At Front & Rear
- Brakes – Electronic Braking system with disc brake in front & Rear
- Passenger Capacity – 31+1 Seats (Can be used as Tarmac Coach)
- Floor height – 400 mm Full low floor
- Max Speed – 80 Km/hr.
- Budgetary Price – 2.5* Cr for Diesel & 2.75* Cr for CNG
Hybrid Electric bus operation

Diesel Genset → Inverter → DC Bus 500 – 800 V → Traction Inverter → IM Motor → Transmission

Battery Pack

Accelerating
Smart Features: Contemporary Styling – Interior & Exterior
Integrated Head Lamp with DRL & LED Position and Side Blinker
Dashboard Swings with Steering Column and VDV based Layout
• Front Inswing Door and Rear Outswing Door for easy ingress and exit for passengers
• Large Panoramic Windows
• Fully Low Floor till Back
• Warm Interiors
Seats for Disabled with Seat Belt and Back Support
Seats for Disabled with Seat Belt and Back Support
Over Hang Seats
USB Charging Integrated with Seats
Domestic commercial vehicle major Tata Motors today handed over 25 Starbus Series hybrid (electric-diesel) buses to the Mumbai Metropolitan Regional Development Authority (MMRDA), as part of the state government’s effort to adopt lower emission vehicles in public transport. These buses are the electrified version of Tata Motors’ Starbus.

The Union minister for Heavy Industries and Public Sector Enterprises, Anant Geete, said: “Our ministry is focused on promoting the FAME Scheme. We had invited all states and cities to take advantage of the subsidy towards adopting electrified vehicles that will reduce pollution in the cities. I am happy that MMRDA has taken a lead in adopting the new technology which will help Mumbai city reduce emission levels.”
• TML is ready with capacity to build more than 100-200 buses per month and increase the capacity multiple times once we have sufficient time to ramp up production. Need 6 months to start supplies especially batteries which are imported.

• Power infrastructure has to be planned well in advance before buses are produced. At some of the locations buses procured under FAME 1 are not in operation as power infrastructure is still not there after more than 2 year’s of having placed orders for buses.

• Routes have to be selected and tweaked if required to improve on efficiency and utilization so that we can get the best out of electrification. Accordingly range of bus should be selected to enable fast charging at intervals instead of having battery capacity which would last for complete day. To choose between carrying people vrs carrying batteries.
How to make electric buses in public transport sustainable

We need to find out ways and mean to make electric mobility viable without subsidy if we want it to be sustainable.

• Preference to buses over private transport.

• Improvements through innovation has to be incorporated as a process in working of all stakeholders.

• City buses would give higher benefits over intercity buses as primary purpose is to reduce pollution and congestion in the cities.

• Finances have to be arranged for complete contract period before the project is started. This could be one of the most critical factor for success of PPP model of operation in future of public transport. Guaranteed payments have to be ensured.

• Follow guidelines of DHI/ MCA (Niti Aayog) and procurement through GeM portal should be done instead of working on different tender terms and conditions.
## Electric buses are now in the range of commercial viability

<table>
<thead>
<tr>
<th>New CNG Fleet</th>
<th>New e-Bus Fleet</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>New Bus Capex</strong></td>
<td>45 – 50 Lacs / bus</td>
</tr>
<tr>
<td><strong>Capex/ km (for life of vehicle)</strong></td>
<td>27 – 33%</td>
</tr>
<tr>
<td><strong>Operating costs</strong></td>
<td></td>
</tr>
<tr>
<td>• Fleet Maintenance</td>
<td>35 – 40%</td>
</tr>
<tr>
<td>• Fuel</td>
<td>25 – 27%</td>
</tr>
<tr>
<td>• Insurance</td>
<td>2%</td>
</tr>
<tr>
<td><strong>Cost/ km</strong></td>
<td>100%</td>
</tr>
</tbody>
</table>

## Additional Benefits
- Environmentally friendly – no tailpipe emissions
- Higher ease of maintenance
- Lower CNG subsidies for Delhi government
- Additional features to improve customer experience & cost – e.g., vehicle connectivity
THANK YOU