# ISGF Presentation

*Implementation Plan for Electrification of Public Transportation in Kolkata*


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# ISGF

**www.indiasmartgrid.org**

- *A Public Private Partnership initiative of Ministry of Power, Government of India for accelerated development of smart grid technologies in the Indian power sector;*
- *ISGF work with MNRE, MoUD, DoT, DST, DHI, CEA, CPRI, CERC, Niti Aayog, NSGM, NCIIPC; and also with State Governments, Utilities and Regulators*
- *Work with national and international agencies in standards development and help Utilities, Regulators and the Industry in technology selection, training and capacity building*
- *Conducts research studies and publishes White Papers and Technical Reports, Training Programs and Seminars, Bilateral and Multilateral collaboration Workshops*
- *Advise Governments on policies and programs for electric grid modernization Evolved as a Think-Tank of global repute on Smart Grid and Smart Cities; 6 Working groups focused on different aspects of Grid Modernization*

# Why Kolkata?

- First electric utility in the country -1899
- Pioneer in Electric Transportation in India – Trams: 1902, Metro:1987
- Extensive and diverse public transport network – bus, rail, metro, tram, 3W, taxis, ferries, cycle rickshaws
- Efficient operators of transportation and electricity networks – both public and private
- History of DC distribution and knowledge base of handling DC systems
  - 550 V DC network in operation by the tram company
  - CESC used to supply DC power for almost a century to industrial customers in Kolkata
- High percentage of users of public transport amongst vehicle owners
- Cultured and disciplined citizen receptive to new ideas and technologies

# Existing Transport Infrastructure in Kolkata

**Rail Infrastructure**

- Sub-urban rail system with 145 railway stations is electrified; metro network of 27.22 km with 24 stations in operation another corridor 14.67 km is in advanced stages of construction. Plans for expansion of another 100 km.

**Trams**

- Calcutta Tramways Company (CTC) operates 151 trams on 24 routes (57 km)
- 550 V DC network from 10 substations supplied at 6KV AC support the tram network

**Taxis**

- About 14,000 conventional taxis and 30,000 taxis under Uber and Ola

**3-Wheelers**

- 11,315 number of 3-Wheelers on CNG/LPG run on 125 fix routes; another 100,000+ e-Rickshaws (locally known as TOTOs) with lead acid batteries

**Buses**

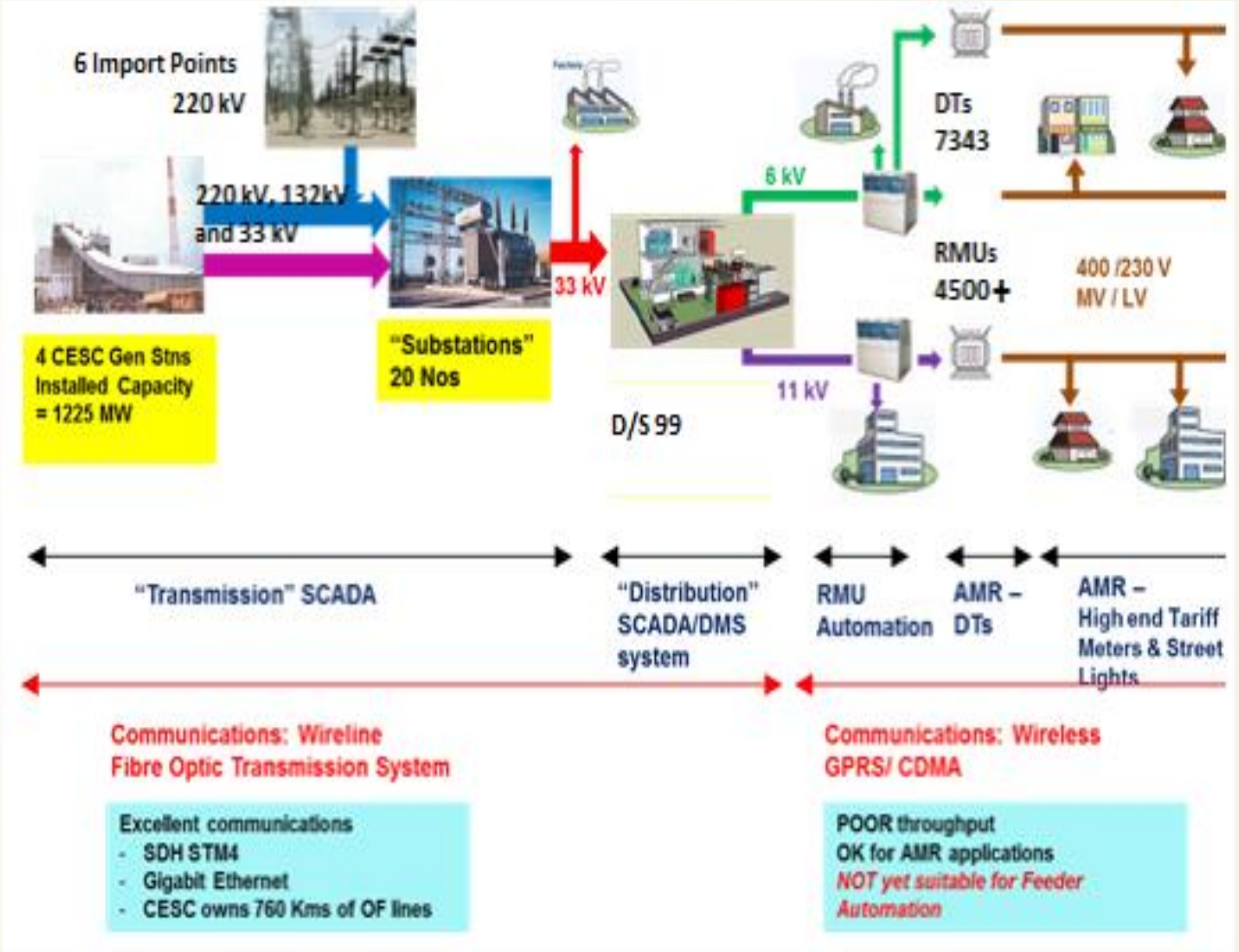
- 11621 buses operates on 925 routes – 1866 by government agencies, rest by private

**Ferries**

- 52 large boats in operation on 16 routes – capacity 400 people and/or 300 vehicles

# Existing Electrical Infrastructure in Kolkata

- Two electricity distribution utilities in Kolkata – CESC and WBSEDCL
- Also Overhead 550V DC systems of CTC which could be leveraged for fast charging of bus fleet
- The area covered in this study is serviced by CESC
- Impact of EV charging on the grid has been analyzed in the study



# Bus Route Analysis

- Under a World Bank TA in 2016, Ideation Technologies surveyed all the 925 bus routes and digitized on a GIS map as well as compiled traffic data including pollution levels in select areas in the city
- With support from World Bank, ISGF and Ideation Technologies analyzed the traffic data and selected top 10 bus routes for electrification based on:
  - **Route Congestion:** Most congested routes contribute to higher fuel consumption and higher emission; this was verified with smart sensors for pollution monitoring - **evidence based route selection for electrification**
  - **Route Distance:** Shorter routes opted to optimize lower battery size and hence lower cost of EVs
  - **Overlap with Electric Tram Infrastructure**: Access to the 550 V DC network

# Top 10 Bus Routes Identified for Electrification

| Sl.No | Unique Route Name | Source to Destination | Average Passenger per trip | Route Length (km) | Overlap with Tram Route (%) | Peak Hour Frequency |
|---|---|---|---|---|---|---|
| 1 | S-12D | HOWRAH - THAKURPUKUR 3A BUS STAND | 45.26 | **17** | 9.38 | 10 mins |
| 2 | S-05 | GARIA BUS STAND - HOWRAH | 42.95 | **17.5** | 21.74 | 15 mins |
| 3 | E-01 | JADAVPUR 8B BUS STAND - HOWRAH | 41.03 | **13.5** | 14.29 | 5 mins |
| 4 | VS-1 | AIRPORT 2 NO GATE - ESPLANADE | 37.41 | **20** | 21.88 | 10 mins |
| 5 | S-47A | BEHALA AIRPORT - HOWRAH | 35.62 | **15** | 36.36 | 10 mins |
| 6 | S-07 | GARIA BUS STAND - HOWRAH | 35.46 | **16.5** | 26.47 | 15 mins |
| 7 | S-03B | BEHALA 14 NO - KANKURGACHI | 35.26 | **14.5** | 51.71 | 15 mins |
| 8 | S-12 | HOWRAH - NEWTOWN BUS DEPOT | 34.30 | **20.5** | 17.24 | 10 mins |
| 9 | S-03A | SEALDAH (JAGAT CINEMA) - THAKURPUKUR 3A BUS STAND | 33.87 | **17** | 43.47 | 15 mins |
| 10 | S-22 | SAKUNTALA PARK - KARUNAMOYEE (SALT LAKE) | 32.51 | **16.5** | 12.5 | 20 mins |

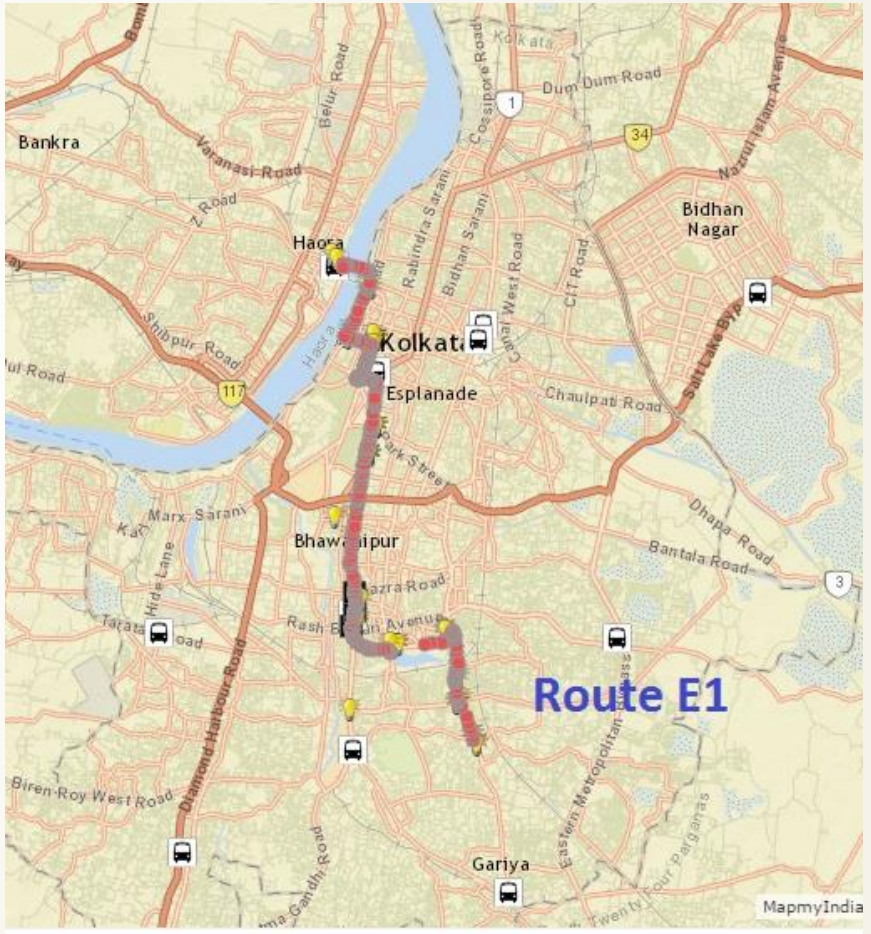
**Most of the buses travel only 100-120 km per day**

# Route E1: Jadavpur 8b Bus Stand – Howrah

BUS STOPS: DHAKURIA / ANWAR SHAH ROAD / RASHBIHARI MORE / KALIGHAT / HAZRA / RABINDRA SADAN / PARK STREET / ESPLANADE / B B D BAG / BARABAZAR

| Peak Hour Frequency | Average Number of Passenger/day/Journey | Number of bus operated | Bus trips/day/bus | Number of Bus Depots (Start – On route – End) |
|---|---|---|---|---|
| 5 Mins | 41.03 | 19 | 3 | 2 |

| Bus Depot Name | Substation | Transformer Capacities (kVA) | Peak Load (Amp) | |
|---|---|---|---|---|
| | | | Day | Night |
| Howrah | Mukhram Kanoria Rd O/T | 315 | 168 | 204 |
| Esplanade | Esplanade (S) P/T | 315 | 204 | 300 |



# Key Findings

| Transport Type | Findings | Remarks |
|---|---|---|
| **Buses** | Top 10 routes (119 buses) in the city core having significant overlap with the tram network<br>There are 7 Bus Depots on these routes; 4 of them are in close proximity to Tram network | The CTC's DC network is under-utilised and can be leveraged with capital investment for establishing fast charging stations in 4 Bus Depots<br>**WBTC has placed order for 80 electric buses; first batch of 20 will be delivered in September 2018** |
| **3-Wheelers** | Top 7 auto-rickshaw routes represent approximately 25% of the total auto-rickshaws; each having >300 autos which may be taken up first for conversion to electric | There is a bigger opportunity for conversion of lead acid batteries to lithium ion batteries in >100,000 e-rickshaws (TOTOs) operating in city outskirts |
| **Taxis** | No specific routes identified owing to lack of access to authentic data | Opportunity exist for approximately 40000 taxis and shared cars to be electrified |
| **Ferries** | Top 2 routes out of 16 passenger routes recommended for conversion to electric ferries | 6 boats operating in these two routes can be serviced from single charging station at Howrah Jetty |
| **Trams** | Dedicated Goods Tram service during the night between Sealdah and Howrah | Help local vendors transport goods brought to Sealdah railway station to different locations within the city at cheaper rates and also de-congest the city roads |

# Cost Benefit Analysis (CBA) - Buses

CBA model compared the Total Cost of Ownership (TCO) over 10 year life as well as Net Present Value (NPV) of a Diesel Bus and 3 models of Electric Buses with different sizes of onboard batteries – 100 kWh, 200 kWh and 300 kWh (LFP Batteries and 12m buses)

| | Diesel Bus | EV1 (100 kWh) | EV2 (200 kWh) | EV3 (300 kWh) |
|---|---|---|---|---|
| TCO (INR Crores) | 7.91 | 5.02 | 7.63 | 9.79 |
| NPV (INR Crores) | 4.43 | 3.1 | 4.63 | 5.99 |

- EV1 with a 100 kWh battery is far cheaper to own and operate than a diesel bus over the life of 10 years. There is a net savings of INR 7 million (or almost a full diesel bus)
- In another look, STU can afford 3 EV1 100 kWh buses for the price of 2 diesel buses over the life of 10 years
- Even the EV2 with 200 kWh battery gets a close parity with diesel bus on both on TCO and NPV

# Some Key Takeaways

- Presently available buses come with 300km driving range and >300kWh batteries. Battery usually weighs around 6 tons (much more than the weight of passengers + rest of bus) – more electrons spent on moving the battery!
- In most Indian cities average driving range is 100-120 km/day; 100-150 kWh battery should be sufficient. This will reduce the cost of bus by almost 30-40% and becomes cost effective with out government subsidies
- Cost difference between AC and Non-AC buses is only 10% (in Non-AC buses also batteries need to be kept below 30 degree C)
- AC buses will offer pollution free (air + noise) and fatigue free travel to passengers which will promote shared mobility
- Vehicle-Grid Integration (VGI) services will help low voltage electric grid balancing – integration of rooftop PV on distribution grid
- EVs offer multiple benefits: emission reduction, shared mobility, promotion of clean energy – all leading to transition to low carbon economy

# Implementation Roadmap: Buses

| Priority Determinant | Implementation Roadmap | | |
|---|---|---|---|
| | Immediate (up to 2 years) | Near-Term (3-5 years) | Long-Term (6-8 years) |
| **Proposed Deployment** | 119 buses in 10 selected routes | All 1,866 buses operated by the State government agencies on 376 routes | 100% of the buses operating in Kolkata (includes school, private, PSU buses) |
| **Social and Environmental** | • Monetize diesel savings of 32,500 litres/bus/year x 119 buses = 3.9 Million Litres/year for electrification<br>• Monetize $CO_2$ savings of 87 Tons/bus/year x 119 buses = 10,350 Tons/year for electrification | • Monetize diesel savings of 32,500 litres/bus/year x 1,866 buses = 60 Million Litres/year for electrification<br>• Monetize $CO_2$ savings of 87 Tons/bus/year x 1,866 buses = 162,350 Tons/year for electrification | • Monetize diesel savings of 32,500 litres/bus/year x 15,000 buses = 490 Million Litres/year for electrification<br>• Monetize $CO_2$ savings of 87 Tons/bus/year x 15,000 buses = 1.3 Million Tons/year for electrification |
| **Policy and Tariff Design** | • Finalize specifications for 9 meter buses and with battery size of 100 kWh capacity<br>• WBERC to issue enabling regulations for WBTC and/or CESC to own and operate charging infrastructure<br>• Ease the import duties for lithium ion batteries and chargers<br>• Training of O&M personnel on the use EVs | • Finalize specifications for 9 meter buses and with battery size of 200 and 300 kWh capacity<br>• Promote local manufacturing and/or assembly of EVs, batteries and components, and charging stations<br>• WBERC to issue regulations to allow franchisees to set up charging stations<br>• WBERC to notify separate tariff for EVs<br>• Creation of a large pool of trained O&M personnel on the use EVs<br>• Education and outreach to raise awareness among public to adopt EVs | • Large scale local manufacturing and import of EVs, batteries and components, and charging stations<br>• Enabling electricity market redesign to use EV, as grid resources |
| **Charging Standards** | • Mandate BIS recommended standards for EV and charging infrastructure. Consider both power and communications, including grid<br>• In case, the release of BIS standards is delayed, Kolkata should not adopt any EV and charging infrastructure with proprietary protocols | | |
| **Business Models for EV Operations** | • WBTC shall own and operate this first batch<br>• WBTC to own and operate appropriate chargers in their bus depots | • Bus operators to set up appropriate charging stations in their bus depots<br>• DISCOM/Franchisees to set up charging stations at bus terminus/bus interchanges | • Third party operators to set up public charging infrastructure at highways and other strategic locations |
| **Vehicle Grid Integration** | • None | • Enabling regulations and dynamic tariffs for VGI<br>• Infrastructure upgrade plans to facilitate VGI | • Infrastructure upgrade to facilitate VGI |

# Electric Bus Rollout in Kolkata

- West Bengal Transport Corporation (WBTC) has in principle accepted the recommendations of the study report including the routes identified
- WBTC received grant from GoI under FAME program for buying 80 electric buses and procured those buses from Tata Motors
  - 40 buses of 9 Meter with 125 kWh batteries (operational since February 2019)
  - 40 buses of 12 Meter with 188 kWh batteries (are expected to be delivered in July 2019)
- These buses are deployed in the congested routes and also the routes running across the city catering to maximum passengers
- To ensure hassle free operation of the electric buses, WBTC procured 80 EV chargers comprising of 58 nos. of 60 kW slow charging stations for overnight charging at the depots and 22 nos. of 120 kW (double gun 60 kW*2) fast charging stations for opportunity charging at the terminus
- One fast charging station of 120 kW has also been installed in each of the depots to facilitate opportunity charging during daytime

# Electric Bus Rollout in Kolkata – FAME II

- West Bengal has been allocated 150 buses under FAME II and will be applying for more buses for the Kolkata city
- Apart from the existing nine depots for electric bus parking in Kolkata city, three new depots will be added whereas only one depot in Asansol, Haldia and Siliguri, and two depots in Durgapur and New Town will be allocated for the parking of electric buses
- Charging points for the buses installed in Bus Depots where buses are charged overnight; and also at Bus terminuses where buses are charged during turnaround time (opportunity charging).
- Battery performance being compiled. the operational data of the existing electric bus fleet in terms of depth of discharge (DoD) of the battery after completion of a particular trip, charging time of the battery to achieve 100% state of charge (SoC), impact on battery SoC due to temperature, passenger load, route congestion etc. will be evaluated to figure out the best suited battery capacity for these 150 buses
- World Bank appointed ISGF to assist WBTC for creation of electrical infrastructure in Bus Depots and Bus Terminuses for installation of Chargers

# *Question & Answers*

# *Thank You*

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