Technical Assistance for BMTC Transitioning to an all - EV/Clean Fuel Public Transport Fleet

Business Case for Full Electrification of BMTC Fleet
Part 2 – Implementation and Procurement Strategy

C40 Cities Finance Facility

November 2020
ABOUT THE C40 CITIES FINANCE FACILITY

The C40 Cities Finance Facility (CFF) is a collaboration of the C40 Cities Climate Leadership Group and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. The CFF supports cities in developing and emerging economies to develop finance-ready projects to reduce emissions to limit global temperature rise to 1.5°C and strengthen resilience against the impacts of a warming climate. The CFF is funded by the German Federal Ministry for Economic Cooperation and Development (BMZ), the Children’s Investment Fund Foundation (CIFF), the Government of the United Kingdom and the United States Agency for International Development (USAID).

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LIST OF ABBREVIATIONS

AC    Airconditioned
AMC   Annual Maintenance Contract
BEST  Brihanmumbai Electricity Supply and Transport
BMTC  Bangalore Metropolitan Transport Corporation
BESCOM Bangalore Electric Supply Company Limited
BBMC  Bruhat Bengaluru Mahanagara Palike
BP    Bangalore Police
CAPEX Capital Expenditure
CNG   Compressed Natural Gas
DTC   Delhi Transport Corporation
e-bus/ e-bus Electric bus
FAME  Faster Adoption and Manufacturing of Electric vehicles
GCC   Gross Cost Contracting
GoI   Government of India
GoK   Government of Karnataka
ICE   Internal combustion engine
KPI   Key Performance Index/Indices
OEM   Original Equipment Manufacturer
O&M   Operations and Maintenance
OPEX  Operating Expenditure
PPMU  Pilot Project Management Unit
PIU   Project Implementation Unit
SPV   Special Purpose Vehicle
EXECUTIVE SUMMARY

Shift to green and clean technology in urban bus operations has come to focus from both the national and state governments. As city bus operations (presently fuelled by Diesel and CNG) are one of the large contributors to PM2.5 levels, adoption of electric bus technology has been driven by central government funded FAME scheme(s) in Indian cities. Adoption of electric bus technology, combined with a review of operational planning and service delivery, would not only bring medium to long term operational improvements but also prospective cost reductions, service level improvements and user satisfaction through rationalisation and optimisation in resource usage.

The business case of BMTC’s full transition to electric bus technology by 2032 (Business case report-Part1), has analysed and recommended for a gradual transition from diesel-based operations to electric bus-based operations. The study provides a tactical outlook on possibilities and scale of transition that BMTC may consider while adopting the actual path of transition.

Given the complexities as well as lack of long term experience of BMTC with adoption and deployment of this new technology, strong need is felt that BMTC devise, adopt and execute an Implementation Strategy as well as a procurement strategy whereby the implementation strategy provides an overall structure, direction and push to the electric bus induction and transition within BMTC, and the procurement strategy provides a functional platform and engine of transition, in line with the identified scale, pace and outcomes.

This report deliberates the suggested approach towards formulation of two strategies alongside their primary components needing focus and consideration. A project-based approach defining purpose, details, timelines, outputs and outcomes will be the starting point for setting the ball rolling on e-bus adoption and transition. An early and phased implementation with external support from industry, finance institutions, Green equity funds and experts can provide extended support and advise in technology adoption, implementation and training of internal staff.

A brief set of examples of e-bus adoption by cities across the globe are added for a quick overview of adopted strategies.
1 INTRODUCTION

1.1 Background

Metropolitan city public bus service is a prominent and important element of transportation among the urban dwellers. However, public bus agencies are facing multiple challenges, primarily around competition from new and existing urban transport systems, falling ridership level and growing cost of operations. There is constant need and pressure to upgrade service levels even when financial losses keep mounting. The public transit agencies are required to find new opportunities of not only cost reductions but also of improving, or at least safeguarding the prevalent patronage levels. Service re-organisation, identifying new demand pockets and technological upgradation are possible areas of opportunities toward managing the above ongoing challenges.

Shift to green and clean technology in urban bus operations has come to focus from both the national and state governments. As city bus operations (presently fuelled by Diesel and CNG) are one of the large contributors to PM2.5 levels, adoption of electric bus technology has been driven by central government funded FAME scheme(s) in Indian cities.

The electric bus technology adoption is very closely linked to route operational characteristics such as duration of operations, daily distance coverage by electric bus, availability of gaps in operations for possible recharging, service level requirements and passenger load levels. The Business case analysis for full transition of BMTC fleet operations to electric bus technology, as carried out under this technical assistance, has indicated that such a transition is expected to be financially viable over medium to long term than continuing with the diesel-based operations of buses.

1.2 Need for Implementation and Procurement Strategy

Adoption of electric bus technology, combined with a review of operational planning and service delivery, would not only bring medium to long term operational improvements but also prospective cost reductions, service level improvements and user satisfaction through rationalisation and optimisation in resource usage.

With above background and given the complexities as well as lack of long-term experience of BMTC with adoption and deployment of this new technology, strong need is felt that BMTC devise, adopt and execute an Implementation Strategy as well as a procurement strategy for the recommended transition over next decade or so. With implementation strategy providing an overall structure, direction and push to the electric bus induction and transition within BMTC, adoption of a procurement strategy will provide a functional platform and engine of transition, in line with the identified scale, pace and outcomes.

For electric bus technology adoption, the two will provide a planned approach, guided timelines, scale and nature of transition. This would simultaneously project BMTC and government’s commitment to this transition, that in turn will further benefit BMTC through prospective strong tie ups with industry, technology and academia.
1.3 Suggested Approach for Electric bus technology Implementation & Procurement

The business case, of BMTC’s transition to electric bus technology, has analysed and recommended for a gradual transition from diesel-based operations to electric bus-based operations. It provides a tactical outlook on possibilities and scale of transition that BMTC may consider while adopting the actual path of transition. The deliberation on suitable approach, of the implementation and procurement strategy, is carried out through following areas of actions that BMTC may initiate for this transition.

Adoption of long-term commitment and strategy, reflecting clarity and flexibility towards transitioning to electric bus technology, will immensely help initiating a formal dialogue and plan of transition. Such approach will also showcase organisation’s zeal for continual improvement through technological advancements, service level enhancements, and meeting up of social and environmental obligations.

Additionally, and importantly, the strategy for transition to new technology needs to accommodate exhaustive market study of products and solutions availability for identified specific requirements of route and service operations, as these are considered for transition by BMTC. Accordingly, adoption of slow and steady pace of transition is essential to ensure selection of appropriate solutions from among multiple options of battery size, chemistry, charging infrastructure and vehicle specifications.

Another dimension of suggested approach is look out for multiple technology solutions for different operational and service level needs that organisation BMTC would have to keep exploring, strengthen and innovate. For example, needs of electric bus transition of a dedicated bus operations corridor will be different from that of an ordinary bus service, operational in normal roads and traffic environment. Similarly, specially designed bus services for dedicated user base may pose opportunities for mid-day charging and accordingly technology selection can scan across smaller battery size, battery swapping and/or combination charging.

As electric bus technology is maturing fast alongside impressive cost corrections, availability of a platform for continued and early understanding within the organisation can provide immense benefits towards a planned transition. In this context starting early on the journey of transition to new electric bus technology will provide an edge to BMTC. The team engaged with project of transition could take informed decisions on suitability and scale of adoption for differing operational needs.

Develop partnerships with relevant city agencies (primarily BESCOM, BMC, BDA and Traffic police) as well as electric bus industry, financial institutions, green climate funds and prominent R&D institutions as extended hand, mind and heart of BMTC in shaping up of the transition. City bus operations, diesel/CNG/electric/any other fuel based, generally require facilitations in the form of planning, provision and upkeep of various infrastructure. BMTC’s ongoing tie-ups with city development and operating agencies will need additional dimension around opportunity and flash charging/ battery swapping infrastructure development across the city in medium to long term, as and when technology maturity and commercial viability is foreseen.
Engagement with private sector, through appropriate PPP models, is an area that BMTC may look into for initiating and effecting the transition to new technology vehicles and operations. Such engagements could bring not only the much-needed CapEx support but will also assist BMTC and its staff in assimilating the nuances around the new electric bus technology applications in bus operations.

In addition to above, BMTC may initiate a formal program of Training and Capacity Building of BMTC staff - not only around electric bus technology but also covering areas of service delivery, contract management and monitoring & evaluation.

Adoption of a project-based approach, encompassing above mentioned areas of implementation and procurement would help steer the electric bus induction towards a timely and definitive path.

And last but not the least, combining technology transition with various ongoing/prospective service delivery improvement measures will help project and protect a long-term positive image of BMTC brand across its operations. These improvement measures may be around vehicle specifications, crew behaviour and image building, contactless ticketing, other passenger amenities and facilitations. Having same standards or norms across diesel and electric buses will support BMTC’s brand development.

The implementation and procurement strategies for initiating the transition to e-bus are based on above suggested approach to facilitate a smooth and continuous process over short, medium and long term. Figure 1 depicts a pictorial presentation of suggested approach.

**Figure 1: Suggested approach for implementation and procurement strategy**

1. Long term commitment and strategy, depicting clarity and flexibility
2. Start E-bus adoption early and gradually
3. For E-bus technology - one size fits all approach is costly and inefficient. Multiple technology choice suiting broad route/schedule operational categories
4. Market study and consultations with vendors to understand cost implications for available and expected advancements
5. Develop partnerships with city agencies, vendors, industry and R&D institutions
6. Adoption of PPP for technical backup and transfer of risks
7. Adopt a Project based approach for timely and definitive path to transition as planned
8. Training and Capacity building of staff
9. Combine technology transition with ongoing/prospective service delivery improvements

Source: Consultant Team
2 IMPLEMENTATION STRATEGY FOR FULL TRANSITION TO ELECTRIC BUS TECHNOLOGY

Transitioning or shifting to a new technology is imminent but at the same time not an easy proposition for BMTC, given its financial condition and social obligations. Business case of transition to electric bus provides a prospective roadmap of transition and has analysed that full transition to electric bus-based operations makes a reasonable business case for BMTC. However, adoption of an actual path of transition will be a complex decision that organisation will need to take and therefore, formulation and functioning of an implementation strategy for technology transition becomes essential.

BMTC may consider adopting a two-pronged strategy for induction of electric bus fleet – one through small pilot projects for immediate induction and second through an adoption plan over short, medium to long term. The organisation is already on its way to start pilot projects of electric bus induction into its fleet through two ongoing tendering processes. Additionally, preparation of a detailed plan of gradual electric bus induction, either as replacement or augmentation or both, over coming years needs to be initiated.

Following steps and actions are important as part of the implementation strategy.

2.1 Electric bus project definition and details

The organisation develops project purpose, definition and details of electric bus induction with timelines, processes, targets, outputs and expected outcomes. The project timelines through a phased induction process will transmit commitment and clear message within the organisation as well as to the prospective partners in the journey of transition to electric bus/clean technology vehicles.

The period of electric bus induction and gradual transition needs to allocate first two years from now (2021-23) for preparation of an implementation strategy and plan, first phase project details, identification and selection of partners, arrangements for project funding and formation of an organisational strengthening plan.

The prominent components of electric bus project adoption and transition, over next decade or so, are shown in Figure 2. A conceptual framework of its components is shown in Figure 3.

Figure 2: Electric Bus Project definition and details

Define e-bus Project Purpose, Definition and Timelines

Capacity and Skill Development Plan

Technology Adoption and Transition plan

Project Funding & Implementation

Project Procurement

Project Operations

Project Monitoring & Evaluation

Funding partners: Implementing agencies:
Figure 3: Electric bus transition project implementation framework

Transitioning to clean technology/Electric fleet

- Adopt Project based approach
- Define Project Purpose, Outcome and Output for phased adoption process
- Marketing of project and Lobby with Govt, Multi-donor agencies/financial institutions, Green climate funds, Prospective Industry partners
- funding for implementation and monitoring
- Establish SPVs for Project creation, funding and for implementation and monitoring

Undertake Pilots
(to test operations, technology)

Establish Pilot Projects Management Unit (PPMU)

Route Rationalisation study of BMTC operations & to identify New service potentials

Establish Project Implementation Unit (PIU)

Prepare Phase 1 details and Feasibility study for securing funding/PPP

Develop and Finetune Phased Implementation of project through process of Continuous learning, Industry Support, Technology upgrades and Feasibility of technology adoptions suiting BMTC’s Operational needs

2021-2023

2024 Onwards

Funding partners:

Implementing agencies:

[Various logos of funding and implementing agencies]
2.2 Constitution of E-bus Pilot Project Management Unit

**Role**

The PPMU will be a dedicated unit from within BMTC to closely work with the pilot electric bus operator(s) of 300 standard size and 90 midi size electric buses (under tendering process) and liaison with city agencies to resolve issues in day to day operations. Allocation of routes and schedules, collection of required data and information, understanding of electric bus technology aspects as well as that of charging and maintenance of buses will be primary responsibility of PPMU. PPMU staff will monitor the KPIs and any other service levels that the pilot e-bus operator are expected to meet as the contractual conditions.

**Primary Functions**

Some of the important specific actions that PPMU needs to take up are:

1. Selection of routes/schedules for pilot electric bus service providers
2. Undertake TCO analysis for routes/schedule selections for operations of pilot electric buses
3. Manage tendering for pilot electric buses (300 + 90)
4. Manage Trial runs as part of pilot E-bus adoptions, if and when its undertaken
5. Supervise and monitor KPIs of pilot E-bus service provider
6. Collect data, liaise with local agencies to resolve city wide issues of pilot E-bus operations
7. Collect maintenance data undertaken by service provider for pilot e-buses, as per following illustrative structure (Table 1), to be elaborated by the PPMU.

<table>
<thead>
<tr>
<th>Bus No/Date</th>
<th>Maintenance details (frequency, spare and material consumption, scheduled or unscheduled, reason for unscheduled maintenance)</th>
<th>Service Provider remarks</th>
<th>BMTC remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bus 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bus 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bus 3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>.....</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bus 300</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Consultant Team
Staffing

The staffing of PPMU will be primarily managed from within BMTC and may be supplemented with new hiring of specific skilled manpower at the managerial/execution level for required technical support and inputs around electric buses. The BMTC staff from Traffic & Operations and Electrical & Maintenance departments will be deployed to the PPMU. The deployment of all staff will be full time from the start of pilot project implementation phase, to not only support but also to learn.

The unit will utilise their available learnings of city bus operational needs and add learnings around specific understanding of technical aspects of the E-bus rolling stock, battery systems, their management, charging infrastructure, during the course of pilot project implementation and its running.

Additionally, if a need is felt, technical experts/consultants can be selected for guidance and support on managing the pilot e-bus service provider. Such a technical experts’ team can assist in resolving technical issues around implementation and create systems of project management as well as train the PPMU staff through hands-on learning and demonstrations.

Management and Funding

The staffing and associated cost will be primarily funded from within BMTC’s own budgets or supported through the pilot project implementation funding, provided by the Government/municipality. However, hiring of technical experts’ team can be arranged through multi-donor agencies/Green climate funds, as part of their electric bus capacity building initiatives/projects.

2.3 Constitution of E-bus Project Implementation Unit (PIU)

Formation of a Project Implementation Unit (PIU) to spearhead the implementation of above defined project from the word GO will be necessary for execution and matching of project objectives with actions. The PIU to mainly comprise BMTC departments and staff, will also include important and relevant city infrastructure and service delivery agencies as additional hands and mind of implementation.

BESCOM, BBMC, BMC, Bangalore traffic police, Development Authority alongside city PWD, Indian railways and Airports Authority offices will together create a consortium to support power, land, roads and traffic management facilitations for batches of electric bus inductions.

The departments of Human Resources, Finance, Traffic and Operations & Maintenance from within BMTC alongside ITS and other vendor representatives shall provide their management and execution staff with primary responsibility of PIU functionalities. The participation of pilot electric bus project management unit will help resolve not only their impending issues in infrastructural and operational aspects but will generate valuable information and datasets around technical aspects of electric bus inductions. These learnings and knowledge base will contribute towards formulation of the long terms project details covering scale, time, phasing, typology and routes selection strategy for transition to electric bus-based operations.
In order to make electric bus PIU a lean and mean unit, only three/five permanent staff with part time support of staff, from within BMTC and from supporting city agencies, can be considered. However, its organic growth shall be encouraged to be guided by need based development and expansion of the electric bus induction project components steering to gradual transition.

The PIU responsibilities shall cover following main areas:

1. To plan out induction of successive electric buses into BMTC fleet - to achieve full transition by 2032.
2. To prepare appropriate routes operations, traffic and infrastructure gaps studies for selected electrified city bus routes
3. To carry out route rationalisation study every five years, starting with one on immediate basis
4. To identify legal barriers and institutional strengthening needed to support the transition to new technology buses and support efforts for alleviating their status quo.
5. To carry out procurement of project sub-components as guided by procurement strategy
6. To monitor and evaluate outsourcing of O&M services
7. To manage, maintain and update E-bus performance levels vis-à-vis type of technology, duration of operation, charging/discharging cycles, impact of route conditions on battery charging, cost of operations and maintenance and so on
8. All requisite data collection for E-bus operations and maintenance

Depending upon scale of transition and capacity of PIU members and staff, a dedicated technical support to PIU can be considered, specially during the period of 2021-2024. The PIU support unit will assist and guide preparation of electric bus induction and transition project details and its phasing guided by depot, route operations and technology selection strategy, master planning of power and charging infrastructure development, economic and financial feasibility of specific project components as well as project costs and benefits over the electric bus transition period.

2.4 Constitution of Special Purpose Vehicle(s)

SPVs are mostly formed to raise funds from the market due to its legal standing and single well-defined purpose. In the context of raising capital, a SPV (usually structured as LLC) can be used as a funding structure, by which all investors are pooled together into a single entity.

During the course of transition to electric bus-based operations, BMTC may need to form one or many Special Purpose Vehicles (SPVs) with partner agencies, across public and private sector. These SPVs will support necessary project planning, funding, procurement, implementation, operations and monitoring and will be constituted with qualitative objectives and quantifiable delivery of outputs and outcomes.

Establishing SPVs will help not only add value but also reflect commitment to the project. This will more importantly, assist in procuring funding from national and
international doner agencies, committed to the cause of green climate growth. The structure and legal framework of SPV establishment will be finalised by BMTC on the basis of identified needs, purpose and interested investors (public and private sector).

2.5 External electric bus project advisory and support for transition

In addition to above project implementation measures for electric bus transition, wider support and advise from state departments of transport, urban development and finance will be necessary for confirming in-principal project scaling, timelines of execution, budget provisions and funding availability from public and private sector infrastructure development and financing institution(s). The electric bus project transition plan and project details will be prepared and finalised in consultation with above primary state departments for a comprehensive inclusion of underlying climate protection goals and wider policy framework.

Additionally, support for training and capacity building of BMTC staff, by associating with state/national/international institutions and industry partners, will be highly beneficial for project implementation and achievement of expected outcomes.

The electric bus and infrastructure technology are closely inter-liked with power, heavy industry and technology advancements. By partnering with relevant industry and funding partners, under the shadow of line ministries and government departments, BMTC will benefit through not only an early capture of successful and commercially viable solutions for adoption, but will have opportunity to influence further technological advancement and/or commercial production of specific solutions of urban e-bus technology, to facilitate operations and to bring in economy and performance.

BMTC could use the support from line departments/ministries for brand development and lobbying of the project at state, national and international levels as well as for mentoring and guidance from political and industry leaders.

2.6 Training and Capacity Building

Transport undertakings in India have started introducing E-buses in their fleets in recent years. In all these years, the bus agencies have been operating IC engine based conventional buses and very few cities have introduced premium segment air-conditioned buses. The bus crew and maintenance staff, with these establishments, have been mostly trained and experienced in driving and repairs & maintenance of normal IC engine buses. A fundamental technical barrier faced by transit agencies and bus operators is lack of information and experience around electric bus performance. In most cities, the operators have never driven an electric bus, technicians/mechanics have never serviced an e-bus, and electricians have never installed a charging infrastructure and done maintenance. Globally, it has been a challenge to find appropriate and adequate information about e-bus operations and performance as it is a relatively new technology, being gradually introduced in the market. It becomes, therefore very crucial to train these staff for electric bus technology and maintenance aspects through regular formal and on-the-job training programs from reputed institutions.
3 PROCUREMENT STRATEGY

BMTC has been operating Diesel and CNG buses, procured through outright purchase model and has been carrying out all operational and maintenance activities mostly in-house. For this reason, outright purchase model may seem attractive for induction of new technology electric buses.

However, the CFF study of Technical and Economical Gap assessment for transition to electric bus fleet at BMTC, has indicated low level of preparedness of technical capacity of BMTC staff. Simultaneously charging infrastructure provisions’ assessment is rated low. BMTC, although has high support from policy framework and co-ordination from allied city agencies and the Government of Karnataka, but accessibility to funding high capex of e-bus is rated low, primarily due to organisation’s low financial performance and credit rating.

The technical and funding limitations, alongside imminent need for transitioning from diesel-based operations to electric/clean fuel-based bus operations, leads to a crucial need for shaping up of a procurement strategy that can assist and guide in procuring new e-bus technology, still undergoing maturity and cost corrections.

3.1 Learnings from BMTC pilot electric bus procurement

BMTC has initiated a pilot electric bus induction project through procurement of 300 standard size and 90 midi size fully electric buses, through funding support from the state and central government schemes (GoK budget, SMART CITY MISSION and FAME-II). These procurements are planned under two separate all-in-one contracts, based on an Opex model, to lease out electric buses+charging infrastructure through private players. The power supply is organised by BMTC through BESCOM, a public sector entity dealing with power distribution across the city of Bangalore.

The contracts have not been finalised till date due to low participation from the market and also on account of higher than expected per km rate for operating electric buses under BMTC. A review of the RFPs by the Consultant team has indicated higher order of risk perception and few avoidable penalty clauses, causing prospective operators to add risks to per km rates. The tender for electric buses is published for third time with some modifications and is presently at stage of clarifying queries from the bidders. The tender outcomes are awaited for the desired success since more than a year of its initiation by BMTC.

The primary learning from the above electric bus tendering by BMTC is the technical capacity gaps within BMTC to not only handle new technology induction but also the contract for private sector participation. There has been a consistent desire, within BMTC, for outright purchase of electric buses, as has been the case with diesel buses. This approach seems to have influenced the overall outlook and tender conditions. Low level of confidence on private players’ involvement in the pilot project, may have led to addition of penalties, provisions and risks, with the expectation of their high level of performance and commitment. The penalties and risks have, actually, come back to BMTC in the form of high per km Opex rates and low participation from market players.
Additionally, the induction and transition to electric bus technology is yet to be formalised by BMTC alongside a view on its future role as ‘only an operator’ or ‘operator cum manager’ or ‘purely a manager’ of urban bus operations within and around the city of Bangalore. The non-clarity on above important guiding factors for future imminent transition to clean fuel/electric technology is reflected in the tender conditions issued for pilot e-bus, whereby it is felt that private sector participants are viewed as outsiders and not as partners on the road of technology transition.

The electric bus-based operations will be multi layered needing selection of appropriate fleet, battery size(s) and charging strategy. The power supply and associated infrastructure development will be necessary for uninterrupted supply of required pointed loads at depot and terminal locations, where primary charging stations for electric buses will be established. With the scale of new infrastructure development and technology selection, route operations' reorganisation is generally recommended for reaching desired demand and supply equilibrium and for enhancing performance of electric buses due to their operational range limitations.

All of the above require experience, capacity and capital for planning and execution within the realm of a well-defined project. Procurement of men, material, machine and services for electric bus transition would need external support and an appropriate procurement strategy can ensure cost efficiency and requisite minimum quality during project implementation.

### 3.2 Basis of Procurement Strategy

The purpose of procurement is primarily to raise capital, acquire assets and garner skill-based support in a timely and cost-effective manner ensuring minimum requisite quality. Accordingly, basis of procurement strategy for electric bus technology induction will be guided by envisaged scale of operations and timelines, availability of budgets and funds as well as organisational capacity and capability profiling. BMTC may like to enhance the e-bus project support by partnering with government and private sector entities.

The corresponding outsourcing or sourcing needs, if any, are then identified and determined for procurement of men, material and services. Once decision on self-sourcing (including leasing) and outsourcing is taken, procurement through open bidding, or selective bidding needs to be taken for contracting at Fixed price, Cost-reimbursable or Time and Materials based. A reasonable market understanding for negotiating the terms of contract, will be necessary to arrive at a cost efficient and timely procurement ensuring minimum requisite quality.

The consulting team’s analysis from consultations with electric bus market players, business case findings, risks and mitigation and technology adoption plan suggest a phased transition plan and start early for more gains and better outcomes, both for BMTC and the city. With an existing fleet of about 6,700 diesel buses, required fleet size of 9,500 buses now and that of 16,500 buses by 2030, BMTC’s transition to electric buses will be complex decision matrix of when, what and how to make the shift. The guiding factors for phased transition are fleet replacement and augmentation planning alongside city bus operational needs during corresponding timelines.
BMTC needs to utilise scientific tools and processes for evaluation of different routes, depots, schedule combinations to reduce overall cost of operations. Availability of a financial analysis and technology selection tool can support a scientific and analytical working out of the possible combinations. These will support determining procurement size and nature of equipment. With early formulation of phased transition plan, BMTC stands to gain through positive feelers from the electric bus industry and help develop local vendor network.

Additionally, the procurement strategy will be based on how organisation sees its role in future city bus planning, operations & maintenance and its management. BMTC is primarily a bus operating agency, managing all aspects of diesel bus fleet procurement, operations or maintenance in-house, without any significant engagement or support from outside/private sector players. With its many years of experience in city and suburban bus operations alongside growing dependence and need for expansion of bus services in the cities, both in quality and quantity, BMTC may think of getting into the shoes of city bus planning and management functions, with bus operations and maintenance under its wings. The bus route rationalisation dovetailed with requisite transition to electric bus technology, provides an opportunity to step up into a bigger role of bus operations. A pictorial presentation of different components to form as the basis of procurement strategy is shown in Figure 4.

Figure 4: Large scale electric bus procurement strategy framework

Source: Consultant Team
3.3 Identification of Sub-Projects

Both the numbers of market players and electric bus products and associated infrastructure are expected to see a substantial growth with the expansion of capacity and maturity of technology – globally as well as locally. Similar to the growth of diesel bus supply chain over last few decades, the electric bus market is expected to grow, however at a much faster rate as indicated during the consultations with e-bus market players. It’s not the question of ability to produce the electric bus and components locally but the assessment of the future demand to plan and setup production lines and marketing chain establishment, are felt as the primary issues impacting future sectoral growth. Accordingly, transition to electric bus-based operations is a multi-layered and multi-year project.

Larger adoption of electric buses, during the phased transition will benefit from breaking up the electric bus procurement project into a number of smaller sub-projects for maximisation of experiences gained by multiple project partners who will be providing technological solutions. Additionally, BMTC can have better negotiating power and bring in cost efficiency due to competition and economies of scale. A conceptual project breakup, across technical functionalities of e-bus operations, is shown in Figure 5, whereby BMTC functions as the project manager coordinating the different sub projects. However, this will require good contract management skills and capacity within BMTC to manage multiple partners, in addition to products and services availability suiting BMTC needs at the time of procurement.

The other manner of breaking up of large project is dividing the single large contract into smaller fleet size contracts, but all with similar KPIs and functionalities. For example, for phase 1 e-bus transition, of the order of 2100 buses (refer BC Part1 report), BMTC may split the project into four sub projects, each of 500-600 or smaller packages of e-buses. The phase 1 project breakup can also be thought of as a mix of packages divided across fleet size and functionality as well (see Figure 6 for a conceptual view, where power supply for all e-bus operations is through one separate contract).

The adoption and transition to electric bus technology strategy accordingly, may cover following sub-projects:

1. **Procuring electric bus fleet** – The reduction of upfront cost by hiring of e-buses through operating lease model (that covers capex+opex) has been a popular and effective model for e-bus induction. A large bus operating company, like BMTC, generally deals with different routes and service operations. The fleet procurement contracts can accordingly be divided by types of buses (presently BMTC operates midi, standard non-AC and standard AC buses), to reduce variability in product supply in a single contract, and further gain in cost efficiency;

2. **Procuring batteries separately, whenever its techno-commercial viability is realised in local market** – separate out the battery from e-Bus body+Chassis to reduce e-bus fleet owning cost and simultaneously shift the battery technology risks alongside its high ownership cost and performance to private player, through an operating lease model. With reasonable sizing of battery lease sub-project, both the battery service provider as well as public transit agency stand to gain from economies of scale;
3. **Procuring charging infrastructure** - with expansion of e-bus fleet size and operations, network level charging can be developed for improved flexibility in route operations and enhancing daily range. With participation of multiple private sector players (in construction of the network charging infrastructure and O&M) through the route category-based allocation or geographical territory-based allocation or based on both, would ease technology selection in addition to economies of scale. BMTC will need to work with development authority, municipality and roads and power infrastructure development agencies to plan and reserve plots of land for network charging.

4. **Procuring power supply from conventional and renewable sources** - As e-bus charging is observed to cause fluctuations in power supply network, required upgrades in cabling and transmission are necessary for larger e-bus fleets. Moreover, the power requirement will increase and so will increase the need for power infrastructure upgradation, both at charging nodes as well as at the transmission network level, in accordance with the expected rate and quantity of power drawn for a given charging solution, battery size and its chemistry. Hiring of power infrastructure development agencies (public or private sector) on an operating lease model, through single or multiple players, will invite economies of scale and benefit BMTC through lower power rates. Additionally, the power supply can be sourced through different market players dealing with conventional and renewable power generation sources by way of separate contracts.

5. **Procurement of other services such as projects’ monitoring & evaluation, management, planning and other support** – Although M&E is not a core activity in e-bus operations, but procurement of such project management services can track project progress, outputs and outcomes against the expectations/set targets. The shortfalls and/or surpluses from the targets will be analysed for future corrections in project details, timelines and KPIs. The M&E services will support contract management through KPIs and other contract outcomes, and thereby provide an umbrella service for all e-bus procurements, deliveries and outputs.

In addition to procurement of e-bus fleet, infrastructure and services, **procuring skilled and experienced manpower** directly from the market, and more importantly through training and capacity building of its 33,000 staff, will be necessary for BMTC to not only gain self-sufficiency in handling e-buses on its own but also to manage and supervise possible multiple contracts with private and public sector players, supporting BMTC. **Contract Management**, **Project preparation**, **e-bus design and maintenance**, **battery management**, **charging terminals/nodes development** and **project monitoring and evaluation** are seen as the relevant areas of capacity development. A regular schedule of training and capacity building programs, across all the cadres/levels of staff need to be identified. A set of qualification criteria for handling aspects of e-bus based operations will encourage employees for skill upgradation. Additionally, BMTC can ask the bus operator or the OEM to prepare comprehensive bus operations and maintenance manuals with pictorial diagrams which are easy to understand. This helps the drivers and maintenance mechanics understand the new technology easily. Classroom and on-field training help the staff to gain confidence and understand the functionality of various components.
Figure 5: Conceptual Electric bus sub-projects breakup across functionalities

- E-Bus Supply Contract
- BMTC Managing contracts
- Power Supply
- Battery Lease
- Charging Infrastructure
- E-Bus Lease

BMTC Managing contracts

- sub-project 1 - 500 electric bus + battery + Charging
- sub-project 2 - 500 electric bus + battery + Charging
- sub-project - 5 on Power Supply (conventional & renewable) for all operations
- sub-project 3 - 500 electric bus + battery + Charging
- sub-project 4 - 500 electric bus + battery + Charging

Figure 6: Conceptual Electric bus sub-projects breakup across fleet size and functionality
3.4 Procurement models for BMTC E-Bus induction

Three primary procurement models are prevalent in the city bus services. These are:

1. Procurement through Outright purchase of equipment (buses, tyres, fuel & lubricants and spares) with inhouse service and operations – presently practiced at BMTC for diesel/CNG buses whereby all the capex, Opex and revenue risks are borne by the public transit agency;

2. Gross cost contract (GCC) with procurement of equipment and services through an Opex based lease model for necessary capex support and transfer of Opex risks. The revenue risks, however remain with the public transit agency;

3. Net cost contract (NCC) with procurement of equipment and services outsourced, alongside the traffic revenue collection. The public transit agency receives a royalty for giving route operations rights to the external operator and has no direct risks.

However, responsibility of maintaining service quality levels and passenger satisfaction lies with the public transit agency (in this case BMTC) in all of the above models. The procurement contract conditions are accordingly drafted and finalised in consultation with market players.

Applicability and adoption of all three or a combination of two or any one procurement model is guided by capacity and capability of the transit agency. A fully capable transit agency will generally, follow outright purchase model of procurement for minimum dependence on external partners. In some cases, outright purchase is coupled with Annual Maintenance Contract (AMC) for specialised support (as adopted by DTC and BEST during introduction of CNG bus fleet) in city bus maintenance. On the other hand, an agency with low capability and capacity will tend to follow NCC model; that are also exploited by the agency for lower revenue routes, having potential for increased patronage through additional services and enhanced service levels. The GCC model of bus procurement has been a preferred model by many public transit agencies in India, not only for the capex and Opex support but also to support the labour-intensive route operations activity.

For the e-bus induction and full transition BMTC can primarily follow two procurement models – GCC for pilot e-buses and Phase 1 e-bus procurements followed up with mix of Outright purchase and GCC model from Phase 2 onwards, as the organisation develops better understanding of the e-bus technology as well as more cost-efficient e-bus models with better performance become available subsequently. This approach and strategy are expected to reduce risks of project implementation delays as well as provide technical capacity building of the internal manpower.

The 300-pilot e-bus procurement by BMTC, presently underway and funded by the FAME-II scheme of GoI, follows the single operator selection covering owning, operating, infrastructure provisioning and maintenance by private player under the Opex lease model (GCC model). Accordingly, the technology, O&M and funding risks will be with the private player but the revenue risk will be with BMTC, which will also provide its depot space to e-bus operator for charging, maintenance and night parking of e-buses.
Table 2 lists out various e-bus procurement strategies as adopted by cities across the globe for their initial to large scale transition towards electric bus.

**Table 2: Examples of e-bus and infrastructure procurements in cities across globe**

<table>
<thead>
<tr>
<th>City</th>
<th>Model</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>New York MTA</td>
<td>Operating lease</td>
<td>3-year agreement for 5 Proterra E Buses</td>
</tr>
<tr>
<td>Pune, India</td>
<td>GCC</td>
<td>De-risking of concession structure, clarity in scope of services and active participation of STU helped in achieving very competitive GCC rates.</td>
</tr>
<tr>
<td>Kolkata, India</td>
<td>Own procurement GCC</td>
<td>Phase 1 buses being under-utilised due to range anxiety. Additional chargers being procured to increase daily operational kms.</td>
</tr>
<tr>
<td>Park City Transit, Utah, USA</td>
<td>Outright procurement with battery leasing</td>
<td>Authority could procure more buses (6) with the same amount of grant using a 12-year battery leasing contract.</td>
</tr>
<tr>
<td>San Francisco/ King County, USA</td>
<td>Joining forces</td>
<td>Bulk ordering reduced procurement costs</td>
</tr>
<tr>
<td>Warsaw, Poland</td>
<td>Capital lease</td>
<td>6-year lease agreement for 10 Solaris E buses, part of the rentals paid out of Opex savings</td>
</tr>
<tr>
<td>Shenzhen, China</td>
<td>Financial lease of e-buses</td>
<td>Phased approach adopted for transition to electric bus, spread over 9-year period by end of 2017. Total electric bus fleet of 17,000 comprise 66% midi size buses. Finance leasing company purchased and owned and leased out to public bus agency</td>
</tr>
</tbody>
</table>
### GCC for Charging Infrastructure and services

The Shenzhen bus group (SZBG) does not own or operate the charging infrastructure but pays charging service fee to the charging service provider who constructs the charging infrastructure (including charging terminals, transformers and other charging related facilities) and provides charging services (including hiring technicians to perform daily charging and maintenance).

### Santiago, Chile

**GCC model of e-bus procurement, not involving competitive bidding but through expansion of ongoing private operators’ contracts**

Present 400 electric bus fleet procured through Opex lease model of 10-year period alongside renewable energy from power utility company at 40% discount.

Challenges like charging standards and interoperability, grid upgrade at depots to handle peak power loads etc. are being addressed.

Not e-bus Technology but formalisation of bus operators is observed a key building block for large scale deployment.

### Campinas, Brazil

**All bus procurements and operations through private sector concessions**

250 e-buses being procured for BRT lines.

The city (of 3.7 million inhabitants and a bus fleet of 1500 buses) downtown has a demarcated ‘white zone’ for clean technology vehicle operations and the zone is planned to be supported with Only e-bus operations by 2022.

A detailed background of some of the above city experiences are available in Annexure 1.
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Annexure 1. Global Case Studies of Electric Bus Transition

Electric buses are still an emerging technology. The following case studies provide a cross section of some of these early experiences, highlighting examples of success as well as challenges that agencies have been forced to overcome in the process of getting electric bus services off the ground. The lessons learned in these early experiments will be crucial in informing future deployments of this technology. These case studies help to understand challenges and opportunities in transforming to a completely new technology for public transportation.

1. Shenzhen, China
The city claims to have world’s first and largest full E-bus fleet transition. In the year 2013, the passenger ridership share of buses was 62%, metro 26% and taxi 12%. However, there was a decline in bus ridership from 2.2 billion in 2013 to 1.6 billion in 2018 i.e. average 8% decrease. This trend was reversed after full electrification was achieved in 2017 and ridership increased by 2.4%. Flexible routes were also introduced to connect suburban communities and metro stations as well as on-demand services through mobile App. Thus, by end of 2017, about 17,000 urban buses were electrified in Shenzhen and it took approximately 8 to 9 year period and buses were procured from 3 different manufacturers. Phased approach was adopted in achieving full transition as below:

2009-2011: demonstration stage
2012-2015: small pilots
2016-2017: large scale electrification

- The authority, instead of trying different technologies, adopted single proven vehicle technology to achieve daily mileage requirements.
- 66% of the e-bus fleet is of Midi Buses (10.5 m length) and capable to operate with average daily route length of 19.0 kms in single charge.
- There are more than 1700 charging terminals spread over more than 100 locations (bus terminals and depots).
- Charging facilities are constructed and managed by 9 different service providers.
- Majority of charging terminals are equipped with 150Kw and 180Kw DC fast chargers with different configurations.
- On most of the routes, the range offered by bus is higher than daily operating distance and most buses get charged during night time. Only some buses operated on long routes require mid-day opportunity charging for 30 minutes.
- All the routes have charging stations at both ends.
- There is 1 charger per 5 bus
- In 2016, a pilot of ‘network charging concept’ was done where 4 buses were charged at a time on one charger. This increased charging time per bus from 2 to 6 hours. It saves labour cost as buses are not required to move during night time. A more flexible
charging concept was later introduced with the charging terminal adjusting the power output of each charger to maximize efficiency.

- Government mandated for complete transition accompanied by national and local level subsidies to support fast and full electrification of bus fleet by lowering upfront cost.
- Subsidies were directly paid to bus manufacturers. National subsidy was 5,00,000 RMB for Midi bus in 2015. With subsidy, the total cost of ownership (TCO) of E-bus over 8 year period lifetime was 36% less than that of diesel bus.
- The authority does not own or operate the charging infrastructure but pays charging service fee to the charging service provider who constructs the charging infrastructure (including charging terminals, transformers and other charging related facilities) and provides charging services (including hiring technicians to perform daily charging and maintenance). This arrangement turns out to be a common model in China and in a way has nurtured a healthy and competitive market for charging service providers including grid companies. The business model is viable since the investment in bus charging stations breaks even in five to six years, with government subsidies included.
- For DC fast charging, every charger received a subsidy of 600 RMB/kW. AC charging facilities with power rates exceeding 40 kW received a subsidy of 300 RMB/kW whereas AC charging facilities rated less than 40 kW received a subsidy of 200 RMB/kW.
- The local government simplified and made fast the process of application and approval for charging infrastructure construction.
- A robust institutional mechanism was adopted with all concerned stakeholders. Coordination was led by a nodal public stakeholder while the main private stakeholders were the bus manufacturers.
- Bus manufacturers provided 8 year product warranty, maintenance support and training for the bus operator staff.
- To reduce upfront costs, financial leasing model was adopted which had a financial leasing company who purchases and own the vehicles and leases them to the authority. The bus operating company takes ownership of the vehicles at the end of the lease period. Batteries are returned to bus manufacturer for recycling and disposal whereas the bus body is sent for scrapping and recycling. The lease period was set equal to bus life so high procurement cost was converted into affordable annual rental/lease payments. The financial lease model is graphically presented below.
During initial stages, E-buses were operated on specific short distance routes and later on used on all routes after balancing charging schedule and operational planning.

The E-bus fleet on an average saves 1,94,000 tonne of CO₂ annually.

Land acquisition for construction of charging stations was challenging. Additional infrastructure had to be created for new transformers and electricity lines.

Bus breakdown rates were very low compared to conventional buses. A stepped transformation plan was made for training, re-assignment, incentives and compensation for drivers, maintenance staff. Staff training played a crucial role in the acceptance of the new technology.

In the bus user satisfaction survey, users rated comfort as highest followed by safety and affordability. The bus fares were maintained at same level.

The high upfront cost is still a challenge for future bus procurements as it is linked with government subsidy. Life cycle cost of E-bus over diesel bus is still not economically viable. Overall repair and maintenance costs are low in E-buses.

Maintenance and repair standards and procedures are set to minimize service disruptions and ensure safety compliances.

With the expanding metro system, integration was planned and many bus routes were converted to metro feeders resulting in shorter daily operating distance which can be easily covered by E-buses with overnight charging. Long driving distance improves cost effectiveness of E-bus due to low operation v/s capital cost from TCO perspective.
2. Santiago, Chile

In 2018, Santiago was the first city in Latin America to adopt Euro-VI emission standards for buses and this helped set the stage for E-bus deployment. By March 2020, the city had deployed more than 400 E-buses and has set the target of full electrification by 2035. Santiago’s public transport system has 380 routes operated by 6 private operators with fleet size of 6756 buses and carries about 7,00,000 passengers. The system is undergoing reforms currently. Santiago’s electric bus journey began with early demonstration projects in 2011 and 2013.

- Pilot projects were done in 2017 wherein a private operator deployed two standard (12m) size E-buses on a route and operated it for one year with five trained drivers.
- Operating costs were calculated at $0.10/km, based on a $0.10/kilowatt hour (kWh) price and an energy consumption of 1.006 kWh/km
- In 2019, another 100 buses were added on lease model for 10 year period. The operator pays a fixed maintenance rate of $0.09/km to the bus manufacturer. The power utility provider has agreed with the operator to provide certified renewable energy at 40% discount.
- The buses are operated on Latina America’s first electric corridor with 40 new bus stops having free wi-fi, USB chargers, ETA panels, solar panels, LED lighting, wheelchair access and off-board fare collection at some stations.
- The private operator has increased its fleet to 285 buses and plans to add another 150
- Another private operator tied up with financer and bus manufacturer and inducted 100 E-buses. One terminal 13 nos. of 150 KW DC chargers for 25 buses and another terminal
opened in March 2019 has 37 nos. of 150 KW DC chargers for 75 buses. The total energy demand for the terminal is estimated to be 6 megawatt (MW) and includes a 2.1 MW backup system.

- Another 215 buses would be added to the fleet of one private operator soon on similar model where a private financer finances the buses.
- Articulated (18m) buses have been tested in Santiago from two different manufacturers but not introduced in the fleet.
- Compared to 2018 levels, there has been a 5% reduction achieved in CO₂ emissions.

User gave rating of 6.3 out of 7 for the E-buses and 5.8 rating for Euro VI buses. It is expected that the E-bus fleet size would reach 800 by 2020.

- It is important to note that this deployment in Santiago was accomplished outside of fleet renewal tenders and by taking advantage of contract extensions to current operators. It was not through competitive bidding. The business model having split of bus ownership and operations is acceptable. Depot management is done by the authority. E-bus tenders are awarded for 10 year period extendable for further 4 years more.
- Currently there are 10 depots with over 22 MW of installed capacity to operate 411 E-buses. The total bus fleet size is 6,800 buses.
- Santiago is the first city in Latin America to develop its own drive cycle for urban buses type approval.
- Challenges like charging standards and interoperability, grid upgrade at depots to handle peak power loads etc. are yet to be addressed.
- Although many of these lessons are transferable to other cities, challenges like formalization of bus operators remains a key building block for large scale deployments and the process is dependent on political will rather than technology.
- By June 2020, the city had fleet of 411 E-buses with an additional 365 in order to be added in the fleet by end of 2020 and has invited a bid for over 2,000 E-buses.

3. Seneca, South Carolina, U.S.A.
The electric bus market in the United States has expanded dramatically over the last five years. There are more than 500 E-buses currently in service across the country. California has been at the forefront of moves towards electrification. In 2018, the California Air Resources Board approved a state-wide rule committing to shift to 100% all-electric transit buses by 2040. Large transit agencies in the state will be required to purchase 25% E-buses starting in 2023, then 50% by 2026, with no new purchases of non-electric buses beginning in 2029. In 2017 the Los Angeles Department of Transportation (LADOT) and Los Angeles County Metropolitan Transportation Authority (LA Metro) committed to full-fleet electrification by 2030. As of 2019, California has 210 E-buses in service and a backlog on order, bringing its total commitment to electric buses to around 450. New York City’s MTA, the country’s largest transit network, has committed to an all-electric bus fleet by 2040. In 2018, MTA began a pilot
project operating 10 E-buses throughout the city, and in 2019 added 15 more to its fleet. Minneapolis Metro Transit debuted its first E-bus in 2019 and aims to deploy another 200 over the next decade. The South-eastern Pennsylvania Transportation Authority (SEPTA) rolled out 25 E-buses in South Philadelphia in 2019 and has another 10 arriving in 2020 for deployment in 2021.

In September 2014, Seneca became the first city in the world to launch and all-electric municipal bus fleet. Having overcome various challenges presented by the new technology, Seneca views its electric buses as a successful, scalable model of full-fleet electrification. Seneca’s transit fleet is operated by Clemson Area Transit (CAT), one of the country’s largest public fare-free transit services, serving an estimated 2 million riders per year. More than half of CAT’s total fleet now consists of electric buses. Since 2014, all of the buses it operates in Seneca have been electric.

- In 2010, the City of Seneca applied for a government grant to develop the first scalable model of an all-electric bus transit system in the U.S. In contrast to other cities, which had to that point only deployed one or two electric buses as “parade buses” in their fleets, Seneca intended from the start to convert the entire operation to all-electric service.
- After receiving the federal grant, City of Seneca signed an agreement with a private bus operator in 2012 to purchase its first four E-buses with two charging stations.
- Following a period of field testing and driver training, the buses went into passenger service in September 2014.
- An additional two buses were added shortly afterwards, and in 2017 CAT purchased an additional 10 E-buses and charging infrastructure for deployment in the other areas it serves.
- The agency as a whole currently has a total of 16 electric buses, each of which replaced a diesel bus. Of these 16, six are deployed in Seneca, with the rest in the other areas CAT serves.
- Prospective funders recognized that the deployment of electric buses would enable the FTA (Federal Transit Association) to demonstrate the viability of this technology to reduce emissions and establish the nation’s first transit system with no carbon footprint.
- Since 2014, these buses have consistently outperformed the authority’s diesel buses operating in the other areas it serve in fuel economy and maintenance costs.
- Four years into their deployment, more than 160,000 gallons of diesel consumption have been avoided and tailpipe carbon dioxide emissions have been reduced by just over 2.7 million pounds.
- In several areas the buses are exceeding original expectations, for example: (i) the charging time initially claimed was 10 minutes which in reality turned out to be 6 minutes. (ii) range of the bus was supposed to be 30 miles but CAT drivers are getting 40+ miles. (iii) battery useful life was expected to be 80% after 6 years at which point,
they would need replacing. The buses entered their sixth year in September 2019 and were still charging at 98-100% as of July 2019. (iv) Replacement of brake pads is required every 30,000 to 40,000 miles in Diesel buses but in E-buses even after 5 years, there was no need to replace the brake pads. When Seneca’s first electric bus hit 100,000 miles (the first in the U.S. to do so), the brake pads were inspected and found that they had only worn down to 50%.

- Initially, CAT trained one mechanic through the bus supplier and built into the contract that for the first 2 years, the bus supplier mechanic would be working under its maintenance manager, reporting all mechanical issues and improvements so that CAT can maintain the records of developments. As the fleet expanded, the rest of the agency’s maintenance team was gradually trained.
- Seneca’s electric buses are supported by both on-route fast chargers and depot plug-in chargers. The fast charger locations were deployed at a location served by two different electric grids such that if one loses power, the other can be utilized. The bus operators rely primarily on fast chargers.
- The authority pays one steady rate for electricity charges and does not charge peak demand charges. The agency started out on an electricity rate plan with demand charges, with a flat fee of $13 per kWh for first demand on each on-route charging station. After a month, it opted to switch to a rate structure with higher energy use charges but no demand fees, which saw a reduction of energy costs from $1.50 per kWh to $0.90 per kWh.
- Early phases of deployment resulted in a handful of issues that the manufacturer was required to fix. The agency found that buses themselves don’t have an issue with temperature variations, but use of heaters and defrosters drains the battery. In extreme heat, the batteries need to be cooled. The system will slow the charging to keep the battery from overheating, leading to a few minutes’ increase in charging time.
- A diesel bus has around 3,700 moving parts while an electric bus only has 70, meaning that many of the problems that affect the diesel buses (cold water leaks, freezing up, etc.) do not arise with the electric buses. They require no oil changes, and save money on wear and tear.
- The Seneca experience is the first real test of E-bus technology in a small city environment with a mix of rural, suburban, campus and urban routes. According to CTA, E-buses are huge benefit for small cities and can be easily scaled for large fleets.

4. Izmir, Turkey

The first E-bus fleet of Turkey has been established in Izmir. The procurement process is initiated by ESHOT (Izmir Metropolitan Municipality) which has planned to introduce 400 more E-buses for the city in next 3 years. The buses have 29 seats and allows 40 standees and have fast charge technology. The electric energy consumed by the buses will also be supplied
by the solar energy plant which is being installed in the maintenance workshop. These buses can travel 250 km. a day and they do not use any energy sources other than electricity. Electric buses that reduce carbon emissions to zero, saving more than 80 percent compared to diesel buses, offering a quiet and comfortable journey. The city also decided to undertake 45 days test driver of the buses with trained drivers before start of commercial operations. According to the reports, the operating cost for 20 electric buses led to 84% reduction in fuel costs and 60% reduction in total maintenance costs compared to conventional buses. The city used solar power plant to provide electricity to charge the buses has resulted in annual reduction of about 420 tonnes of CO₂ emissions.

5. Campinas, Brazil

Campinas a mid-sized city with population about 3.7 million has one of the largest E-bus fleet in Brazil. The city introduced 10 E-buses since 2015 and as of June 2019, about 15 E-buses were operational. The city has planned to introduce 250 E-buses and deploy them along newly developed BRT lines. The pilot project lasted for more than a year during which the performance of E-buses was demonstrated by the manufacturer. The city has a fleet of 1500 buses and has demarcated an area in the downtown as ‘white zone’ in which it is mandatory to have only E-buses by 2022. Campinas does not have a local electric bus manufacturer, but the city provided incentives for a foreign manufacturer to accelerate implementation. The city government offers a reduced corporate tax for bus business in the city. This attracted the E-bus manufacturer to establish a new bus manufactory factory in Campinas which advanced E-bus development for the city and provided on-site support for local bus operators. The transit agency officials determined that depot up gradation with charging facility was an important requirement which needed coordination with utility companies. By focusing on this issue early, they were able to avoid significant future delays. They established clear actions and responsibilities between organizations for vehicles and infrastructure, which is a common impediment to successful completion of e-bus projects. However, it should be noted that due to lack of charging capacity, a separate diesel power generator was procured by the city for powering E-buses. Initially, the bus drivers showed mistrust for e-buses, and a fear of drastic operational differences between the E-buses and diesel buses. But, after an effective training process, the drivers became familiar with E-bus operations and became more welcoming to the new technology. Many even stated a preference for e-buses over diesel buses due to the decrease in engine vibration and noise.