

> TRAINING REPORT

TRAINING ON MANAGEMENT OF ELECTRIC BUSES

NOVEMBER | 2023



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INTRODUCTION

UITP India conducted a two-day training programme on “Management of Electric Buses” in New Delhi, India from 28-29 November 2023. The training programme was attended by 40 participants representing 12 State Transport Undertakings (STUs), representatives from Original Equipment Manufacturers (OEMs), component manufacturers, and other non-profit organisations.

The aim of the training programme was to provide participants with a holistic understanding of managing e-buses. To ensure this, the training sessions were highly interactive involving discussions and group activities. Besides the technical sessions, the training included a technical visit to an e-bus depot in Delhi.

The training programme commenced with the opening remarks by **Ms. Rupa Nandy, Head of UITP India**. She set the tone of the training programme by providing a brief context on UITP India’s latest project on ‘Advancing Electric Buses in India’, followed by a round of introduction and ice-breaking session for the participants.



KEY SESSION OUTCOMES

The training programme had national and international trainers joining in-person and sharing their insights on topics E-bus planning, operations and implementation, e-bus deployment in metro cities, procurement and contracting, infrastructure and technology planning and implementation, and worldwide deployment of e-buses.

DAY-I

SESSION 1A: PLANNING, OPERATIONS AND IMPLEMENTATION

Route selection for Indian cities

1. Mr. Alok Jain, CEO and Managing Director, Trans-Consult Limited, Hong Kong, started by providing an overview of the different variants of cleaner buses. He then proceeded to illustrate the evolution of Battery Electric Vehicles (BEVs) from fuel vehicles.
2. Explaining the key component of an e-bus, the session involved an in-depth dissemination of knowledge on different types of batteries, price range of batteries and the relationship between battery cost and energy density. These factors are crucial considerations when planning for e-bus operations.
3. The session emphasised the key considerations for route planning, with a particular focus on adopting a systems approach.

➤ KEY CONSIDERATIONS

- Capital cost
 - Fleet
 - Infrastructure
- Fuel/energy cost
- Operating flexibility
- Driving Range
- Maintainability
- Availability
- Drivability
- Passenger safety
- Pricing and revenue
- Bus Capacity
- Customer/stakeholder feedback



4. He explained the unique nature of each bus route and underscored that optimal utilisation is best achieved when tailored to its specific needs. Emphasising this concept, the discussion delved into the importance of operating flexibility.

Scheduling

1. After explaining effective ways of route planning, Mr. Alok Jain briefed on its link with scheduling and charging infrastructure. While emphasising the im-

portance of driving range, he elucidated on the concepts of 'charging', 'balancing' and 'State-of-Charge' (SOC).

2. This session concluded by presenting the different types of charging, along with a case study example illustrating how a city selects the type of charging technology it uses. The presentation also covered the technical aspects of the emerging trend of In Motion Charging (IMC) and e-bus maintenance.



SESSION 1B: PLANNING, OPERATIONS AND IMPLEMENTATION

Introduction to UITP's work on Route Planning and Scheduling

1. Mr. Manel Rivera Bennassar, Bus Manager – Knowledge and Innovation, UITP Brussels led the session by providing an overview of the current bus sector, emphasising the significance of e-buses in contemporary times.
2. Providing a stakeholder overview, he highlighted of 'if', 'when', 'what' and 'how' to implement e-buses, followed by the challenges that lie in its implementation.

➤ Key elements for a successful e-bus operation



- Improved bus service: optimized line and network design adopting BRT-like features: rational number of stops, straightened routes, encouraged network effect, reduced dwelling times...
- Improved bus image with new and cleaner buses
- Improved service and better image = more passengers onboard
- Achieve an outstanding passenger experience during and after implementation of the bus-fleet electrification plans

Bus Network Planning from the operators' perspective
October 2022

<https://www UITP.org/news/clearer-streets-smoother-journeys-paving-the-road-with-bus-network-planning/>

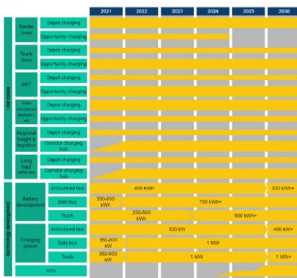


3. Addressing the key elements for successful e-bus operation, he highlighted on the key learnings from the different works conducted by UITP.

Opportunity Charging Strategy and Charging Infrastructure Planning and Optimisation

1. In the second part of the session, **Mr. Manel Rivera Bennassar** directed attention to the ASSURED Interoperability Reference, which serves as a common framework for e-bus charging infrastructure used by suppliers and e-bus manufacturers.
2. The presentation covered different types of charging strategies, discussion considerations to be made before e-buses are deployed. Additionally, a glimpse of charging technology roadmap in the European context was shared.

ASSURED charging technology roadmap (EUROPEAN CONTEXT)



- Opportunity charging for trunk lines and BRT. Feeder lines will mostly rely on overnight charging.
- BRT buses will need smaller battery packs and rely more on opportunity charging, as opposed to solo buses with higher battery capacity charged overnight.
- Pantograph on the roof and plug-based charging are the most used.
- Static and conductive charging have higher potential than dynamic and wireless.
- <https://assured-project.eu/news-and-events/news/facilitating-future-standardisation-efforts-assured-releases-new-deliverable>



SESSION II: E-BUS DEPLOYMENT IN METRO CITIES

A case of Mumbai

1. **Mr. Pravin C. Shetty, Deputy Traffic Manager (Planning), Brihanmumbai Electric Supply and Transport (BEST)**, explained the case of Mumbai by giving a brief introduction to its public bus ecosystem comprising a fleet of 2,949 buses, 27 depots, 55 bus stations and 107 chowkies; catering to ridership of 35 lakh people across Mumbai and its suburbs of Thane, Navi Mumbai and Mira Bhayandar.
2. The presentation lucidly stated the dire need for electrification of the fleet and highlighted BEST's



status of present e-bus fleet and its vision for expansion in this regard for the roadmap ahead. Providing a glimpse of changes in the rate and assured per kilometre, the presentation illustrated the positive impact, resulting in reduction of 3,45,36,368 kg (34,536 metric ton) of carbon emission by operating e-buses for 3,95,45,453 km till date.

3. Continuing, the session provided a detailed understanding of the supply and demand sides of energy requirement for e-bus charging and outlined ways of building a robust charging infrastructure. Recommendations were made for usage of planning and e-bus management tools.
4. The session concluded with giving examples in the form of scenarios created in different case studies to comprehend the diverse implications of various types of adopted charging plans.



GREENHOUSE Emission Reduction by Operation of ELECTRIC BUS



Total Km Operated by Electric Buses: 3,95,45,454 kms
Carbon emission reduced so far-3,45,36,368 Kg(34536 Metric Ton)

(1 Ltr of Diesel produces 2.68 kg Co₂ .)

Ref: Greenhouse(GHG) Emission reduction Link: <https://www.bestundertaking.co:8080/ebusdashboard/>

3. The presentation concluded with the focus of BEST in 'Go Green Initiative' in its future business plan and insights into the learnings derived from operating and tendering experience, operational challenges, salient features of GCC model followed by BEST, strategy for risk mitigation and performance of its e-buses so far.

A case of Delhi

1. Mr. Chandra Kant Goyal, Senior Vice President, Delhi Integrated Multi Modal Transit System Limited (DIMTS) initiated his presentation by outlining Delhi's reformative journey in the public transport system. He emphasised that Delhi has been one of the pioneers in shifting to cleaner mobility transport having transitioned its entire fleet to CNG as early as 31 March 2001.



2. The presentation highlighted various modes of public transport with special focus on the approach of the Government of National Capital Territory (NCT) of Delhi regarding Zero Emission Public Transport.
3. In order to provide trainees with a comprehensive understanding of the trajectory of e-bus deployment in Delhi, Mr. Goyal highlighted various crucial aspects including procurement, depot electrification plans, last mile connectivity through feeder services, the adoption of an Artificial Intelligence (AI) based approach for identifying feeder bus routes, and the operation of electric buses in the feeder service.
4. The presentation concluded by summarising key learnings from Shenzhen and illustrating how Delhi leveraged technology to make public transportation more convenient. This included the launch of National Common Mobility Card (NCMC) and the implementation of the One Delhi Application.

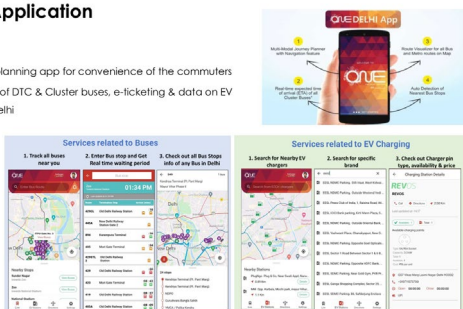
One Delhi Application

ONE DELHI APP

- An integrated travel planning app for convenience of the commuters
- Realtime data & ETAs of DTC & Cluster buses, e-ticketing & data on EV charging stations in Delhi

KEY FEATURES

- Live Bus Tracking
- Contactless Ticketing
- Journey Planner
- EV Charging and Passenger
- Official Complaint and Feedback System

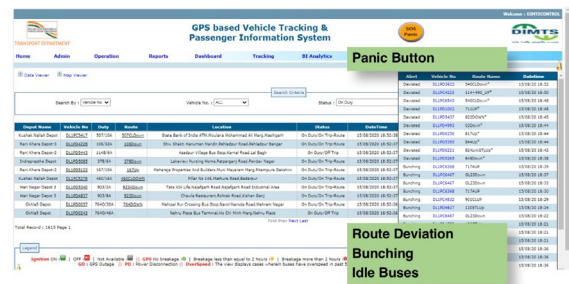


SESSION III: PROCUREMENT AND CONTRACTING

Contract Management and Performance Management for E-Buses – GCC and Outright Purchase

1. Mr. Chandra Kant Goyal started this session by addressing the key implementation challenges faced by Public Transport Authorities (PTAs), thereby clarifying the problem statement. He then systematically delved deeper into topics such as conducting a needs assessment of bus requirement in a city, feasibility assessments, and the selection of batter types. While explaining the Gross Cost Contract (GCC) model for e-buses, he highlighted on some important factors such as State Government Contractual Obligations, Load Assessment of Parent Depots, feasibility for opportunity charging. He then provided an example of Delhi, outlining key terms and conditions in its Bid Document, Concession Management, the system of real time alerts, integration of technology with daily operations and the use of Key Performance Indicators (KPIs) for performance analysis.

Real Time Alerts



RFP and Contract Designing – GCC and Outright Purchase

1. In this session, Mr. Alok Jain navigated through the flow of events in developing an e-bus operation plan / e-bus project and highlighted key considerations that would help in determining the business model to be adopted.

Gross or Net Contracts

Advantage	Disadvantage
Gross contracts	
Attractive for operators: more bidders and easier entry	Little commercial initiative on operator side (no incentive for revenue increase)
Stable situation with limited risk of disputes among parties	High level of monitoring required
No revenue sharing among operators	Detailed knowledge at Transport Authority required
Stable income for operator	
Net Contracts	
Operator has incentive to increase ridership and deliver quality	Revenue risk perceived to high by operators (barrier to entry); less interest of operators
Lower level of monitoring	Disputes in case of lower ridership than expected
Cost efficiency is naturally aligned	Level of tariffs - who sets the tariffs?
Operator know the market the best	Operator may pull out of the market

Current Pandemic has dealt a big blow to net cost contracts

2. Highlighting on the contract types, he explained the concept and the advantages and disadvantages of each type of contract, providing an overview of the current trends.
3. He explained the concept of Platform as a Service and the role played by different stakeholders in the procurement process. Additionally, he spoke about the challenges, revenue impacts, concluding the session by sharing the idea of multi-storey depots through a video.

SESSION IV: GROUP ACTIVITY ON TENDER DESIGNING FOR GCC PROCUREMENT

Day 1 of the training programme concluded with a group activity in its last session. The group activity required each group to prepare a framework based on selecting the ideal option from the checkboxes provided. The framework was to guide the planning of e-bus procurement / tendering. The objective was to provide a platform for all the participants to collaborate and brainstorm in groups, applying the concepts covered during the training.



DAY-II

SESSION 5: INFRASTRUCTURE AND TECHNOLOGY PLANNING AND IMPLEMENTATION

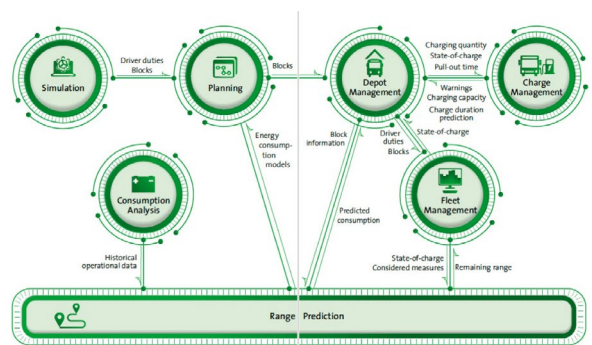
Charging infrastructure technologies, ITMS / MIS and BMS planning

1. Mr. Alok Jain initiated the session by introducing the various components of real-time monitoring and explaining the crucial role of Battery Management System (BMS) in e-bus operations.



2. While expounding on the key components of BMS, he elaborately on BMS algorithms, on-board BMS, BMS interfaces, On-Board Diagnostics (OBD), and the communication system.
3. The presentation compared e-bus with conventional buses, followed by a comparison between on-board and off-board diagnostics and the importance of the later in analytics.

➤ Off-Board Analytics



- The presentation highlighted the importance of data collection in service optimisation and its impact on operations. He also discussed the standards and regulations followed in various countries.

Depot infrastructure planning

- In this session **Mr. Manel Rivera Bennassar** articulately presented the bus sector's commitment to decarbonisation. Speaking on adapting depots for clean buses, he highlighted some of the key works carried out by UITP in the domain.
- Providing an overview of the inputs and outputs of charging infrastructure, the presentation demonstrated in detail the key considerations to be taken into account while depot planning.



➤ Depot planning considerations



- Proximity to high voltage (HV) grid connection point:
 - Consideration of future extensions and depot upgrades
 - Adherence to regulations and rules of the Distribution System Operator (DSO)
- Cabling costs optimization:
 - Minimization of expenses associated with bringing power supply to the depot
 - Focus on cost-effective solutions for efficient operation
- Available surface for infrastructure:
 - Adequate space for transformers, substations, cabinets, and chargers
 - Evaluation of space requirements for pantograph-based and plug-based solutions
 - Changes in run-in/run-out process
- Transformers and substations placement:
 - Adherence to safety regulations in determining the location
 - Ensuring compliance with applicable safety standards



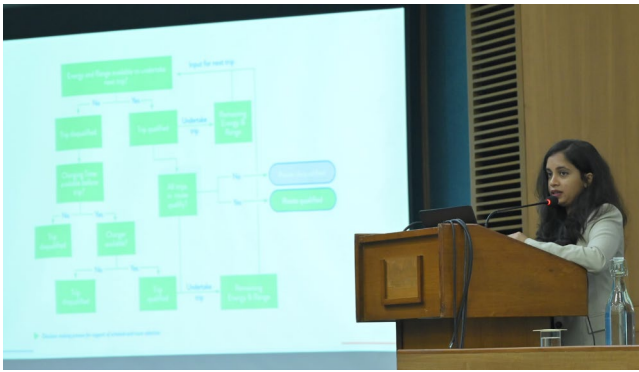
▶ Plug-based charging at Waterloo Garage. Source: Go-Ahead London

- The presentation also highlighted various charging infrastructure facilities such as installed power requirements, the ideal location of chargers, and suitable space requirements in the depot. It focused on aspects of workshop facilities, including requirements for working at heights, battery movement and storage requirements, and preventive measures to be taken.
- The session concluded by showcasing the case study of EMT Madrid - La Elipa Depot and introducing the participants to UITP Bus Committee.

SESSION 6: WORLD-WIDE DEPLOYMENT OF E-BUSES

Advancing Electric Buses in India

- Ms. Divyanka Dhok**, Researcher, UITP India provided an overview of the project conducted by UITP India. She highlighted the technical assistance provided to Kalyana Karnataka Road Transport Corporation (KKRTC) through the study. She shared insights on the learning outcomes of the project, documented in a knowledge brief titled 'Planning for Electrification of Rural and Intercity Buses'.



2. She also informed the participants about UITP India's ongoing projects and how UITP is providing technical assistance to its partner Indian cities, achieving the common goal of advancing public transport towards sustainable mobility.

World-wide learnings

1. Mr. Manel Rivera Bennassar and Mr. Alok Jain Presented detailed case studies on Santiago Chile BYD and EnelX, and Shenzhen, respectively, discussing key learnings from global best practices in e-bus management.

2. This session witnessed extensive interactions, with participants particularly representatives of the different STUs - enthusiastically sharing their experiences of managing e-buses in their respective states. The presence of both STUs and OEMs facilitated comprehensive discussion, allowing for the exchange of perspectives from both the demand and supply sides of e-bus management.



VALEDICTORY SESSION

The technical sessions of the training programme concluded successfully with participants engaging in holistic discussions and active interactions, creating the perfect forum for knowledge sharing. There was feedback collected from the participants to get an understanding for designing future training programmes. In the valedictory session, Ms. Rupa Nandy addressed the participants and presented mementos to the trainers and certificate of participation to the trainees.



TECHNICAL VISIT

The two-days training programme concluded with the technical visit to Shastri Park Bus Depot in Delhi, organised with the support of DIMTS Limited. The objective of the technical visit was to provide participants with practical exposure to the e-bus depot layout, functioning of the charging infrastructure, and the features of e-bus.



Mr. Amit Ahuja, Depot Manager highlighted the technical details of e-bus operations, emphasising mileage, charging time, various charging modes, the bus's battery location, and charger capacity. He demonstrated how the chargers work, explaining the relationship between battery capacity and efficiency. He stressed the importance of judicious route planning and opportunity charging in city bus operations.



Discussing the operation and design of the e-buses to make public transport accessible, the depot manager mentioned their frequency of approximately five to eight minutes and their low-floor design. Returning to the depot, he explained the layout, showcasing the location of transformers, 11 chargers (10 operational and 1 spare), and parking bays accommodating nearly 30 buses. Safety protocols, well-displayed through signage, were also detailed. The depot manager shared the electricity tariff to provide insight into the financial implications and energy requirements for daily e-bus operations. Insights on incident management and precautionary measures to avoid incidents were also shared.



In conclusion, the technical visit enabled trainees to witness a live demonstration of the theoretical training, marking a key highlight of the programme.

The trainees experienced a short ride in the e-bus around the depot's feeder road, where these buses provided feeder service for Delhi Metro Rail Corporation (DMRC) metro services. During the ride, the depot manager showcased features inside the e-bus and explained how the Intelligent Transport Management System (ITMS) functions as a Public Information System (PIS)/announcement system. Highlighting the e-buses' noise pollution-free nature, he emphasized the importance of honking at crucial road junctions to alert pedestrians to the approaching e-bus.



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This Report was prepared by UITP India.



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