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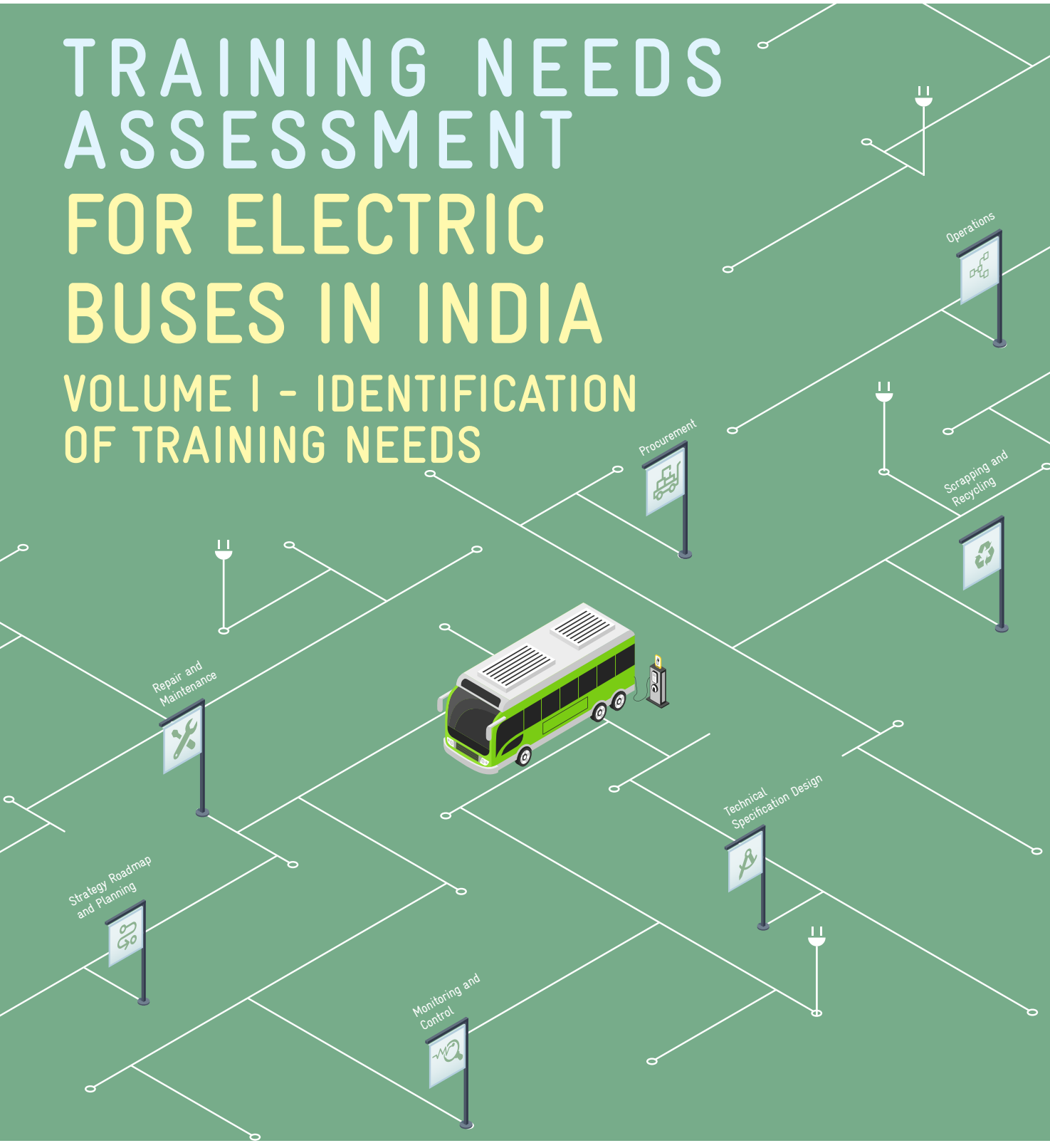
Green Urban Mobility Partnership

TRAINING NEEDS ASSESSMENT FOR ELECTRIC BUSES IN INDIA

VOLUME I - IDENTIFICATION OF TRAINING NEEDS



Published by
Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH

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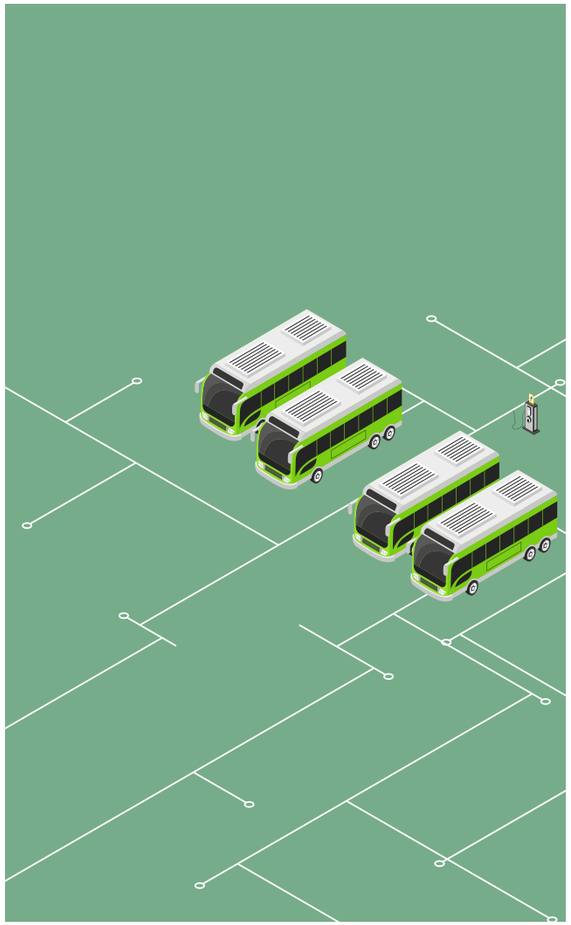

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GIZ is responsible for the content of this publication.
On behalf of the German Federal Ministry for Economic Cooperation and Development (BMZ)

ACKNOWLEDGMENT

The team would like to thank the following public transport authorities (PTAs) for providing all necessary data and assistance during the detailed stakeholder consultations and surveys: Himachal Road Transport Corporation (Shimla-Manali), Navi Mumbai Municipal Transport (Navi Mumbai), Bangalore Metropolitan Transport Corporation (Bangalore), and West Bengal Transport Corporation (Kolkata). The team gratefully acknowledges the support and knowledge contribution from following organisations:

Electric bus Vehicle Manufacturers: Tata Motors, Ashok Leyland, JBM-Solaris, Foton PMI, Olectra-BYD

Battery Manufacturers: Exicom, Sun Mobility, Grinntech

Charger Manufacturers: Exicom, Delta

Private Operators: Prasanna Purple, Hansa, Shyama Shyam

Policy Makers/ Government: Ministry of Housing and Urban Affairs, Department of Heavy Industry, Ministry of Heavy Industries & Public Enterprises, Government of India, Ministry of Road Transport & Highways, Government of India

Institutions/ Associations: Central Institute of Road Transport (CIRT), Automotive Skills Development Council (ASDC), Association of State Road Transport Undertakings (ASRTU), Society of Indian Automobile Manufacturers (SIAM), Bus Operator Confederation of India (BOCI), CEPT University, IIT Madras

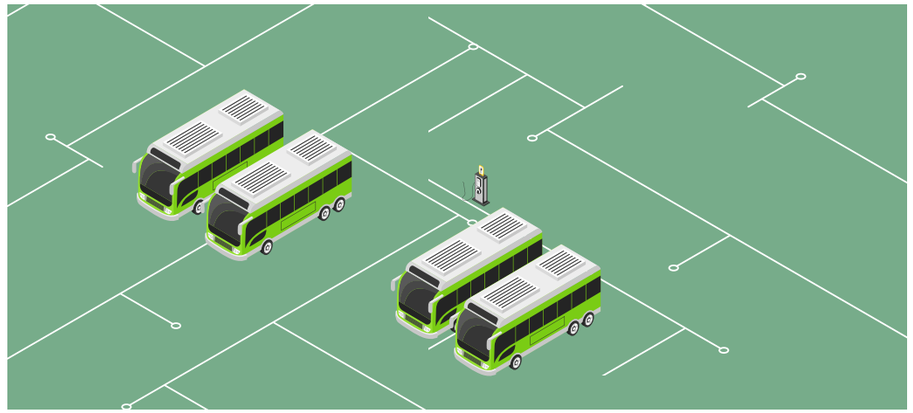
Public Sector Undertakings: National Thermal Power Corporation Limited (NTPC), Power Grid Corporation of India Limited (PGCIL), Bharat Heavy Electricals Limited (BHEL)

Testing Agencies: Automotive Research Association of India (ARAI)

Discoms: BSES Yamuna Power Limited

Additionally, we are thankful to Mr. Ravi Gadepalli (Consultant, UITP and The World Bank Group), Mr. Sumit Mishra (Director, M/s. Deloitte), Mr. Kishor Nathani (Senior Advisor, UMTC Ltd.), Mr. Karthick Athmanathan (SVP & BU Head – EV & eMobility, M/s. Ashok Leyland), Mr. Gautam Patel (Principal Consultant, Coordinates Infrastructure Consulting), Mr. Hiren Joshi (Consultant, Coordinates Infrastructure Consulting) Mr. Wilfred Davidar (Retd. IAS, Additional Chief Secretary, Govt of TN), Mr. Shailendra Kaushik (Co-founder, Cities Forum), Mr. Vivek Chandran (Associate Director – Transport, Shakti Sustainable Energy Foundation), Mrs. Nayana Gunde (Former MD, Pune Mahanagar Parivahan Mahamandal Ltd), PMPML staff and others, for their guidance and review of interim results.

The team is hopeful of the project being a useful guide for deploying and integrating electric buses with existing public transport infrastructure and enhance capacity building.



ABOUT THIS REPORT

The report has been prepared as part of the bilateral technical cooperation project"Integrated Sustainable Urban Transport Systems for Smart Cities (SMART-SUT)" commissioned by the German Federal Ministry for Economic Cooperation and Development (BMZ) and jointly implemented by Deutsche Gesellschaft fuer Internationale Zusammenarbeit (GIZ) GmbH and Ministry of Housing and Urban Affairs (MoHUA), Government of India. The objective of the project is to improve the planning and implementation of sustainable urban transport systems in selected Indian cities.

The study focuses on e-Bus related Training Needs Assessment (TNA) in Public Transport Authorities (PTAs) and development of skill upgradation and addition mechanisms. The outcomes of this study are presented in three volumes as stated below:

Volume I identifies clear training needs in PTAs across e-Bus life cycle functions, various departments, and hierarchies.

Volume II presents detailed training modules coverage, their delivery mechanisms and national level institutional structure for sustainability and adoption.

Volume III reviews the existing organisational structure of large State Transport Undertakings (STUs) and city level Special Purpose Vehicles (SPVs). In addition, the study proposes changes in the organogram and recommends upskilling required at different staff levels for transition from Internal Combustion Engine buses to Electric buses.

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ABBREVIATIONS AND ACRONYMS

Abbreviation	Full Form
AMC	Annual Maintenance Contract
ATR	Action Taken Report
BEE	Bureau of Energy Efficiency
BMS	Battery Management System
BMTC	Bangalore Metropolitan Transport Corporation
BS	Bharat Stage
CEA	Central Electricity Authority
CERC	Central Electricity Regulatory Commission
CNG	Compressed Natural Gas
CO_2	Carbon Dioxide
DHI	Department of Heavy Industries
DISCOM	Distribution Company
DST	Department of Science & Technology
electric bus	Electric Bus
EVSE	Electric Vehicle Supply Equipment
FAME	Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles
FoR	Forum of Regulators
GCC	Gross Cost Contract
GDP	Gross Domestic Product
GoI	Government of India
GHG	Greenhouse Gas
GVW	Gross Vehicle Weight
HRTC	Himachal Road Transport Corporation
ICE	Internal Combustion Engine
IT	Information Technology
ITMS	Integrated Transportation Management System
Kms	Kilometres
KPI	Key Performance Indicator
KRA	Key Responsibility Areas
kWh	kilowatt-hour
MD	Managing Director
MIS	Management Information System
MoNRE	Ministry of New and Renewable Energy
MoEFCC	Ministry of Environment, Forest and Climate Change
MoE&IT	Ministry of Electronics and Information Technology
MoF	Ministry Finance
MoHUA	Ministry of Housing and Urban Affairs
MoM	Ministry of Mines
MoP	Ministry of Power
MoPNG	Ministry of Petroleum and Natural Gas
MoRTH	Ministry of road, Transport & Highways
NMMT	Navi Mumbai Municipal Transport
NCC	Net Cost Contract
O&G	Oil and Gas
O&M	Operation and Maintenance
OEM	Original Equipment Manufacturer
PIS	Passenger Information System
PPP	Public Private Participation
PT	Public Transportation
PTA	Public Transport Authorities
RFQP	Request for Quotation and Proposal
SERC	State Electricity Regulatory Commissions
SLAs	Service Level Agreements
SoC	State of Charge
STU	State Transport Undertakings
TCO	Total Cost of Ownership
TNA	Training Needs Assessment
VMs	Vehicle Manufacturers
WBTC	West Bengal Transport Corporation

1 INTRODUCTION

₹3,545 Cr
Allocated by the Indian Government for supporting adoption of 7,090 elecrtic buses by STUs

5,594 electric buses
Have been sanctioned by the Government to 64 cities for intra-city and inter-city operations over the next 3 years

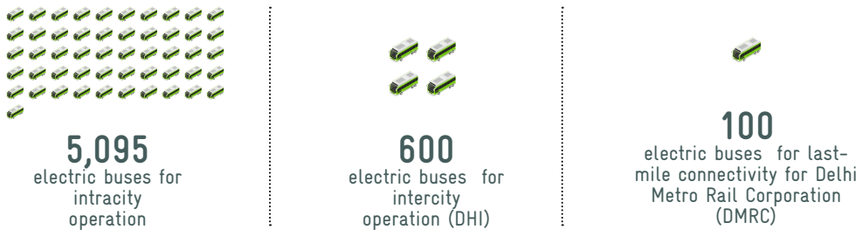
~800 electric buses
have been deployed, as of April 2021(DHI)

1.1 Background

In India, cities contribute to 82% of GDP and are responsible for 78% of greenhouse gas emission and air pollution. The transport sector in India alone accounts for approximately 13.2% of the total CO2 emissions, and road transport has been known to contribute up to 90% of total greenhouse gases emission from the transportation sector in India. As the country continues to urbanise rapidly, policymakers are continually working on plans that abide by the required emissions reduction. One such action is to incorporate electrification of buses operated by Public Transport Authorities (PTAs) for intra-city and inter-city operations. Public transport is considered as a sustainable mode of transport for various reasons, including its ability to move more people and simultaneously reducing congestion and pollution on the roads. Large Indian metropolitan cities depend on public transport system to meet a substantial share of commuting demands - 88% in Mumbai, 76% in Kolkata, 70% in Chennai, and 62% in Delhi. Although these cities have rail-based metro system, bus based public transport system still forms an integral part of meeting the travel demand to a substantial level. Further the public transport system in other cities are primarily based on bus-based system. These buses are based on Internal Combustion Engine (ICE) and contribute towards carbon emission air pollution. A gradual transition from ICE to electric buses can help reduce carbon emissions from the mobility sector. To meet the Paris Climate Change Agreement targets, India declared reducing the emission intensity of GDP by 33%-35% by 2030 below the 2005 levels. The transition to electric buses can play a significant role in attaining this target and based on which the Government of India has drawn a public transport electrification plan and various efforts are being made to develop a comprehensive ecosystem to achieve the electrification target.

This study is an effort in this direction with an objective to identify the capacity building requirements and identify training requirement of various PTAs with this ambitious plan of transitioning to electric

Figure 1. Electric buses Sanctioned Under FAME-II Scheme



buses.

The study is divided into three volumes and this report is the first in the volume of three volumes summarizing Stage 1 i.e. identification of training needs. Subsequent volumes will include the structure of the training modules in Volume II and resource requirement for electric Bus training and capacity building program in Volume III.

1.2 Current Scenario

As of 2019, there were around 4,25,000[1] electric buses running on roads globally in municipal public transport fleets. China constitutes ~98% of the market, followed by Europe and the US. As of April 2021, India has reported to have about 800 electric buses plying on roads, a mere contribution of 0.5% to the total PTAs fleet of 1,40,000[2] buses. These early deployments are supported through a combination of subsidies from a scheme sponsored by the Government of India named FAME-I and further through the support of respective State Governments.

The on-going policy push from Government of India (GoI) for green mobility has resulted in launch of a bigger funding support to the bus electrification programme named FAME II scheme. This has further added momentum to adding electric buses in fleets. The government has allocated a total of INR 10,000 Crore (EUR 1.1 billion) funding support for demand incentives and charging infrastructure, of which INR 3,545 Crore (EUR 406 million) is for supporting adoption of 7,090 electric buses by the PTAs. If PTAs wish to access the funding support under this scheme, they are required to follow a standard contracting model based on Gross Cost Contract (GCC) and guided by standard Model Concession Agreement (MCA). This way the effort is to unify the market based on standard terms and conditions and thus invite large players to bid for the projects. Under this scheme, the Government of India has sanctioned a total of 5,595 electric buses to 64 cities for intra- city and inter-city operations over the next three years commencing from 1st April 2019.

In a move to augment 'Make in India' initiative, the FAME II scheme mandates a minimum 40% localisation content. This transition to electric buses has the potential to create significant economic, social, and environmental benefits for Indian cities. Over their lifetime, 5,595 electric buses sanctioned for the subsidy will run nearly 3 billion km without tailpipe emissions, produce oil import savings of 55 lakh (5.5 million) barrels equivalent to INR 3,600 crore (EUR 412 million) and avoid 12 lakh (1.2 million) tons of CO2 emissions[3].

1.3 Need of the Study

With such an ambitious program of bus electrification with a strong Government subsidy support there are still several barriers faced by various stakeholders that have delayed the implementation of the programme and market uptake. Initial experiences have revealed a very large gap in understanding and expertise required in PTAs for electric buses adoption and further skills required with local manufacturing base to support 40% localization requirements. As Electric buses have different operations and management (O&M) requirements through their lifecycle compared to the ICE buses which means the owners, operators and managers need to have adequate knowledge of the electric buses technology.

This includes knowledge support specific to electric buses around tools, processes, skills for effective life cycle management across – planning, specification design, procurement, charging infrastructure setup and operations, integration with legacy fleet, monitoring and control, safety, disposal/ recycling and others.

To address the skills barrier within PTAs, there is a strong need to undertake an industry wide systematic diagnosis of Training Need Areas for PTAs.

Various stakeholders related to bus electrification in electric bus value chain, is shown in Figure 2.

This Project looks into the area of training needs assessment at various PTAs' level and identification of their training needs for adoption and transition from ICE buses to electric buses.

1.4 Objective of the TNA

The study intends to compliment various efforts being made in building a sustainable ecosystem for electric buses adoption in India with training and capacity building being identified as an important component that need to be focused. This study aims to assess the existing skill gaps at PTAs level across electric bus life cycle stages and identify training needs. The key objectives of the study are:

- Review and understand the experiences of an early adopter of electric buses in cities, followed by gap identification in the capacities that requires to be plugged for successful electric buses adoption
- Undertake Training Needs Assessment (TNA) at various levels of PTA's across the electric bus life cycle management
- Assistance to the GoI endeavours to increase adoption of electric buses as envisaged in FAME II scheme through upskilling PTAs' capacities

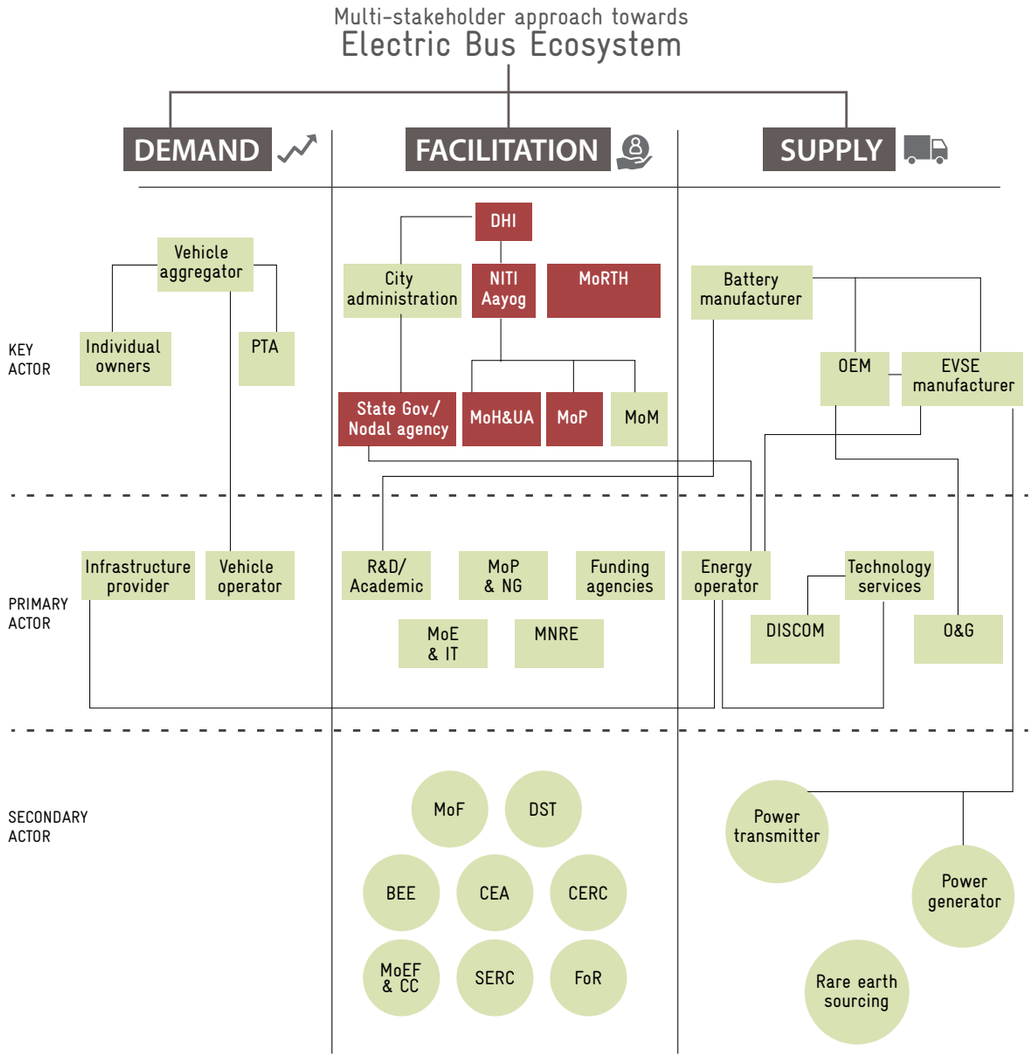
1.5 Assumptions and Considerations in the Study

The report includes detailed analysis of electric bus skill gaps and training needs for PTAs in India across electric bus life cycle stages. Some assumptions and considerations made during setting up the TNA framework and analysis of the study are as follows:

- PTAs face multiple issues, including lack of training for conventional ICE buses. This report looks into incremental training needs they would need for adoption and integration of electric buses only. It does not dive into common aspects of conventional and electric buses.
- The TNA framework is developed for PTAs irrespective of the mode of procurement (outright purchase or PPP). Accordingly, the Training Modules with a high level course contents have been identified for all electric bus functions and can be imparted as relevant for specific PTA.
- The results are based on the survey conducted at four PTAs, though these are well selected across geography and have different models and makes of electric buses and at different life cycle stages of their electric bus adoption. Additionally, experts' views were taken to further refine the findings of the study.

[1] https://www.citylab.com/transportation/2019/06/electric-bus-china-grid-ev-charging-infrastructure-battery/591655/
[2] PTAs Profile and Performance Report 2016-17 by CIRT, Pune
[3] Building an Electric Bus Ecosystem in Indian Cities

Figure 2. Stakeholders Engaged in electric bus Development in India



PTA Public Transport Authorities
DHI Department of Heavy Industries
MoRTH Ministry of road, Transport & Highways
MoHUA Ministry of Housing and Urban Affairs
MoP Ministry of Power
MoM Ministry of Mines
MoPNG Ministry of Petroleum and Natural Gas
MoEFCC Ministry of Environment, Forest and Climate Change
OEM Original Equipment Manufacturer
EVSE Electric Vehicle Supply Equipment
MoEIT Ministry of Electronics and Information Technology

MNRE Ministry of New and Renewable Energy
MoF Ministry Finance
DISCOM Distribution Company
O&G Oil and Gas
DST Department of Science & Technology
BEE Bureau of Energy Efficiency
CEA Central Electricity Authority
CERC Central Electricity Regulatory Commission
SERC State Electricity Regulatory Commissions
FoR Forum of Regulators

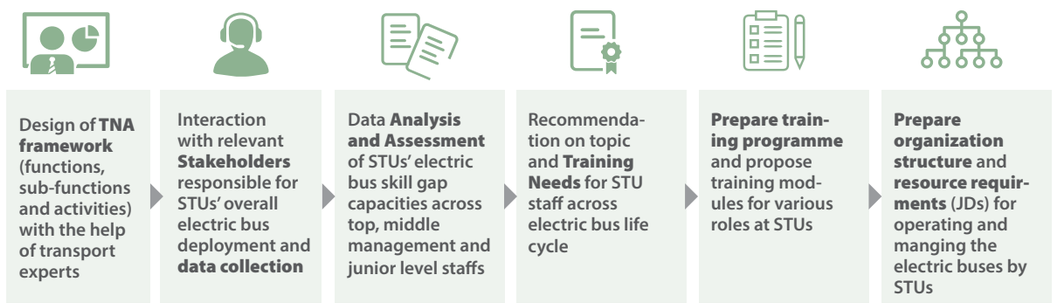
2

APPROACH AND METHODOLOGY

A Training Needs Assessment (TNA) is the first step for the development of any successful training program. Accordingly, in this study, training needs assessment has been conducted by identification of the individuals' current levels of competency, skills or knowledge in one or more areas and compares the competency level to the required competency standard as a result of adoption of electric buses.

The following steps as shown in Figure 3, have been used to assess current skill levels and identify training needs for PTAs across different departments and roles involved in various life cycle stages of electric buses at the PTAs:

Figure 3. Approach and Methodology

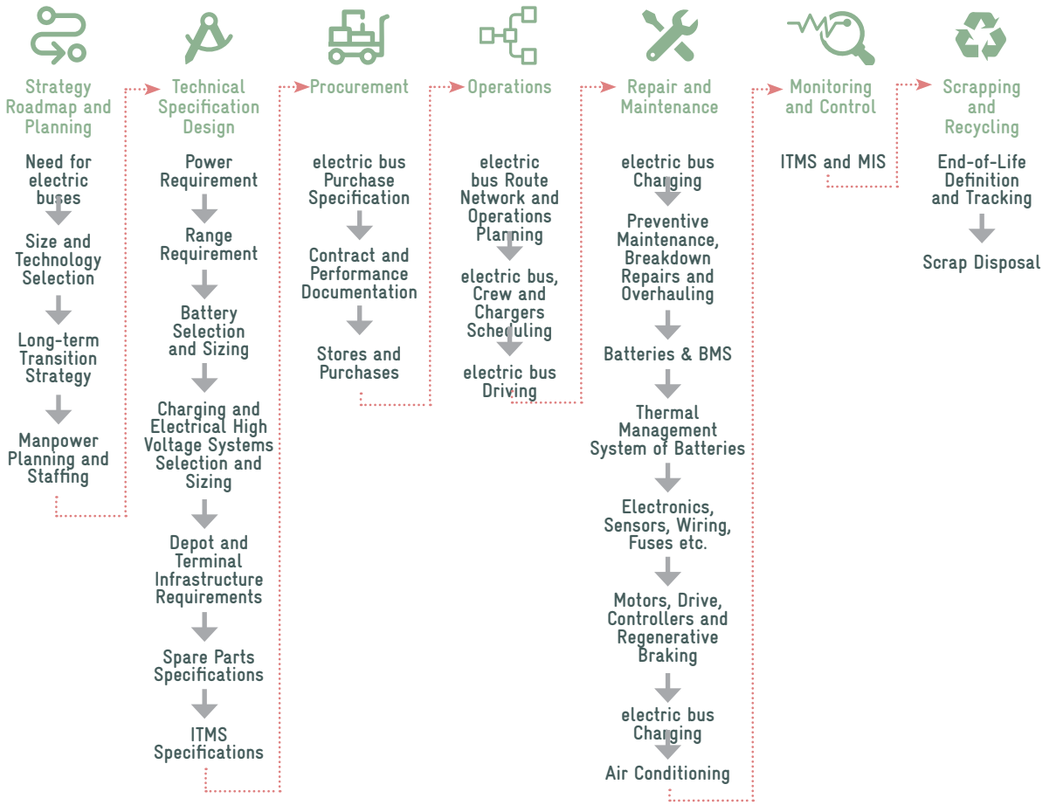


TNA Framework Design

The design of TNA framework across electric bus life cycle includes seven functions, as shown in Figure 4. Each of these functions are sub-divided into sub-functions (total 28) and further into activities (these activities are further elaborated in Chapter 3).

This framework and essential set of functions and sub-functions involved in electric bus adoption by PTAs, were developed in consultation with various electric bus stakeholders and experts in the transport sector. All these functions and sub-functions are applicable for successful deployment

Figure 4. Electric bus TNA Framework for PTAs



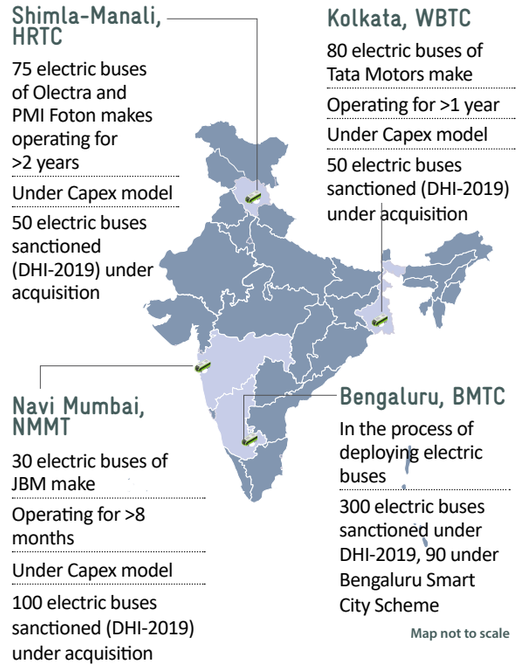
of electric buses through their life cycle irrespective of the mode of procurement (outright purchase or PPP).

Interaction with Stakeholders

Different questionnaires for supply and demand side stakeholders were developed for online surveys and in-person consultations respectively. A skill scale of 'Low', 'Medium' and 'High' was used in the survey questionnaire to assess the current skill levels of PTA staff based on various electric bus activities. The 'High' rating selection for a particular activity would mean PTA staff has requisite skills for that activity, while 'Low' and 'Medium' rating selection would indicate skill gaps to be acquired for better outcome from that activity.

Within demand side (i.e. PTA), the survey has been conducted across different hierarchical roles (top management, senior management, middle management driver, technicians and storekeepers), departments (Traffic, Civil, Electrical, Mechanical, IT, Procurement) and units (corporate office, depot, terminal, workshop). The electric bus PPP operator/ vehicle manufacturer's staff including managers, engineers, supervisors and technicians were also consulted. The interviewed personnel were requested to rate current skill levels corresponding to various electric bus activities in which they and their departments are involved. The survey was led by a team of domain experts through in-person visits to four PTAs, as

Figure 5. PTA Profiling



shown in Figure 5. The PTAs selection was guided towards obtaining a balanced and optimal representation of current adoption of electric buses in India to enable study results' applicability to all PTAs.

Moreover, in order to get deeper insights from supply side stakeholders and related industries, an online survey was conducted for the aforesaid functionalities. The main objective was to understand an external stakeholder's perspective about the skill sets in PTAs for perceived roles and required training needs for electric bus adoption since they frequently interact with PTAs in their respective roles and purposes (business/advisory). The survey respondents from the supply side included, electric bus vehicle manufacturers, battery and charger manufacturers, and remaining from other related organisations and industry experts (actively involved in electric buses, their sub-systems and or their infrastructure and the market development).

PTAs' Electric Bus Skill Assessment

The assessment of PTA electric bus skill levels across all hierarchies were based on the survey data collected through online surveys and in-person consultations. The data was further consolidated at function and sub-function levels. To obtained a combined perception of current skill levels vs required skill levels for successful adoption of electric buses. The low, medium, and high skill response ratings obtained from the respondents were combined into weighted average score at individual electric bus activity and sub-function levels. For easier visualisation, this is then converted to a 4-pointer percentile (0-100%) score and represented into four colour coded skill levels, as shown in Table 1.

Table 1. Current skill level representation

Percentile Score	Color Code	Currently available Skill Levels of STUs w.r.t. electric buses	Level of Training Needs
(85%, 100%]		High	Low
(65%, 85%]		Fair	Medium
(35%, 65%]		Medium	Fair
[0, 35%]		Low	High

PTA Training Needs Identification

Different skill levels with reference to functions, sub-functions and activities at PTAs are broad indicators of skill gaps in PTAs, leading to different levels of training needs (as shown in Table 1). These unmet training needs limit overall PTA staff abilities to effectively manage various PTA functions related to electric buses. The training needs identified through this systematic assessment will be utilised to develop training modules for PTAs (across different departments, roles and hierarchies). These training modules when methodically

3 ELECTRIC BUS ACTIVITIES AND ROLES AT PTAs

The electric bus ecosystem at PTAs level is divided into seven main functions as explained earlier in Chapter 2. These functions group typical activities undertaken by different departments and roles at various PTAs.

Strategy, Roadmap and Planning

Electric bus technology is continuously evolving to address real-world challenges and having updated strategic roadmap and planning is imperative for a smooth transition from the existing ICE to electric bus fleet. It will help PTAs in decision making for electric bus adoption from scratch and to further scale-up in a systematic manner. Some of the key activities across various PTA roles are identified, and is shown in Figure 6:

Figure 6. PTA Key Activities and Roles for Strategy, Roadmap and Planning

Key Activities	PTA Roles
Identify the need for electric bus	Top Management (MD, Joint MD)
Select the right size and technology (for electric bus, battery and charging systems) as per driving conditions	Senior Management (Heads of Traffic, Civil, Electrical, Mechanical, Procurement, Finance, and IT Departments)
Plan for year-wise fleet augmentation, staff requirement and funding strategy	Middle Management (Depot Manager, Works Manager and others)

Technical Specification Design

Designing technical specification of electric buses, their systems, sub-systems and defining the Key Performance Indicators (KPIs)/ Service Level Agreements (SLAs) are critical for electric bus procurement. Therefore, it is important for PTAs to understand these technical aspects to make appropriate choices for standardising electric bus acquisition. Various activities under this function are represented in Figure 7:

Figure 7. PTA Key Activities and Roles for Strategy, Roadmap and Planning

Key Activities	PTA Roles
Understand power requirements by different systems and sub-systems	Senior Management (Heads of Mechanical, Civil, Electrical and IT Departments)
Understand battery sizing (kWh), charging systems and their selection parameters	Middle Management (Works Managers, Engineers and Supervisors)
Estimate the operational range (kms) based on battery sizing and charging systems	
Determine depot infrastructure, spare parts and ITMs requirements	

Procurement

Procurement is one of the most critical function for a smooth and economical transition to electric bus fleet. Post specification design, PTAs need to develop required tender documents of electric buses and other associated services procurement. Figure 8 lists down key activities essential for harmonising the electric bus procurement process:

Figure 8. PTA Key Activities and Roles for Procurement

Key Activities	PTA Roles
Define electric bus, its aggregates specifications and operational plans	Senior Management (Heads of Mechanical, Civil, Electrical and IT Departments)
Detail performance SLAs, associated incentives and disincentives	Middle Management (Works Managers, Engineers and Supervisors)
Define quality assurance parameters and spare parts inventory	
Mention supply of user service, repair, spare parts manuals and necessary training to PTA staff	

Operations

In case of ICE buses, PTAs have necessary skillsets to operate the services immediately after the quality check of procured fleet. However, in case of electric buses, there are new areas that needs to be understood to operationalise the electric bus fleet, such as operating range between consecutive charging; locations of the charging infrastructure; interoperability of charging systems; and other associated matters. PTAs can achieve better operational outputs by understanding the importance of the activities mentioned in Figure 9:

Figure 9. PTA Key Activities and Roles for Operations

Key Activities	PTA roles
Plan and schedule electric bus (route)-charging-crew system	Senior Management (Heads of Traffic, Mechanical and Electrical Departments)
Provision of additional space and time schedule for electric buses charging, maintenance and parking requirements	Middle Management (Depot Manager, Traffic Officers, Works Managers and Engineers)
Plan electric bus fleet operations, charging, scheduling and monitoring in-sync with the existing ICE buses fleet	Technicians (responsible for charging and monitoring of electric buses)

Repair and Maintenance

Good repair and maintenance are crucial for keeping the fleet up and running efficiently. Unlike conventional buses, electric buses require less maintenance but call for quite different skillssets. In most of the current contracts, the vehicle manufacturer itself is responsible for repair, maintenance and disposal of electric buses. However, PTA technical staff need to have a strong understanding of all aspects related to this function for efficient supervision. Some of the key activities which play a very important role for improving repair and maintenance are represented in Figure 10:

Figure 10. PTA Key Activities and Roles for Repair and Maintenance

Key Activities	PTA Roles
Regular maintenance of the fleet and charging infrastructure, preventive maintenance and overhauling procedures of electric buses and their sub-systems	Senior Management (Heads of Mechanical, Electrical and ITMS Departments)
Fault diagnosis and replacement procedures, maintaining spares, materials and tools inventory	Middle Management (Works Manager, Engineers and Supervisor)
	Senior Technicians and Junior Technicians in different trades

Monitoring and Control

Monitoring and Control function for electric buses primarily focus on data analytics by compiling and analysing electric bus operations and performance data through automatic systems (like ITMS), building relevant MIS system and the dashboards for different departments and roles to drive improvements. To optimise operational management, monitoring and control systems play an essential role, and this can be achieved by focusing on activities shown in Figure 11:

Figure 11. PTA Key Activities and Roles for Monitoring and Control

Key Activities	PTA Roles
Collect data and analyse at all levels – electric buses, batteries, charging systems etc.	Senior Management (Head of IT Department)
Collect data and analyse operational parameters with reference to physical and financial performance, energy efficiency, safety, service quality, SLAs and contract enforcement, and overall system monitoring of PTA performance	Middle Management (Depot Manager, Supervisor and Works Manager)

Scrapping and Recycling

Real-world performance of electric buses, batteries and their life cycle benefits are currently not being monitored and are not accessible to PTAs in the country. This is majorly due to the unavailability of monitoring systems at PTA level. Further, PTAs have not faced bigger issues pertaining to end-of-life replacements, disposal of electric buses and their aggregates since vehicle manufacturers provide warranty for more than 5 years and the private service providers' contract ranges between 8-10 years. Key activities represented in Figure 12 are essential for PTAs to understand scrapping and recycling processes:

Figure 12. PTA Key Activities and Roles for Scrapping and Recycling

Key Activities	PTA Roles
Understand and define end-of-life for electric buses and different sub-systems (to execute timely replacements), their associated inventory planning and accounting of asset depreciation to arrive at right TCO	Senior Management (Heads of Mechanical, Stores and Purchase Departments)
Disposal of batteries through certified centres to avoid environmental hazards, and capture economic value in its residual life through reuse and or recycling	Middle Management (Works Managers, Engineers, Supervisors)
	Drivers, Technicians and Storekeepers

The above activities/roles were studied for four PTAs and a mapping of skill level available with skill level required is undertaken to identify the training required.

4

EXISTING SKILL LEVELS AND TRAINING NEEDS

This section identifies the skill gaps between electric bus specific skill sets and those which are already available in PTAs across various levels. The current electric bus specific skills of PTA staff are assessed with responses from both the supply and demand side stakeholders and aggregated at overall functional and their respective sub-functional levels.

On the basis of the identified skill gaps, training needs at functional and sub-functional levels for electric bus deployment are identified. These training needs are further aggregated for different electric bus specific roles in the PTA across various organisational hierarchies. The extent/ level of training is divided into four categories namely 'Low, Medium, Fair and High'. These are mapped to skill level and use same colour codes as shown in Table 2:

Table 2. Level of electric bus Training required at PTA

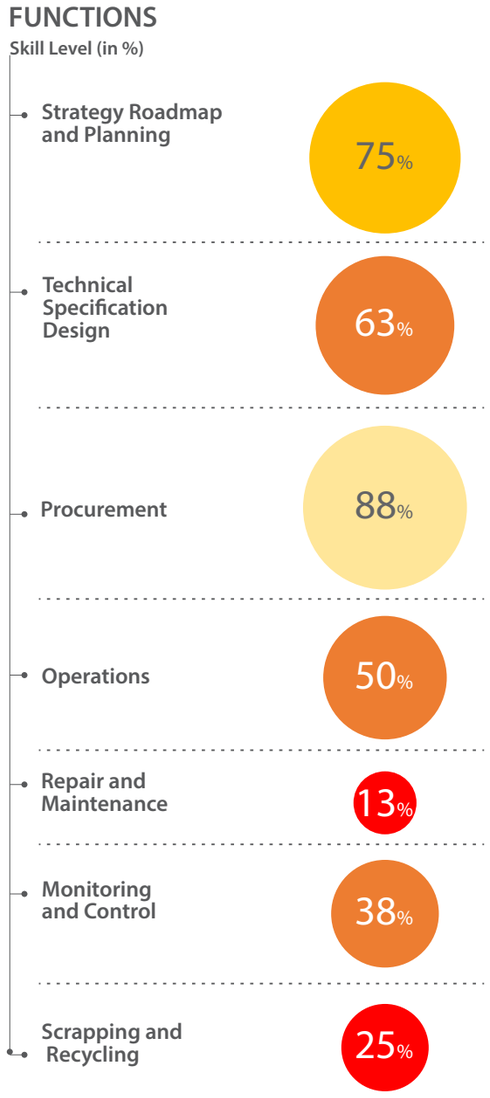
Low	Medium	Fair	High

4.1 Overall Skill Assessment Results

Based on the skills gap analysis, the current skill levels across all functions of different staff categories in PTAs are represented in Figure 13.

As PTAs have experience in procuring conventional buses through the decades and hence, have experience in related functions including strategy roadmap and planning and technical specification design. Accordingly, these functions show a relatively better skill score in comparison to other functions. However there are some gaps that need to be filled in these areas.

Figure 13. Current electric bus Skill Levels Across All Functions



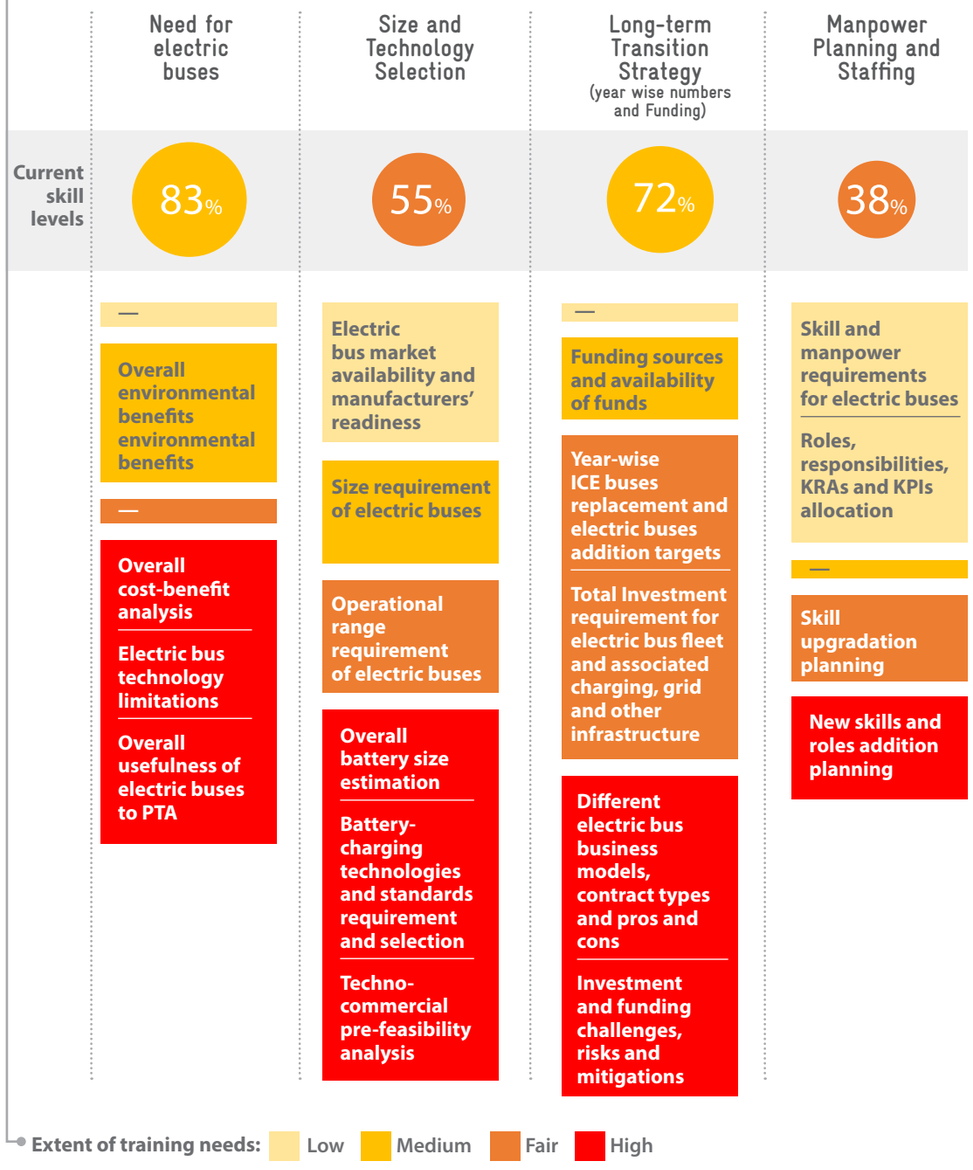
The procurement skills are valuable in transitioning to electric buses and PTAs have shown effective performance in procuring electric buses through FAME-I and/or FAME-II schemes. However, due to the early stages of electric buses deployment on day-to-day operations, the PTAs and staff have not shaped their hands-on skills in functions like repair and maintenance, operations, monitoring and control – skill level for these mentioned functions is still below 50% (Figure 13).

The existing skills analysis has been undertaken in detail for various hierarchies within the PTAs.

4.2 Function 1: Strategy Roadmap and Planning

PTAs are reported to have 'fair' skill level in overall strategy roadmap and planning function. However, they are missing necessary skill sets to lay down a holistic planning for electric buses, resulting a delay in deployment and overall sub-optimal performance. Figure 14 presents skill levels and detailed activity-wise training needs for PTAs across each sub-function.

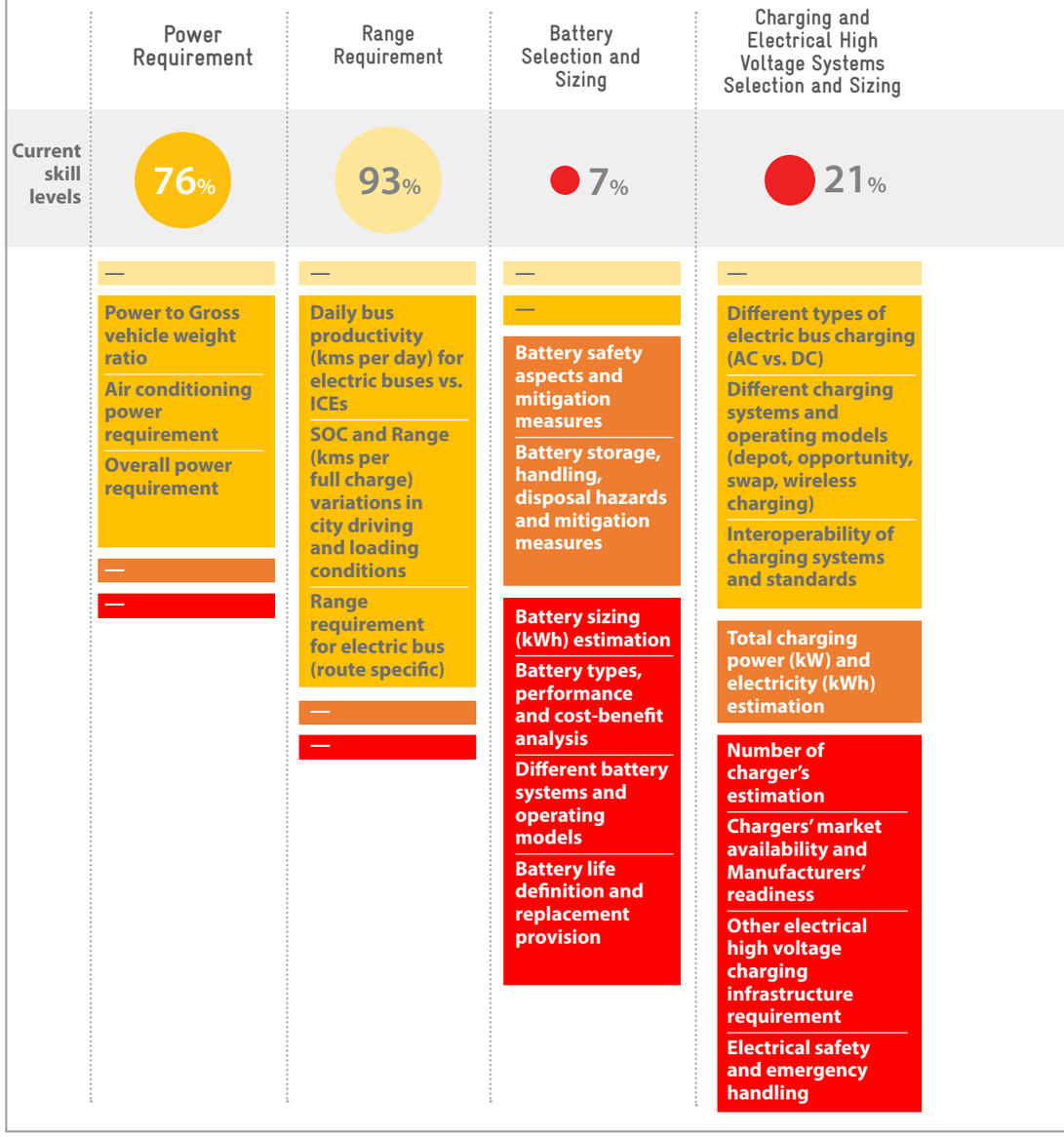
Figure 14. Training Needs for Strategy Roadmap and Planning



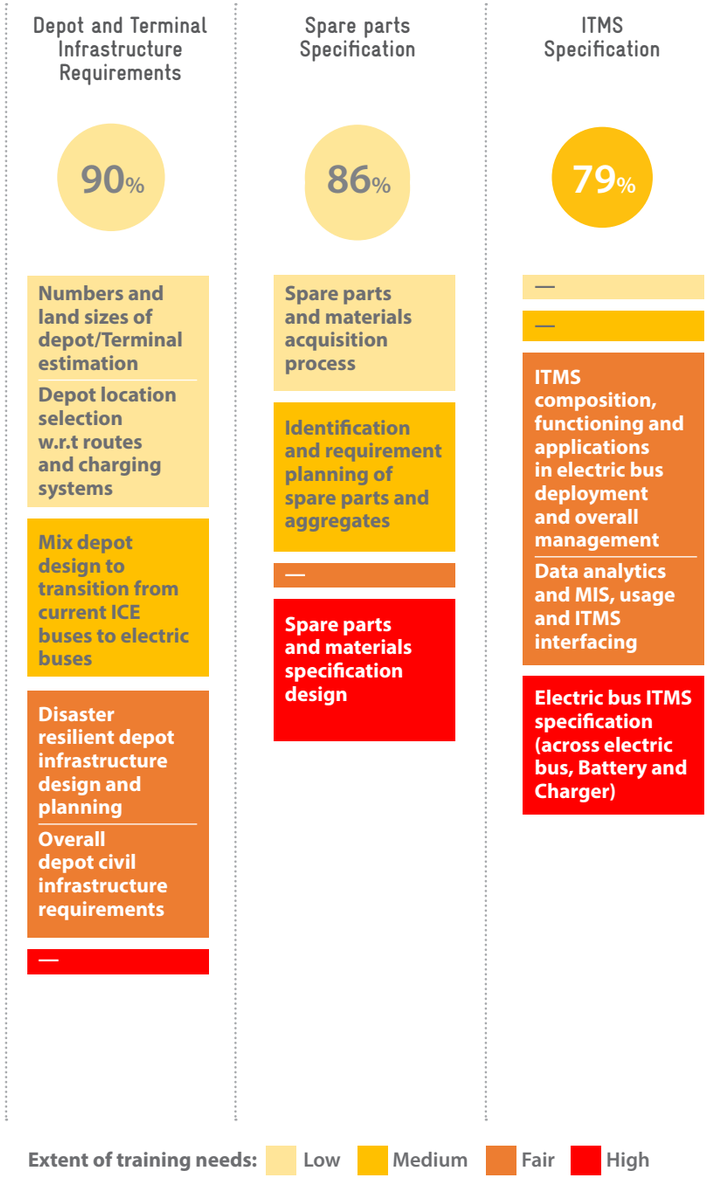
4.3 Function 2: Technical Specification Design

The PTAs are reported to have 'medium' skill level in overall technical specification design function. These current skill levels are resulting into sub-optimal choice of battery sizes and resulting in operational challenges of not meeting expected range,

Figure 15. Training Needs for Technical Specification Design



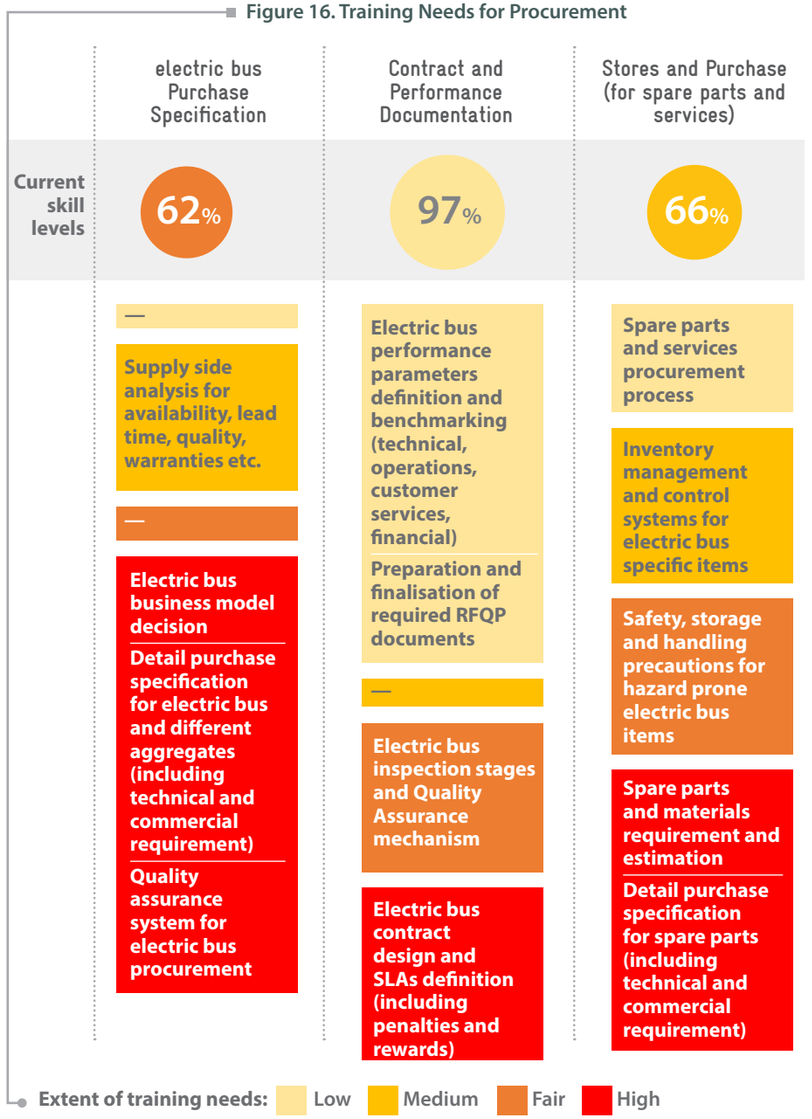
besides reduced electric bus productivity and revenue shortfalls. Figure 15 presents skill levels and detailed activity level training needs for PTAs across each sub-function.



4.4 Function 3: Procurement

The PTAs are reported to have 'high' skill level in overall procurement function due to past experience in procuring electric buses under FAME I and FAME II. However, in recent times PTAs have been facing delays and/or cancellation of tenders, some of the reasons being - not having enough skill sets for designing suitable technical aspect of electric bus tenders; sub-optimal price discovery through tender leading to high acquisition price of electric buses; delayed in order delivery; weak contract enforcement, etc. Figure 16 presents skill levels and detailed activity-wise training needs for PTAs across each sub-function.

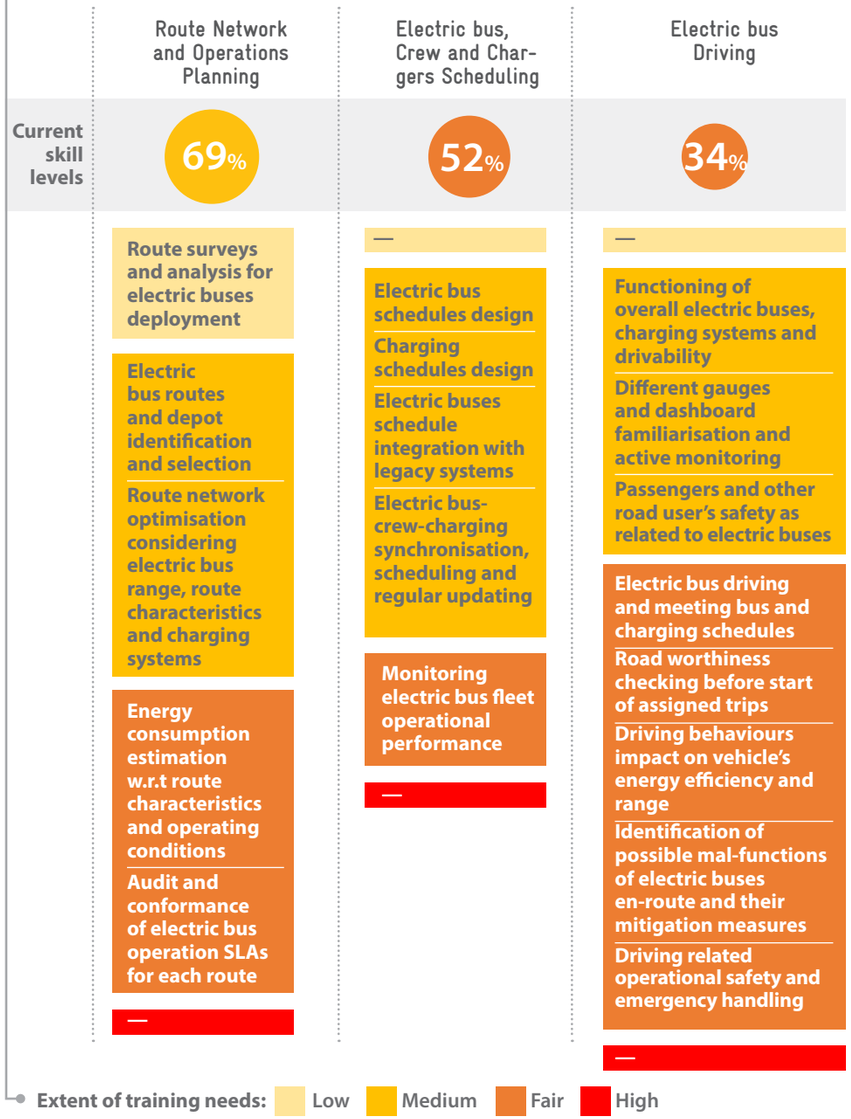
Figure 16. Training Needs for Procurement



4.5 Function 4: Operations

The PTAs are reported to have 'medium' skill level in overall operations function. The current operational skill levels of PTAs have led to underutilisation of assets, since a large number of standby electric buses have to be put on reserve fleet to meet unpredictable battery-range-charging requirements which consequently affect overall productivity. This also leads to irregular route schedules, affecting customer services. Figure 17 presents skill levels and detailed activity-wise training needs for PTAs across each sub-function.

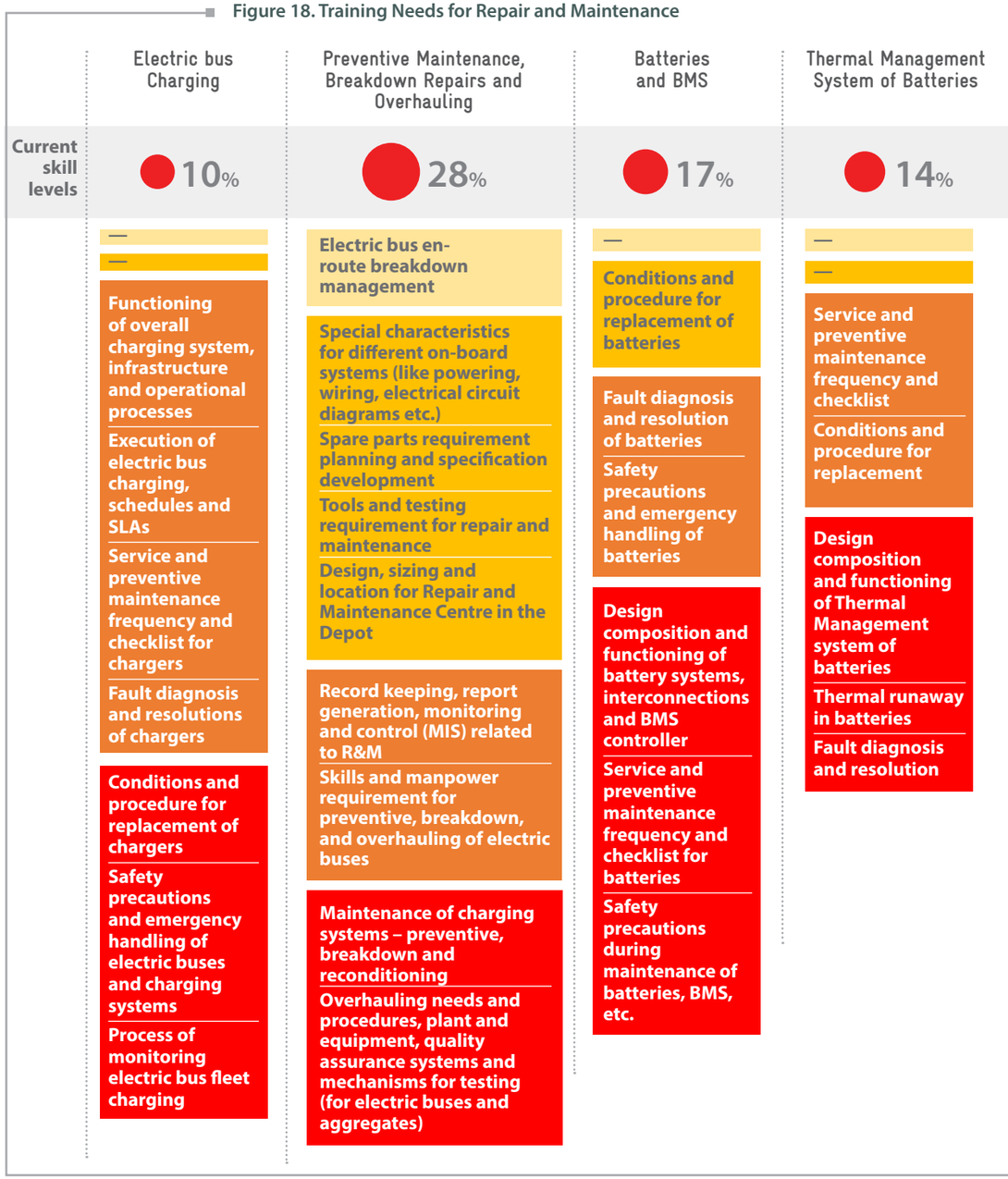
Figure 17. Training Needs for Operations



4.6 Function 5: Repair and Maintenance

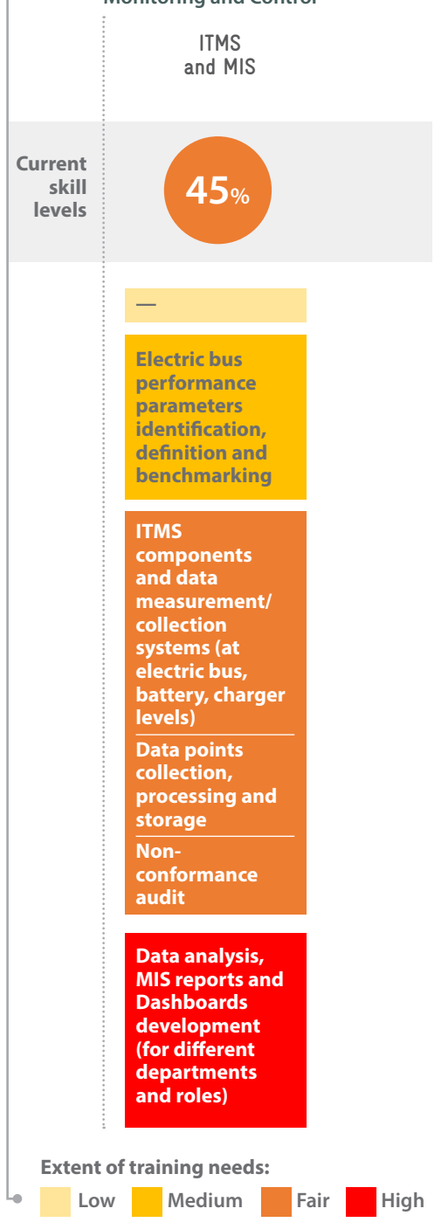
The PTAs are reported to have 'low' skill level in overall repair and maintenance function. Due to lack of specific technical skill sets PTAs face delays in undertaking preventive and maintenance activities of electric buses and

Figure 18. Training Needs for Repair and Maintenance



end-up with having unexpected delays in breakdown repairs, leading to higher downtime of electric buses. Figure 18 presents skill levels and detailed activity-wise training needs for PTAs across each sub-function.

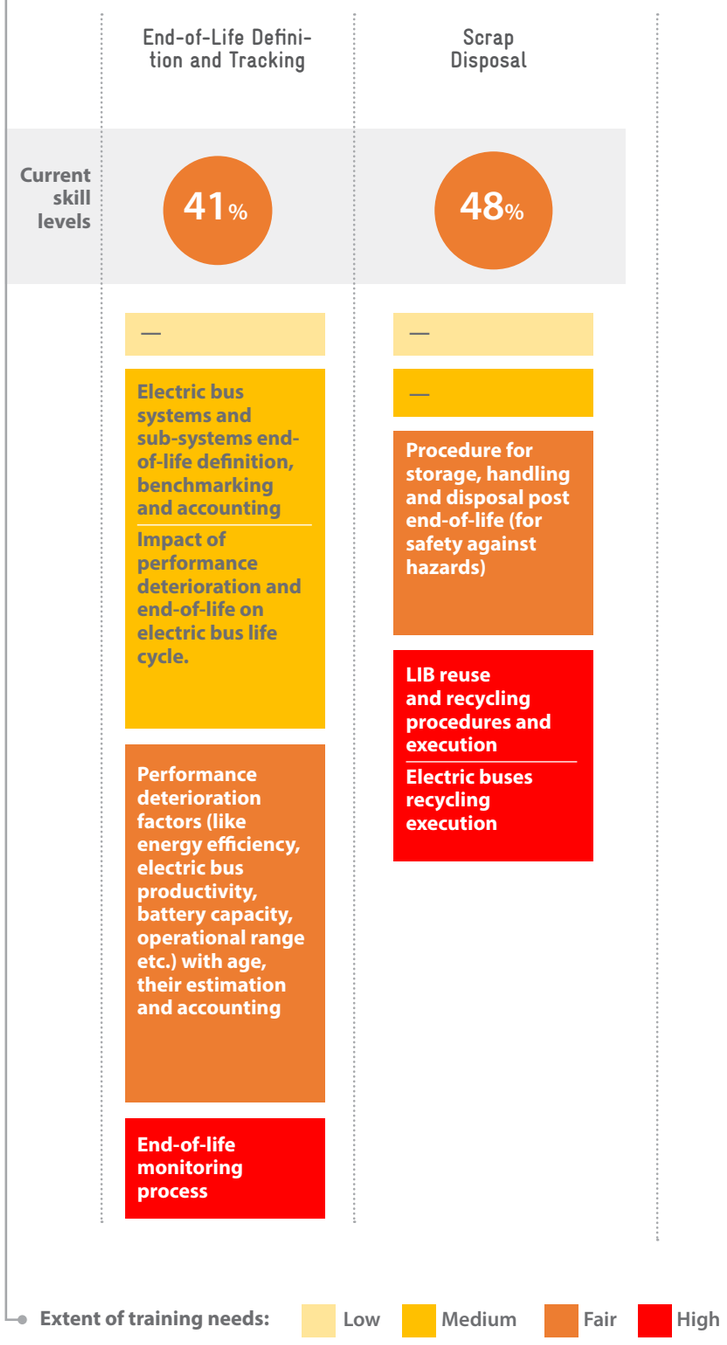
Figure 19. Training Needs for Monitoring and Control



4.7 Function 6: Monitoring and Control

Based on the skill level assessment results, PTAs have 'medium' skill level in overall monitoring and control function. The existing skill levels of PTA staff are not adequate to identify the reasons responsible for reduced operational ranges compared to those as per contract. This results into ambiguity in fixing responsibility of between PTA, vehicle manufacturer and private operator operator. Figure 19 presents skill level and detailed activity-wise training needs for PTAs across each sub-function.

Figure 20. Training Needs for Scrapping and Recycling



4.8 Function 7: Scrapping and Recycling

PTAs have 'low' skill level in overall scrapping and recycling function. They currently lack clarity on battery life expectancy and its reuse/ recycling processes, although this approach is required at a later stage, it is extremely important that PTA understands this process. Figure 20 presents skill levels and detailed activity-wise training needs for PTAs across each sub-function.

4.9 Electric bus Training Needs for key Roles at PTAs

Further to identification of specific training areas across various functions, skills gaps analysis was undertaken for various hierarchical roles within a typical PTA. Based on this analysis, the extent of training needs at various sub-functional level for respective electric bus related roles are identified and presented in Table 3.

The colour coding represents the extent of training needs as used earlier for electric bus activity level.

Table 3. Electric bus Training Needs for Key Roles at PTAs

Functions	Management level	Top Management		Senior Management				Middle Management				
	Sub-functions	MD/ CMD/ Joint MD	Head Traffic	Head Civil Engineering/ Electrical	Head Mechanical Engineering	Head Stores & Purchase/ Procurement	Head IT/ MIS	Depot Manager	Works/ Maintenance Manager	Supervisor	Driver	PTA Technician
Strategy Roadmap and Planning	Need for electric buses	Medium	Medium	Medium	Medium	Medium	Low	High	High	Low		
	Size and Technology Selection	Medium	Medium	Medium	High	Medium	Medium	High	Medium	Low		
	Long-term Transition Strategy	Fair	Fair	Fair	Fair	Medium	Fair	Medium	Medium			
	Manpower Planning and Staffing	Medium	Medium	Low	Fair			Medium	Fair	Fair		
Technical Specification Design	Power Requirement		High	Medium	High	Medium	Medium	High	High	Low		
	Range Requirement		High		High	Medium	Medium	Fair	Fair	Low		
	Battery Selection and Sizing	Low	Medium	Medium	High	Medium	Medium	Medium	High	Low		
	Charging and Electrical High Voltage Systems Selection and Sizing	Low	Low	High	High	Medium		Medium	High	Low		
	Depot and Terminal Infrastructure Requirements	High	High	High	High			Fair	Fair	Medium		
	Spare Parts Specification				High	Medium		Fair	High	Low		
	ITMS Specification		Fair		High		High	Medium	Medium	Low		
Procurement	electric bus Purchase Specification			Medium	High	High			Fair	Low		
	Contract and Performance Documentation		Medium	Medium	High	High			Medium			
	Stores and Purchase				High	High		Medium	High	Low		
Operations	Route Network and Operations Planning		Medium		Medium		Medium	Fair	Medium			
	electric bus, Crew and Chargers Scheduling		High		Medium		Fair	Fair	Low	Fair		Fair
	electric bus Driving		Medium		Medium			Medium	Medium		High	
Repair and Maintenance	electric bus Charging			Medium	Medium		Fair	Fair	High	Fair	Medium	Medium
	Preventive Maintenance, Breakdown Repairs and Overhauling		Low	Low	High	Low	Fair	Medium	High	High		High
	Batteries and BMS		Low	Low	High		Medium	Fair	High	High		High
	Thermal Management System (TMS) of Batteries		Low	Low	High		Medium	Fair	High	High		High
	Motors, Drives, Controllers and Regenerative Braking				High		Medium	Fair	High	High		High
	Electronics, Sensors, Wiring, Fuses etc.				High	Low		Fair	High	High		High
	Communications		Low	Low	Medium		High	Fair	High	High		High
	Air Conditioning			Low	Medium			Fair	High	High		High
Monitoring and Control	ITMS and MIS		Medium	Low	High		High	Fair	High	High		
Scrapping and Recycling	End-of-Life Definition and Tracking		Low	Medium	High	High	Medium	Medium	High	Fair		Medium
	Scrap Disposal			Low	High	High	Low	Medium	High	Fair		Medium

Extent of training needs: Low Medium Fair High

5 KEY RECOMMENDATIONS

India has an ambitious program for bus electrification. In order for this program to be successful, entire ecosystem around electric buses deployment needs to be built and the Government of India is working on various components of this ecosystem and has undertaken various policy level studies. One area that has consistently been identified in such studies is training and capacity building of the PTAs.

Bus technologies have continuously advanced over the decades and PTAs have managed to acknowledge the changes from diesel-powered buses to CNG ones; up-gradation of emission norms, i.e. BS I to BS-VI; and shift from high floor to low floor buses. The evolution of bus transportation through different times has been rough and challenging, proving the need for an enhanced training module in recent times. The role of vehicle manufacturers had always been very important in the formative years of acquisition and deployment of new technologies by working closely with PTAs and helping them build requisite new skills and infrastructure. Similar approach and coordination are necessary for the current phase of technological transition from ICE buses to battery-powered electric buses to achieve faster transition and successful penetration of electric bus fleet.

As procurement, operations and management requirements of deploying electric buses shall require different skills in these areas, GIZ has initiated this study to address the training requirements at PTA level in order to initiate a dialogue to develop a comprehensive road map and delivery of National Capacity Building Training Program for electric bus deployment.

The transition to electric buses is capital intensive because of the higher costs of electric buses along with the additional expenditure on charging and back-end grid infrastructure. Moreover, deployment of electric buses requires a proper knowledge of battery types, sizes, charging capacity and rating as well as their controllers, associated energy infrastructure, and strategies that influence the overall design, cost and performance. Hence, a systematic and holistic planning and deployment strategy is essential for Indian cities to ensure a smooth transition to electric buses fleet.

This TNA study identifies skill gaps (between required skill sets and those currently available in PTAs) for sustainable electric buses deployment across electric bus life cycle functions, sub-functions and activities.

This study aims to bring out quantum and depth of skill upgradation for different functions and sub-functions across various roles in PTAs.

The key skills different functional levels are:

In **Strategy Roadmap and Planning** function, PTAs show 'fair' skill level but missing holistic planning and delayed actions leading to in-sufficient preparations to provide requisite infrastructure support to the operator, resulting in delay in deployment and sub-optimal performance.

In **Technical Specification Design** function, PTAs have 'medium' skill level leading to sub-optimal choice of battery size and results in operational challenges of not meeting expected range, besides reduced electric bus productivity and revenue shortfalls.

In **Procurement** function, PTAs have 'high'skill level due to past experience in procuring electric buses under FAME I/ II, however, still there are challenges leading to delayed and/ or multiple times cancellation of tenders; high price of acquisition of electric buses with a lesser chance for discovery of optimal price; delayed delivery; and/or weaknesses in contract enforcement.

In **Operations** function, PTAs have 'medium' skill level reflected in weak operation plans resulting into poor utilisation of assets as a large number of standby electric buses have to be reserved to meet unpredictable battery-range-charging requirements, consequently hampering fleet productivity. Also, it leads to irregular route schedules affecting customer services because of schedule disruptions of electric buses charging.

In **Repair and Maintenance** function, PTAs have 'low' skill level leading to delays in undertaking preventive and maintenance activities of electric buses, delays in breakdown repairs, etc. and hence higher downtime of electric buses.

In **Monitoring and Control** function, PTAs have 'medium' skills in using data analytics and systematic Management Information Systems (MIS), leading to failure in the diagnostic process and inadequacy in identifying the reasons for reduced operational ranges vs. those contracted, with consequent ambiguity in fixing responsibility of ownership between PTA, vehicle manufacturer and private operator.

In **Scrapping and Recycling** function, PTAs have 'low' skills, leading to lack of clarity on battery life expectancy and its reuse/ recycling procedure, though this approach is required at a later stage.

Following are the extent of Training Needs across PTA hierarchies (and roles):

Top Management includes MD/CMD/ Joint MD level of roles and their training needs range from 'medium' to 'fair' for Strategy Roadmap and Planning function. It will be useful for individuals to undergo familiarisation training on major electric bus management functions for making important decisions

Senior Management includes various Functional Heads (Traffic, Mechanical, Civil, Procurement, IT) and their training needs range from 'medium' to 'high' across most functions. These Functional Heads play a vital role at PTAs as they lead electric bus management across important functions

Middle Management includes Depot Manager, Works / Maintenance Manager and Supervisors and their broad training needs range from 'medium' to 'fair' across

all functions. These roles at PTAs play major responsibility of managing day-to-day operations and upkeep of buses and chargers for ensuring prompt customer service.

Drivers, Technicians and Storekeepers; their broad training coverage ranges from 'fair' to 'high' extent for their respective day-to-day driving repair and maintenance functions.

Various stakeholders including vehicle manufacturers, industry associations, training institutes, skills and certification institutes, standards and testing organisations, academic and R&D institutes, multilateral and Government and Ministries, have earlier joined hands with PTAs organising training and capacity building programs to facilitate a smooth transition to cleaner and sustainable transport systems. Some recommendations to key stakeholders are brought out in Figure 21.

India has a strong opportunity at hand to deepen its public transportation share and leverage clean electric buses for this transition and emerge amongst top global leaders. Timely development of PTAs capacity to steer them in this important transition and to simultaneously retain India's competitive advantage shall only be possible with co-ordinated and complementary working relationships between PTAs and other electric bus stakeholders. This can only be done by undertaking a National Level Training and Capacity Building Program on electric buses. To take this forward, the study will progress further with identification of training module and high level course structure and resources required to conduct the training program. This will be covered in the forthcoming volumes as mentioned below:

- **Volume II** focuses on structured **Training Program** which would help PTA personnel with their skill upgradation. This training program will involve various industry stakeholders to rightly develop and deliver training modules. This will raise the knowledge, skills and abilities of the trainees to improve the electric bus life cycle management.
- **Volume III** focuses on **resource requirements in PTA organisation structure** at various levels, for delivering various functions anticipated for operating and managing the electric buses. This will include the type of resources and their numbers, qualification, job descriptions (JDs), and roles and responsibilities.

Notes

As part of the Indo-German bilateral cooperation, both countries have agreed upon a strategic partnership – **Green Urban Mobility Partnership (GUMP)** between Ministry of Housing and Urban Affairs (MoHUA) and Federal Ministry for Economic Cooperation and Development (BMZ). Within the framework of the partnership of technical and financial cooperation, the German government will support improvements of green urban mobility infrastructure and services, strengthen capacities of national, state, and local institutions to design and implement sustainable, inclusive, and smart mobility solutions in Indian cities. As part of the GUMP partnership, Germany will also be supporting in expanding the public transport infrastructure, multimodal integration, using low-emission or zero-emission technologies, and promoting non-motorised transport in India. Through this strategic partnership, India and Germany intend to jointly achieve effective international contributions to fight climate change.