ELECTRIC BUS TRANSITION PLAN FOR SURAT

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List of Abbreviations

AC	Alternating current
AFCS	Automatic Fare Collection System
AJL	Ahmedabad Janmarg Limited
AMTS	Ahmedabad Municipal Transport Service
BMS	Battery Management System
BMZ	Federal Ministry for Economic Cooperation and Development
BRTS	Bus Rapid Transit System
BTM	Behind The Meter
CAGR	Compound Annual Growth Rate
CB	City Bus
CEMP	Comprehensive Electric Mobility Plan
CESL	Convergence Energy Services Limited
CMP	Comprehensive Mobility Plan
CMUBS	Chief Minister Urban Bus Service Scheme
CNG	Compressed Natural Gas
CPKM	Cost Per Kilometre
DC	Direct Current
DHI	Department of Heavy Industry
DPR	Detailed Project Report
E-bus	Electric bus
EIC	Environmental Improvement Charges
EMPS	Electric Mobility Promotion Scheme
EPKM	Earnings Per Kilometre

ETM	Electronic Ticketing Machine
EVs	Electric Vehicles
FAME	Faster Adoption and Manufacturing of (Hybrid&) Electric Vehicles
GCC	Gross Cost Contract
GERC	Gujarat Electricity Regulatory Commission
GERMI	Gujarat Energy Renewable and Management Institute
GIDC	Gujarat Industrial Development Corporation
GoG	Government of Gujarat
GoI	Government of India
GSRTC	Gujarat State Road Transport Corporation
GUDM	Gujarat Urban Development Mission
GUMP	Green Urban Mobility Partnership
GVW	Gross Vehicle Weight
HMC	High mobility Corridors
HT	High Tension
ICE	Internal Combustion Engine
IPT	Intermediate Public Transport
ITMS	Intelligent Transport Management System
kWh	Kilowatt Hour
LF	Load Factor
LOS	Level of Service

LT	Low Tension
MHI	Ministry of Heavy Industries
MoHUA	Ministry of Housing and Urban Affairs
MoUD	Ministry of Urban Development
NBEM	National Board for Electric Mobility
NCC	Net Cost Contract
NCEM	National Council for Electric Mobility
NEBP	National Electric Bus Program
NEC	National Electricity Code
NEMMP	National Electric Mobility Mission Plan
NMEM	National Mission for electric Mobility
OEM	Original Equipment Manufacturer
ONGC	Oil and Natural Gas Corporation
OPEX	Operating Expenditure
PCS	Public Charging Station
PM E-Drive	PM Electric Drive Revolution in Innovative Vehicle Enhancement
PMP	Phased Manufacturing Programme
PPH	Person Per Hectare
PPP	Public-Private Partnership
PT	Public Transport
RVSF	Registered Vehicle Scrapping Facilities

RR	Replacement Ratio
RTO	Regional Transport Office
SARAL	Safe Accessible Reliable Advanced and Low-carbon
SBP	Service and Business Plan
SDG	Sustainable Development Goal
SJMMSVY	Swarnim Jayanti Mukhya Mantri Shaheri Vikas Yojana
SLB	Service Level Benchmark
SMC	Surat Municipal Corporation
SoC	Status of Charge
SPV	Special Purpose Vehicle
SSCDL	Surat Smart City Development Limited
STU	State/City Transport Undertaking
TLFD	Trip Length Frequency Distribution
TCO	Total Cost of Ownership
VGF	Viability Gap Funding
WRI	World Resources Institute

About the Report

The transition to Electric Vehicles (EVs) in India is essential for the reduction of emissions, with government objectives targeting a 45% decrease in carbon intensity by 2030 and the attainment of net-zero emissions by 2070[1].Local authorities encounter significant challenges in the implementation of EV charging infrastructure, especially for bus agencies that may lack familiarity with EV technology.

A comprehensive study on Surat city, evaluates the current city bus transport system, concentrating on the operational efficiency of electric bus (e-bus) services, including battery capacity, charger specifications, and route optimisation. To address these challenges, two strategic approaches have been proposed: short-term strategies aimed at optimising the existing and anticipated fleet, which involve identifying opportunity charging locations and minimising non-revenue kilometres; and long-term strategies on project fleet requirements by 2035, considering financial considerations and budgetary implications for the authorities involved.

The outcomes of the study yield a detailed roadmap for the transition to e-bus systems, encompassing

key aspects such as infrastructure planning, fleet procurement strategies, battery sizing, and charging methodologies. The standardisation in charging mechanisms and contract conditions help to streamline operations and improve vehicle utilisation. This roadmap will contribute to enhancing operational efficiency and facilitating financial planning over a ten-year horizon, culminating in 2035. Ultimately, the findings from this study may serve as a valuable resource for other Indian cities seeking to improve their electric bus systems.

[1] https://www.pib.gov.in/PressReleaseIframePage.aspx?PRID=2099131

01

Introduction

1.1 Study background

Reducing emissions from transportation has become a top priority due to growing concern about climate change and pollution. The Government of India has pledged to reduce the nation's carbon intensity by less than 45% by the end of the decade and achieve net-zero carbon emissions by 2070[2]. However, transitioning to EVs is a challenge for local administrations as they need to plan, implement, manage, and sustain the deployment of EV charging and electric infrastructure. This challenge intensified for bus agencies who may not be familiar with EV technology, and having concerns on technology battery/charging and range. Therefore, it is crucial to focus on these issues while developing guidance for cities to help them transition to electric vehicles.

The adoption of EVs alone may not reduce the carbon footprint if electricity comes from coal-based power generation. To ensure the full utilisation of green energy in transportation, offering incentives to link renewable energy to EV charging is critical. Evaluating renewable energy sources for depot power requirements would make transportation systems more eco-friendly.

1.2 Study aim and objectives

The study aims to develop a strategic roadmap and implementable action plan to support Surat in transitioning to a e-mobility. Given this, the following objectives for the study are outlined:

1. To assess the current operational efficiency of e-buses as compared to ICE buses

2. To enhance e-bus operational efficiency by minimising non-revenue kilometres and shuttle kilometres

3. To understand the contractual variations and their impact on operations

4. To assess the future fleet requirements for the city

5. To develop a long-term strategy to achieve sustained operational efficiency

1.3 Approach to e-bus transition plan

The e-bus transition plan outlines how the city can adopt e-buses while considering technical feasibility, cost implications, and the financial sustainability of future bus operations. This section details the approach required to plan and implement the transition roadmap for achieving 100% electrification of Surat's city bus services.

To achieve this, the study focuses on key questions such as:

1. What is the present status of e-bus operation and its performance, including e-bus and battery size, e-bus charging status for the entire day, and type of chargers and capacity?

2. How many buses does the city require in the long-term period, and how should procurement of e-buses be planned for the next 10 years (i.e. 2035)?

3. What would be the optimal strategy for planning charging infrastructure for future fleet size?

4. Which strategies are operationally and financially feasible for enhancing public transport services?

To address these questions, the study framework has five objectives as shown in figure below.

[2] https://www.pib.gov.in/PressReleaseIframePage.aspx?PRID=2099131

Objectives	Approach	Outcome
1. To assess the current operational efficiency of e-buses vis a vis ICE buses	• Existing e-bus operational performance, charging pattern, vehicle run-km by shifts, ideal range vs. actual vehicle km etc. • Replacement ratio (ICE Buses Vs E-Buses)	• Planning for battery size for future bus procurement & infrastructure - Increase operational efficiency and cost economic
2. To enhance e-bus operational efficiency by minimising non-revenue kms and shuttle kms	• Identification of routes that have the potential location for opportunity charging at inter depot /terminal • Total number of chargers required and power load assessment • Investment and benefits assessment	Short Term Strategies • Increased operational efficiency & flexibility • Benefits to passengers to avoid unnecessary transfers because of shuttle trips • Total investment and the long-term benefits Support for pilot implementation • Support for pilot implementation
3. To understand the contractual variability	• Understanding variability in contracts from operations' perspective and their impact on operations	• Learnings for future procurement
4.To assess the future fleet requirement for the city - By 2035) **5. To develop a long-term strategy to achieve operational efficiency**	Approaches for future fleet estimates for 2035 1. Based on Service Level Benchmark (SLB) 2. Based on the Travel Demand (potential passenger shift based on distance -TLFD) 3. Based on the operational viability (fleet deployment on strategic PT network 2035) Assessment of the total number of buses that the city could accommodate by 2035 (based on city structure, road network pattern and city characteristics) Strategic planning of depot location and charging infrastructure assessment	Long Term Strategies • Expected PT share for the year 2035 • Bus size and total number of buses required in future • Depot infrastructure facility locations • Assess the investment required for operating desirable fleet size and to develop the infrastructure facilities

Figure 1.1: Approach for e-bus transition plan

Step 1: Baseline assessment of public transport system:

The first step involves conducting a baseline assessment of the public transport system. This includes an in-depth analysis of the current city bus transportation system's effectiveness, including an assessment of the route structure, depot infrastructure, dead km analysis, and demand versus supply. The study focuses on e-bus operations and their efficiency, including detailed analysis of battery size, e-bus size, charger capacity, opportunity charging pattern, and other related factors. Additionally, a financial assessment is performed to determine the cost per km and earnings per km, fare revenue, and the decision for the allocation of budget for public transport in the city is suggested. The contractual conditions for e-bus operations are also reviewed, which recommends further amendments to increase bus operation efficiency.

Step 2: Enhancing operational efficiency in the short-term action plan (2025-2028)

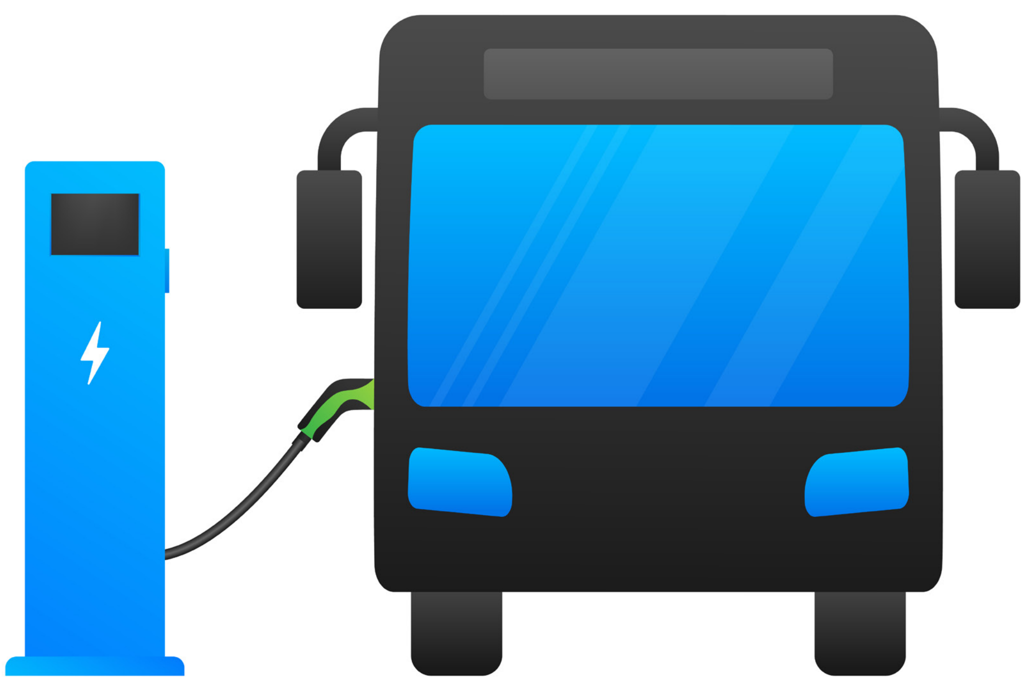
The second step involves developing strategies for a short-term action plan to improve the efficiency and performance of e-bus operations. These strategies will be applied to the existing fleet as well as expected additional fleet within the next 2-3 years. The strategies include identifying locations for opportunity charging, calculating the required power load to determine the number of chargers, and minimising non-revenue kilometres.

Step 3: Developing of future fleet scenarios for year 2035

The third step involves developing an alternative scenario for the future fleet required in the city by 2035. This scenario considers the complete electrification of the public transport system and is developed based on various approaches including Service Level Benchmark (SLB) guidelines provided by the Ministry of Urban Development (MoUD), future travel demand (Trip Length Frequency Distribution -TLFD) and operational viability (supply based). These scenarios have evaluated and assessed the actual fleet that city can accommodate in future.

Step 4: Long -term strategic action plan 2035

The fourth and final step in the process entails the development of a long-term strategic action plan for the year 2035. This plan is based on the scenario evaluation and stakeholder consultation. The key objective of this plan is to provide a roadmap for e-bus transition, which involves the planning of e-bus infrastructure and strategically identification of their locations. Furthermore, the plan addresses the issue and recommends the appropriate battery size and charging strategy, with a focus on depot-based overnight/opportunity charging (depot/terminal/on-road). Additionally, the plan assesses the readiness of e-mobility adoption and make recommendations accordingly.



1.4 Data collection

Table 1 -1 highlights the data required for the study along with their respective sources.

No	Task	Data Required	Data Source
1	City bus transport service assessment	City and BRTS routes alignment and stop sequence	Sitilink, SMC
		Service frequency of all routes	Sitilink, SMC
		Overall fleet size; buses -by size, fuel, operators' detail	Sitilink, SMC
		Bus stop locations (CB & BRT)	Sitilink & Traffic cell, SMC
		Fare structure & various pass type	Sitilink, SMC
		Electronic Ticketing Machine (ETM) data – total ridership on the system	Sitilink, SMC
2	E-bus infrastructure assessment	E-bus depot infrastructure details (chargers and e-buses specification, charging infrastructure, power details, etc.)	Sitilink & Traffic cell, SMC
		E-bus registry details for each e-depot (dead km, SOC for each trip/fleet)	Primary data collection (Sitilink, SMC)
		Dead km & bus operating schedule	Sitilink
		E-bus depot layout	Traffic cell, SMC
		Depot electricity bills (6 months – 1year)	Traffic cell, SMC
3	E-bus infrastructure assessment	Financial details - Payment to operators, service agencies, in-house staff salaries, revenue (fare box & non-fare box) etc.	Sitilink, SMC
		E-bus contract documents	Traffic cell, SMC
4	Organisation structure	Organisational structure (Sitilink Ltd.)	Traffic cell, SMC
5	Depot night activity (Bhestan depot)	Assessment of night activity within the depot charging time – pattern, bus manoeuvring, washing and maintenance activity, etc	Primary survey

Table 1.1: Status of data collection

02

Surat City Context

Surat, the second largest city in Gujarat with a population of around 69 lakhs[3] (SMC estimates, 2021) within 446 sq. km of SMC area. It has been at the forefront of adopting electric mobility and is the first Indian city to develop an EV policy at the city level. Sitilink, a special purpose vehicle (SPV) under the aegis of Surat Municipal Corporation (SMC) is responsible for managing the city bus and Bus Rapid Transport (BRT) operations. Currently, the city has 875 buses amongst which 448 are e-buses (as of February 2025).

2.1 Socio-economic characteristics

Surat is an important centre for both the textile and diamond industries, which contributes significantly to the city's economy. Due to a high level of immigration of single workers, the average family size in 2016 was approximately 4.2 person per household (Surat CMP 2018).

The average household income in SMC area is Rs 31,300 per month; where, about 0.6% of the household have low income (i.e. below Rs 7500 per month). However, around 85% of households in the city own motorised vehicles (Metro DRP 2016). As per household survey in 2016, the vehicle ownership per 1000 population was about 273 two wheelers & 23 four wheelers per 1000 population (Metro DPR, Surat2018).

The figure provided below demonstrates the percentage of vehicle ownership by different income groups.

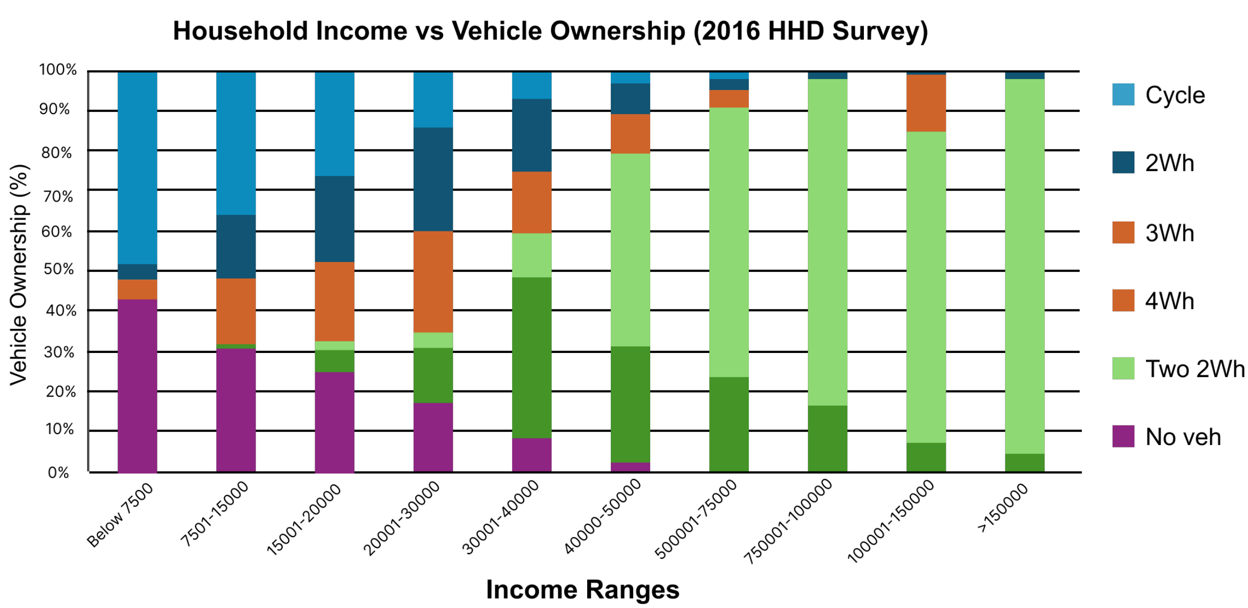


Figure 2.1: Household income & vehicle ownership- 2016

Source: Surat Metro Detailed Project Report (DPR), 2018

[3] https://www.suratmunicipal.gov.in/TheCity/City/Stml13

2.2 Urban transport systems

2.2.1 Road network

As per the Comprehensive Mobility Plan (CMP) 2018 report, the city is well connected with two National Highways (NH-8 and NH-53) and six State Highways. NH-8 is the busiest highway of the country, runs along the eastern periphery of the city, connecting from Delhi to Mumbai.

The existing city's road network has a ring radial pattern, comprises of about approximately 4000 km of total road network length. Amongst the total, about 20% of network consist of major roads. The city's road width distribution is well-placed, with around 24% of the roads exceeding a width of 30 m, excluding local level roads (9m). (Surat CMP 2018).

2.2.2 Vehicular growth

The city of Surat has observed a substantial escalation in motorisation rates over the past few years. According to data from the Surat Regional Transport Office (RTO), the number of vehicles registered has surged from 1 million in 2000 to 30 million in 2023. Notably, there has been an approximate 9% yearly increase in vehicle registrations in the last five years. It is significant to note that two-wheelers have led the growth, followed by four-wheelers and three-wheelers.
In terms of private vehicles, the total number of registered vehicles from 2000 to 2023 is around 30 lakhs. Of these, two-wheelers account for approximately 24 lakhs, while four-wheelers account for 5 lakhs. It is noteworthy that the average annual vehicular growth rate for private vehicles is around 7%.

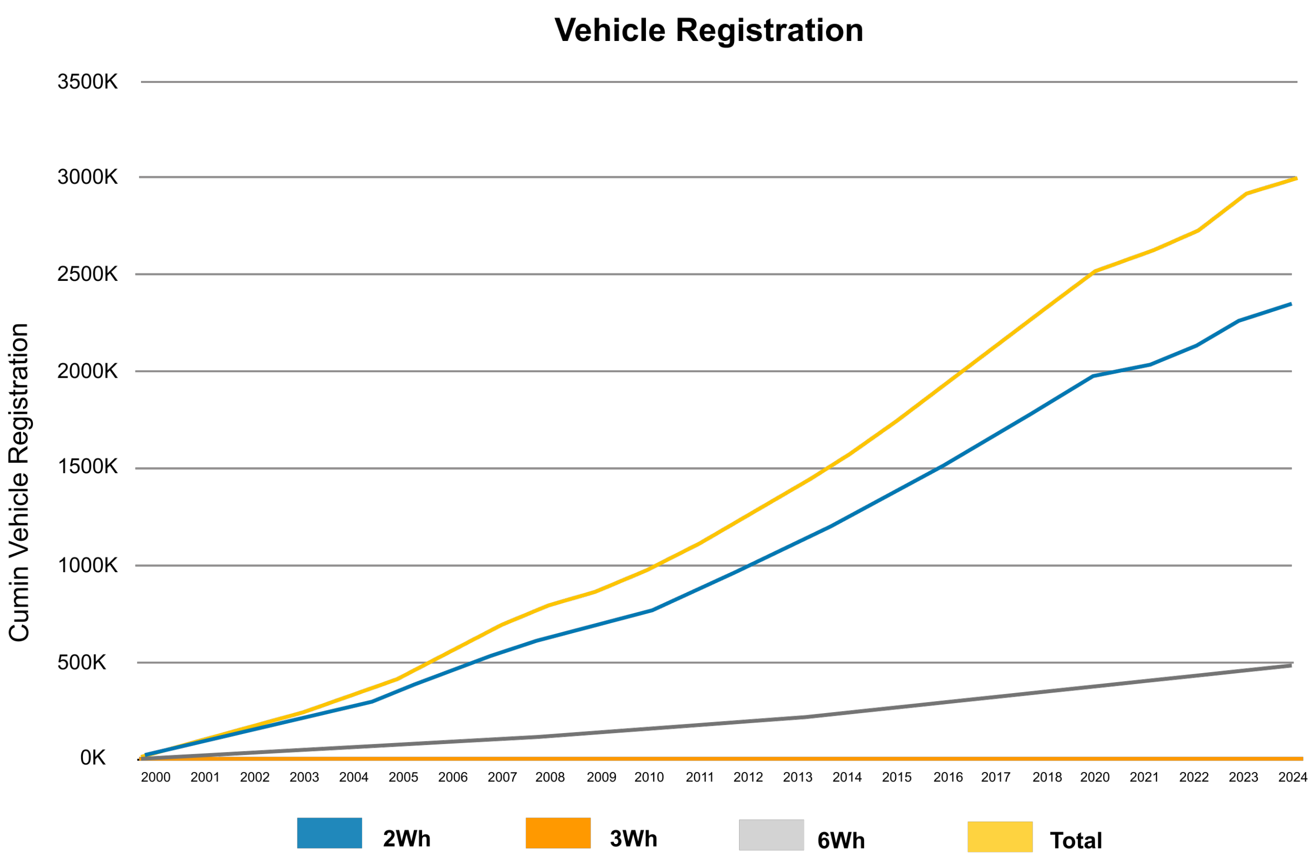


Figure 2.2: Cumulative vehicular growth by modes

Source: RTO, Surat and Vahan dashboard

2.2.3 Travel characteristics

The study of travel characteristics involves analysing of trip rate, mode choice, trip length, etc. These indicators play a crucial role in determining the system needs and its growth. Additionally, socio-economic characteristics also have an impact on the travel pattern and characteristics.

As per Surat CMP 2018, in 2016 the per capita overall trip rate is observed to be 1.60. Excluding walk, per capita trip rate is 0.96 and motorised trip rate is 0.93, while the public transport trip rate is significantly low at 0.02. Intermediate public transport trip rate is higher at 0.12 due to high dependence on auto-rickshaws for travel in the city.

The mode choice for transportation is dominated by two wheelers, accounting for 62% of the motorised trips. Shared auto-rickshaws are most prominent form of public transport, with a motorised share of 17%. While public transport mode share was only 1% as it was only serviced by 30 km of BRT network in 2016. However, with the expansion of the BRT and city bus network the current ridership has increased from 1% to 3% as of 2024 (ETM data, 2024).

2.2.4 Existing public transport system overview

Surat underwent a significant transformation in its urban transport infrastructure between 2014 and 2018. Initiatives, including the CMP, Metro Detailed Project Report (DPR), and bus operations plan studies led to the development of a seamless and integrated public transport system.

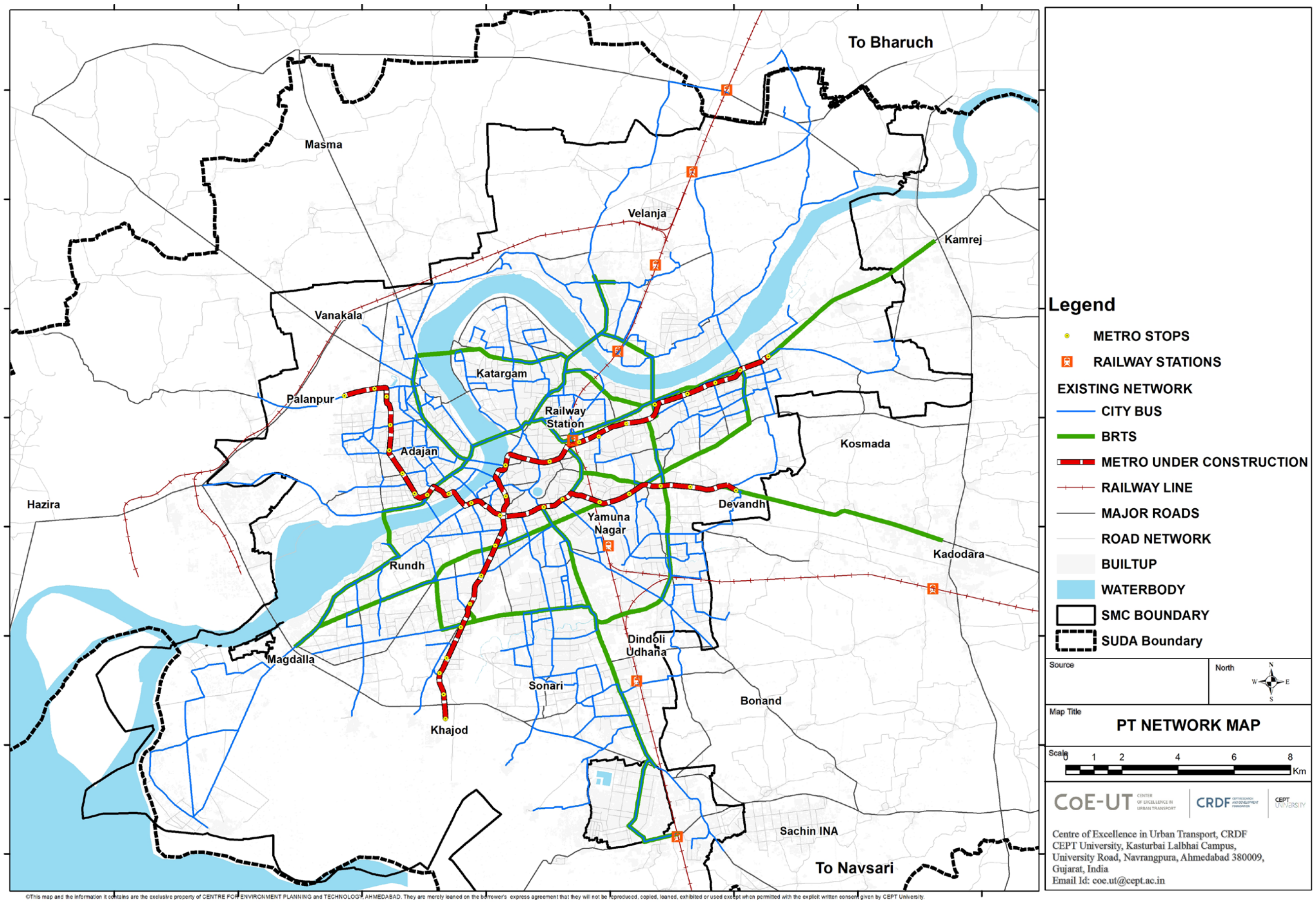
In 2014, Sitilink launched Phase I of BRTS, initially covering a network of 30 km, which expanded to 102 km by the end of 2018. Furthermore, Sitilink proposed an integrated public transport network of approximately 550 km for city bus services via the Bus Service Operations Plan 2017. As of March 2025, the city operates around 875 buses serving approximately 2 lakh passengers daily, which has remained consistent over the past few years.

Surat is a well-planned city with a unique ring radial structure that allows for integrated services. The BRTS serves as the trunk corridor, while the city bus routes function as feeder services. Currently, there are 53 city bus routes and 13 BRTS routes in operation. City buses are designed to be BRTS compatible, with right-hand side door that enables them to dock at BRTS stations and provide seamless interchanges. Additionally, a High Mobility Corridor (HMC) bus service operates along the inner ring road, which has a high-density commercial land-use (Figure 23). This service connects two major bus terminals, the railway station and Katargam, from where most of the radial routes start, making it easy to integrate with almost all the radial routes.

Surat is the only city in India that has implemented a single-ticket travel system across its various modes of transportation. The Automated Fare Collection System (AFCS) enables passengers to travel seamlessly within the city using city buses and the BRTS with a single ticket.

In addition to BRTS and city buses, Surat is currently constructing two metro corridors covering a length of about 41km (Phase I), which is expected to be operational by 2027 (Map 21). The finalisation of the metro corridor was based on CMP, which assessed multiple corridor options, before their inclusion in Metro DPR.

Integration of public transport is often challenging task in the large cities. However, Surat successfully coordinated BRTS and city bus services through institutional integration and strategic planning of its entire public transport network. This proactive approach ensures that people can move around easily in the city, enhancing accessibility and overall mobility.



Disclaimer: This geographical map is for informational purposes only and does not constitute recognition of international boundaries or regions; GIZ makes no claims concerning the validity, accuracy or completeness of the maps nor assumes any liability resulting from the use of the information therein.

Map 2 1: Integrated public transport network in Surat (2024)

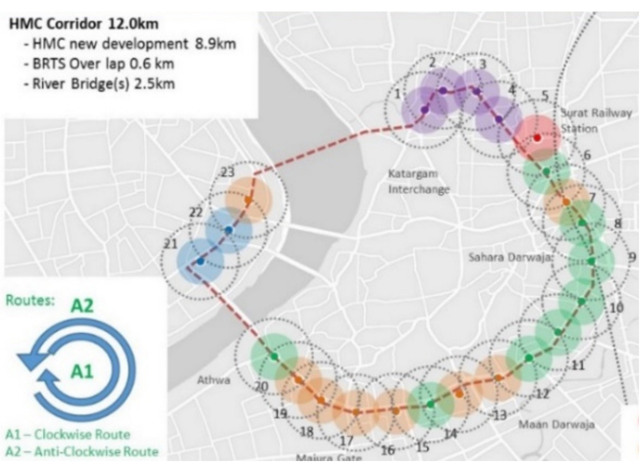


Figure 2.3: High Mobility Corridor (HMC)

Figure 2.4: City bus and BRT buses in a corridor (Physical integration)

Source: Surat Bus Operation Plan, 2017Source: Surat Bus Operation Plan, 2017

2.2.5 Shared three-wheeler (auto) services

Surat has been long known for its auto-rickshaw services, which played crucial role in meeting mobility needs of people during the absence of formal public transport system between 2003 and 2014. Currently, there are approximately 51,600 registered passenger three-wheelers since year 2013 which can be considered as the existing number of three-wheelers being operated in the city. The lack of an efficient bus service has resulted in a shift of travel preference from buses to illegally operating autos, which offer point-to-point services. As per CMP 2018 reports, around 8.6 lakh passenger trips are being undertaken by autos in 2016 (11% Intermediate Public Transport (IPT) share from overall mode share).

However, the unorganised operations of IPT services, overloading, poor vehicle quality, and their contribution to increased congestion and pollution levels remains problematic. Despite of these issues, shared auto services along the city's major road networks provide better frequency and coverage than the bus network, making them a preferred choice for many commuters

03

Existing Policy Landscape & Studies on E-mobility for Surat

Globally, Electric Vehicles (EVs) are being promoted through policy interventions at national, state, and city levels. India has also supported the EV ecosystem through various policies, programs, schemes, and regulations. The promotion of EVs has been envisaged since the National Electric Mission Plan (NEMMP) initiative was made by the Government of India (GoI) in 2013. In Gujarat state EV Policy and Surat city-level EV policy support overall e-mobility, but they do not specifically address the adoption of e-buses.

3.1 National level policy interventions

Error! Reference source not found. illustrates the active policies and programs that support the adoption of electric vehicles in India.

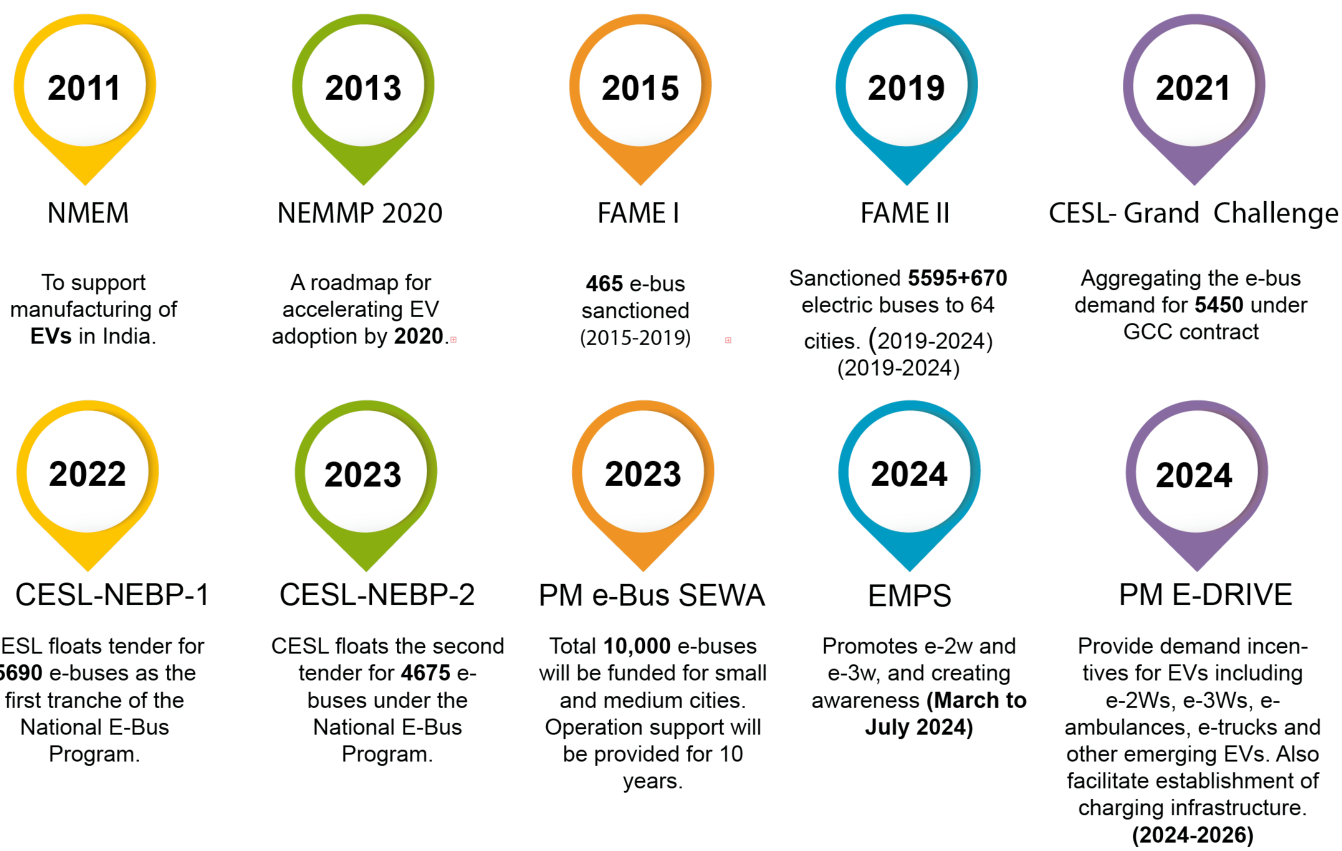


Figure 3.1: Policy landscape for EVs in India

3.1.1 NMEM (2011)

The GoI launched the National Mission for Electric Mobility (NMEM) on March 31, 2011, with the goal of promoting electric mobility and manufacturing EV in India

Under the mission two key bodies were established for speedier decision making and for ensuring greater collaboration amongst various stakeholders.

- National Council for Electric Mobility (NCEM)
- National Board for Electric Mobility (NBEM)

This establishment of these bodies aimed to create a common platform for all electric mobility initiatives, encourage industry, academia, government collaboration, and oversee the approval and monitoring of all allocations made by the GoI for development of hybrid and EVs.

3.1.2. NEMMP 2020 (2013)

The National Electric Mobility Mission Plan (NEMMP) 2020 was launched on January 9, 2013, as a strategic initiative under the NMEM. The plan aimed to position India as a global leader in the electric and hybrid vehicle market, particularly in the two-wheeler and four-wheeler segments.

NEMMP 2020 set a target of achieving 6–7 million sales of electric and hybrid vehicles by 2020, contributing to fuel security, environmental sustainability, and domestic manufacturing growth. To operationalise the goals of NEMMP 2020, several supporting initiatives were introduced, most notably the Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) scheme.

3.1.3 FAME I (2015 -2019)

The Department of Heavy Industry (DHI) launched a pilot scheme called FAME- India (Faster Adoption and Manufacturing of (Hybrid&) Electric Vehicles in India) on April 1, 2015, under NEMMP. The scheme aimed to reduce pollution caused by the transport sector. The GOI, with approval from the Ministry of Finance, allocated a fund worth ₹7,950 crores for this scheme, which was later revised to ₹895 crore. For the first time in India, the scheme sanctioned 465 e-buses to cities and states.

3.1.4 FAME II (2019 -2024)

The DHI launched Phase 2 of the FAME scheme in 2019 investing Rs 10,000 crore in the EV sector. The scheme provided Rs 10,000 incentives on per kilowatt hour (kWh) basis for e2W, e3W, and e4W vehicles, based on the size of their batteries. For buses, the scheme aimed to deploy 7,090 e-buses, which has been successfully achieved[5]. In FAME II (Part I), 64 cities/STUs were targeted to deploy with 5,595 e-buses. However, it was realised that small and medium-sized cities lacked the capacity to procure and operate e-buses due to underdeveloped EV at that time. Consequently, in June 2021, a notification was issued, announcing funding for only 4 million plus cities, and the rest of the cities would be funded based on the Operating Expenditure (OPEX) model.

In March 2023, the Ministry of Heavy Industries (MHI) (DHI was renamed to MHI in 2021) announced that they have approved a total of 7,210 e-buses, exceeding the target of 7,090. Out of these, 2435 buses have already been deployed on Indian roads[6]. Convergence Energy Services Limited (CESL) is also taking charge of deploying 50,000 e-buses under the National Electric Bus Program (NEBP) in a phased manner by 2030.

Under this scheme, Surat city procured a total of 300 midi AC e-buses in two slots of 150 in 2020 and 2022, respectively.

[4] [https://www.ikigailaw.com/article/433/timeline-of-policy-developments-on-emobility-in-india].

[5] [Ministry of Heavy Industries (MHI), https://heavyindustries.gov.in/sites/default/files/2024-01/_loksabhaquestions_annex_1711_as281.pdf]

[6] [Government of India, Ministry of Heavy Industries, Starred Question No 281, 21.03.2023]

3.1.5 E-bus Grand Challenge (2021) & NEBP (2022-2023)

The CESL was nominated by the MHI, which is India's apex organisation for promoting electric vehicles, to lead the Grand Challenge. This initiative was started as part of the e-Sawari: India Electric Bus Coalition, which is a group of central, state, and local government, transit service providers, Original Equipment Manufacturers (OEMs), financial institutions, and ancillary service providers who came together to share information and lessons learned about the adoption of e-buses in India.
CESL has announced three tenders for the procurement of electric buses as part of the Grand Challenge and National Electrical Bus Program (NEBP) for the procurement of 50,000 e-buses by 2030.

1.CESL tender 1 was issued for 5,450 buses (12 meters and 9 meters) with different variants such as AC/Non-AC and low/standard floor for five cities i.e. Delhi, Kolkata, Bengaluru, Hyderabad, and Surat.

2.The National Electric Bus Program (NEBP) launched a tender for 6,465 buses in September 2022. Out of these, 5,315 buses were sanctioned for intracity bus operations, while the rest were sanctioned for intercity/ regional bus operations.

3.A second tender was launched under NEBP in January 2023 for 4,675 buses through a dry lease arrangement, specifically for STUs from Delhi, Kerala, and Telangana who operate buses on their own. However, the OEM refrained from bidding due to the absence of a payment security mechanism in the procurement process[7]

Under the NEBP, Surat procured around 150 standard (12 m) AC e-buses in 2023.

3.1.6 EMPS (April – July 2024)

The MHI has launched the Electric Mobility Promotion Scheme (EMPS) 2024, following the end of the FAME II scheme on March 31, 2024. This new scheme was active from April 1 to July 31, 2024, and aimed to encourage the use of electric two-wheelers and three-wheelers.

The scheme included registered e-rickshaws, e-carts, and L5 (e-3w) vehicles and offered a demand incentive of Rs 5,000 per kWh for e-3Ws with a capping of 15% of ex-factory price. The goal is to support 38,828 e-3Ws, including 13,590 rickshaws and e-carts, and 25,238 e-3Ws in the L5 category.

The scheme is allocated approximately Rs 160 crores from the overall scheme budget of Rs 500 crores. To boost awareness for EV adoption, the scheme conducts Information, Education, and Communication (IEC) activities, events, exhibitions, and roadshows. Additionally, to promote the indigenisation of the EV ecosystem, the scheme also incorporated a Phased Manufacturing Programme (PMP).

However, the implementation of this scheme in Gujarat did not have a significant impact.

3.1.7 PM E-DRIVE scheme (2024-2026)

The Prime Minister's Electric Drive Revolution in Innovative Vehicle Enhancement (PM E-DRIVE Scheme), launched on September 29, 2024, by the MHI, GoI, will be in effect until March 31, 2026. It subsumes the EMPS 2024, which was initiated on April 1, 2024, making its effective duration two years. With a Rs 10,900 crore outlay, the scheme aims to accelerate EV adoption, charging infrastructure development, and the EV manufacturing ecosystem across the country. It supports multiple vehicle segments, including e-2W, e-rickshaws, e-carts, e-3W (L5), e-ambulances, e-trucks, and e-buses.

The e-bus component under the PM E-DRIVE scheme aims to roll out 14,028 e-buses with a total budget of Rs 4,391 crore. To qualify for incentives, only e-buses with an ex-factory price below Rs 2 crore will be considered. A uniform grant of Rs 10,000 per kWh will be provided for two years, with a maximum incentive limit based on bus size: Rs 35 lakh for standard buses (length >10m & ≤12m), Rs 25 lakh for midi buses (length >8m & ≤10m), and Rs 20 lakh for minibuses (length >6m & ≤8m).

[7]https://www.samil.in/Blog-Empowering%20Indias%20Green%20Transit%20%20%20Ambitious%20Govt%20Plans%20for%2038%20000%20Electric%20Buses%20by%202027-36

The final grant per bus will be the lowest among three criteria: Rs 10,000 multiplied by the battery capacity (in kWh), the maximum incentive per size category, or 20% of the e-bus price as discovered through competitive bidding by CESL.

If lower procurement costs are achieved, the scheme allows for an increase in the number of supported buses while staying within the Rs 4,391 crore budget. Initially, the scheme targets nine cities with populations exceeding 40 lakhs: Mumbai, Delhi, Bangalore, Hyderabad, Ahmedabad, Chennai, Kolkata, Surat, and Pune. Additionally, the rollout of intercity and interstate e-buses will be considered in consultation with state governments and stakeholders. The scheme also includes provisions for procuring e-buses in unique geographies such as hilly areas, northeastern states, island territories, and coastal regions under a non-OPEX model, subject to approval by the MHI. Cities and states replacing their buses through authorised Registered Vehicle Scrapping Facilities (RVSFs) will receive priority in e-bus allocation.

Support for e-buses will be provided through State/City Transport Undertakings (STUs) using the Operational Expenditure (OPEX) / Gross Cost Contract (GCC) model, while CESL will continue aggregating e-bus procurement through competitive bidding. The e-bus grant will be released in four stages: 20% as a mobilisation advance, 30% at commercial operation start, 25% after six months, and the final 25% after 18 months of successful operation.

Additionally, Rs 2,000 crore has been allocated to develop public charging infrastructure for various EV categories, including e-buses, ensuring a robust support system for electrification efforts.

3.2 State and city level policies, schemes & study

Currently, a total of 28 states in India have notified EV policy, while two states have their policies at the draft level[8]. Out of these 28 states, only nine states provide funding for e-buses, while the rest are predominantly focused on private vehicles, three-wheelers, and their charging infrastructure. Gujarat has been a pioneer in the promotion of e-mobility, and although the states EV policy does not provide funds for e-bus procurement, the state has a Chief Ministers Urban Bus Service (CMUBS) Scheme which provides Viability Gap Funding (VGF) to e-buses as well as Compressed Natural Gas (CNG) buses. None of the cities in Gujarat have come up with a city-level EV policy except for Surat.

3.2.1 Gujarat EV policy

The state of Gujarat introduced its EV policy, which came into effect on July 1, 2021. Gujarat Energy Renewable Research and Management Institute (GERMI) was responsible for developing the policy on behalf of the government. The policy includes specific tariffs for public and depot charging stations, with a proposed per-unit cost of around Rs 5 instead of Rs 8-9 per unit (i.e. per unit cost of commercial use).

The Ports and Transport Department is responsible for planning, implementing, and reviewing the policy, while the Energy and Petrochemicals Department oversees the charging stations and related subsidies. The GERMI is responsible for conducting research, training, and other activities for various stakeholders.

The following are the objectives of the policy to promote e-mobility:

i. To transition the state's transportation sector towards electric mobility.

ii. To establish Gujarat as a manufacturing hub for EVs and its ancillary equipment.

iii. To encourage start-ups and investments in the field of electric mobility and associated support sectors such as data analytics and information technology.

iv. To improve the quality of the environment.

3.2.2 CMUBS Scheme

The Chief Minister's Urban Bus Service (CMUBS) scheme was launched in 2019 to provide VGF under the Swarnim Jayanti Mukhya Mantri Shaheri Vikas Yojan (SJMMSVY) program. The scheme offers VGF to eight municipal corporations and 22 municipalities that have a population of more

[8] [https://evyatra.beeindia.gov.in/state-ev-policies/]

than 1 lakh. It is the only scheme in the country that provides bus operation support for its contract period as VGF, and the same concept has been adopted by the GoI in formulating the PM e-Bus Sewa Scheme.

The Gujarat's Chief Minister has taken an approach to increase the operating grant for these bus services to Municipal Corporations and Municipalities through Public-Private Partnership (PPP). As per the announcement made in August 2023, Municipal Corporations will now receive Rs 18 per kilometre for operating CNG buses, up from the previous amount of Rs 12.50. Furthermore, the maximum amount available for VGF, has been increased from 50% to 60%.

'A' Category municipality will receive a grant of Rs 22 per kilometre, and the maximum reduction in VGF for CNG bus operations will be increased from 50% to 75%. Currently, e-buses are only being operated in Ahmedabad, Surat, and Rajkot, where these municipal corporations can avail of Rs 30 per kilometre instead of Rs 25 – increased from 50% to 60% of the VGF[9]. Furthermore, a new provision for category 'A' municipalities allows them to receive 75% of VGF capped at Rs 40 per kilometre on e-bus operations, which is very lucrative for them to start shifting towards e-bus operations.

Despite this unique scheme support from the Government of Gujarat (GoG), the admissible buses in eight municipal corporations were 2,713 of which only 1,885 (70%) CNG buses have been deployed. The deployment is even worse in 'A' category municipalities, only 10 out of 22 municipalities have deployed i.e., only 45% of buses of admissible buses[10].

3.3 Surat city level EV policy (2021 -2025)

In 2021, Surat Municipal Corporation (SMC) launched a city level EV Policy, making Surat the first city in Gujarat to do so. From 2018 to 2023, the city saw a significant increase in EV registrations, with the adoption rate reaching up to 29% (WRI, 2023). The purpose of this policy is to promote the adoption of battery electric vehicles and to establish charging infrastructure. These initiatives are intended to position Surat as the first EV smart city in India.

The policy focuses on developing charging infrastructure for private vehicles, aiming to install 500 charging stations. To support this, the SMC offers a three-year 100% rebate on Environmental Improvement Charges (EIC)to all private EV charging station developers. The SMC also plans to support the installation of Public Charging Stations (PCS) through a PPP model. By granting user rights to150 suitable plots or spaces within SMC premises. Developers will have to pay a nominal token rent of Rs 1 per sqm per year for the first two years, after which a revenue sharing model will be implemented.

The second action area of the policy focuses on promoting the adoption of EVs. SMC aims to achieve at least 20% of the EV target specified in the State EV Policy by the end of 2025. Below are the targets specified for different vehicle category:

Vehicle Category	No. of EVs Presently in Surat City (2023)	State's Target in State EV Policy (2025)	SMC's Target in City EV Policy (2025)
2W	6,173	110,000	20,000
3W	164	70,000	15,000
4W	331	20,000	5,000
Buses	49	-	300
Total	6,699	200,000	40,300

Table 3.1 Surat EV policy – Vehicle category and targets by 2025

[9] [https://deshgujarat.com/2023/08/18/gujarat-govt-increases-per-km-grant-vgf-for-cng-and-ev-public-buses-in-towns-and-cities/]

[10] [GUDM, Government of India, March 2024].

To achieve these targets, the policy offers various incentives such as vehicle tax exemptions, rebates for environmental improvement charges, and free parking slots at SMC's Pay and Park locations for three years from the inception of this policy. The policy emphasis the electrification of SMC-operated vehicles, including the city bus fleet, official vehicles, vehicles of employees, and garbage-collecting vehicles.

3.4 Surat CEMP 2023

Surat's Comprehensive Electric Mobility Plan (CEMP) 2023[11] aims to transform the city into a global EV lighthouse. The goal is to establish a scalable framework for urban areas nationwide by devising strategies such as incentives, planning mechanisms, and awareness campaigns. The roadmap is divided into short (<2 years), medium (3-5 years), and long-term phases (6 years onwards).

The short-term initiatives aim to lay the foundation for broader electrification efforts in the city. This includes setting up the initial infrastructure for EV charging stations, promoting EV adoption in government and corporate employee transport, and initiating public awareness programs.

The medium-term phase focuses on scaling up the initiatives from the short-term and accelerating the transition to e-mobility. The long-term phase aims to establish Surat as an EV lighthouse city with a fully developed e-mobility ecosystem. Long-term initiatives focus on achieving full-scale electrification of urban transport, integrating renewable energy sources into the grid for EV charging, and sustaining the momentum of EV adoption.

A comprehensive approach has been devised to address the challenges such as increased traffic congestion, low public transport utilisation, and low coordination among state agencies. The plan includes the formation of a coordinating committee to streamline the public transport deployment and e-rickshaw corridors, as well as the establishment of shared charging networks. Stringent measures to improve air quality are also proposed, such as targeting idling vehicles, scrapping older vehicles, and implementing stricter pollution checks.

Furthermore, the plan prioritises efficient parking management, including reserved EV spaces and charging infrastructure. It recommends expanding the e-bus fleet under an OPEX model and ranks non-electric routes by footfall to transition more customers to EVs as the fleet expands. The plan promotes sustainable transportation through technology and management strategies.

CEMP recommends capacity-building programs for transit network planning, e-bus routes, and fleet monitoring. The plan suggests installing solar panels at the Palanpur depot for EV charging. It would cost Rs 0.89 - 0.95 crore for a 200 kW solar installation. The CEMP recommends developing 2,878 public chargers for e2Ws and e3Ws with a capacity of 3.3 kW in the long term, with Rs 28.9 crore.

3.5 Summary

The GOI has set an ambitious target of achieving 50,000 e-buses on the road by 2030, with a funding ecosystem that has matured over time and has explored various options. In the last scheme by GoI, the ministry has also released funds for developing the charging infrastructure, which would enhance the efficiency of the e-bus operations. Surat has procured 450 e-buses under the scheme, with 300 e-buses under FAME II and 150 e-buses under NEBP.

Recently, GoI has also declared the PM e-DRIVE scheme, which is now the new source for availing funding for e-bus operations for metropolitan cities in India. The city has also availed for the VGF under the state-level CMUB scheme, which has provided additional support. These developments reflect a strong commitment to the promotion of sustainable transportation in Gujarat. Therefore, policy landscape is available to support Surat's target for transitioning to 100% electrification in bus based public transport.

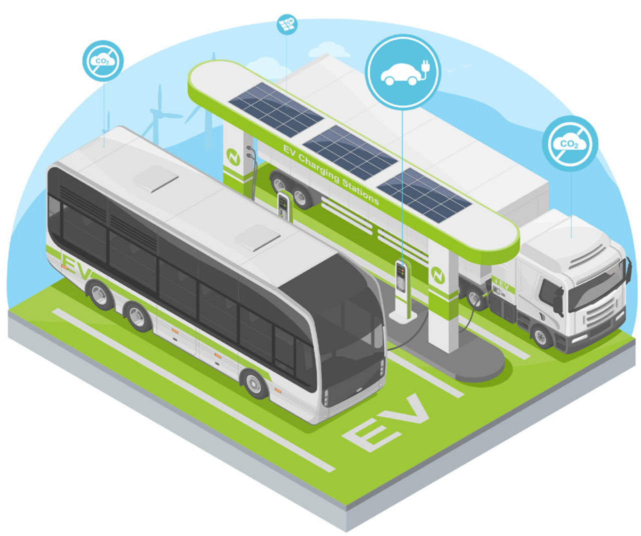
[11] [Surat Comprehensive Electric Mobility Plan, prepared by NITI Aayog and Asian Development Bank (ADB), 2023]

04

Baseline Assessment of Bus-Based Public Transport System in the City

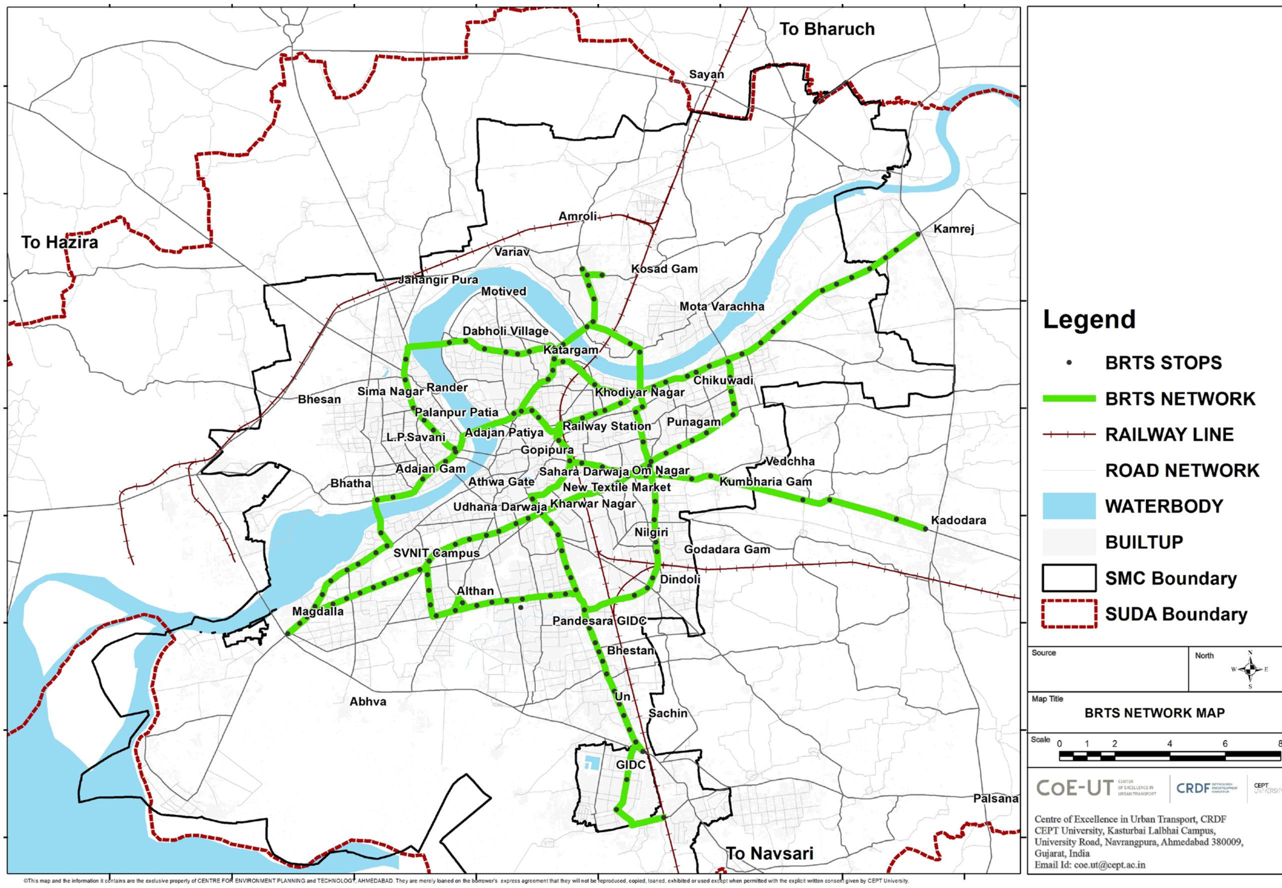
The city bus services in Surat have evolved significantly over the years. Initially, the bus services were operated by a private operator under a Net Cost Contract (NCC). Subsequently, in 2014 and 2017, the city implemented the BRTS and city bus services respectively with integrated services and standardised fares for the entire system. Both these services are currently managed and operated by Sitilink Ltd., an SMC-led Special Purpose Vehicle (SPV), under a Gross Cost Contract (GCC). The city is presently undergoing the construction of 40 km of metro network, integrated with the existing bus based public transport network to enhance public transport connectivity across the city. Currently, the city has a total of 870 buses; out of which 699 are on road (as of December 2024).

In Gujarat, Surat city stands out for its commitment to environmentally friendly transportation comprising the highest number of e-buses currently in operation.



4.1 Bus Rapid Transit (BRT) service

As of December 2024, the total BRT network is about 118 km with 13 routes and 167 stops. Total fleet size is 422 e-buses, out of which 361 buses are on-road depicting 86% fleet utilisation. The e-buses are operated by three OEMs, including Olectra/ Evey Trans, Greencell Mobility Pvt Ltd, and JBM Ecolife Mobility Surat Pvt Ltd. The BRT services operate with 5-10 mins headway during peak hours and about 12 mins headway during off-peak hours. The average speed of BRTS is around 24 kmph.



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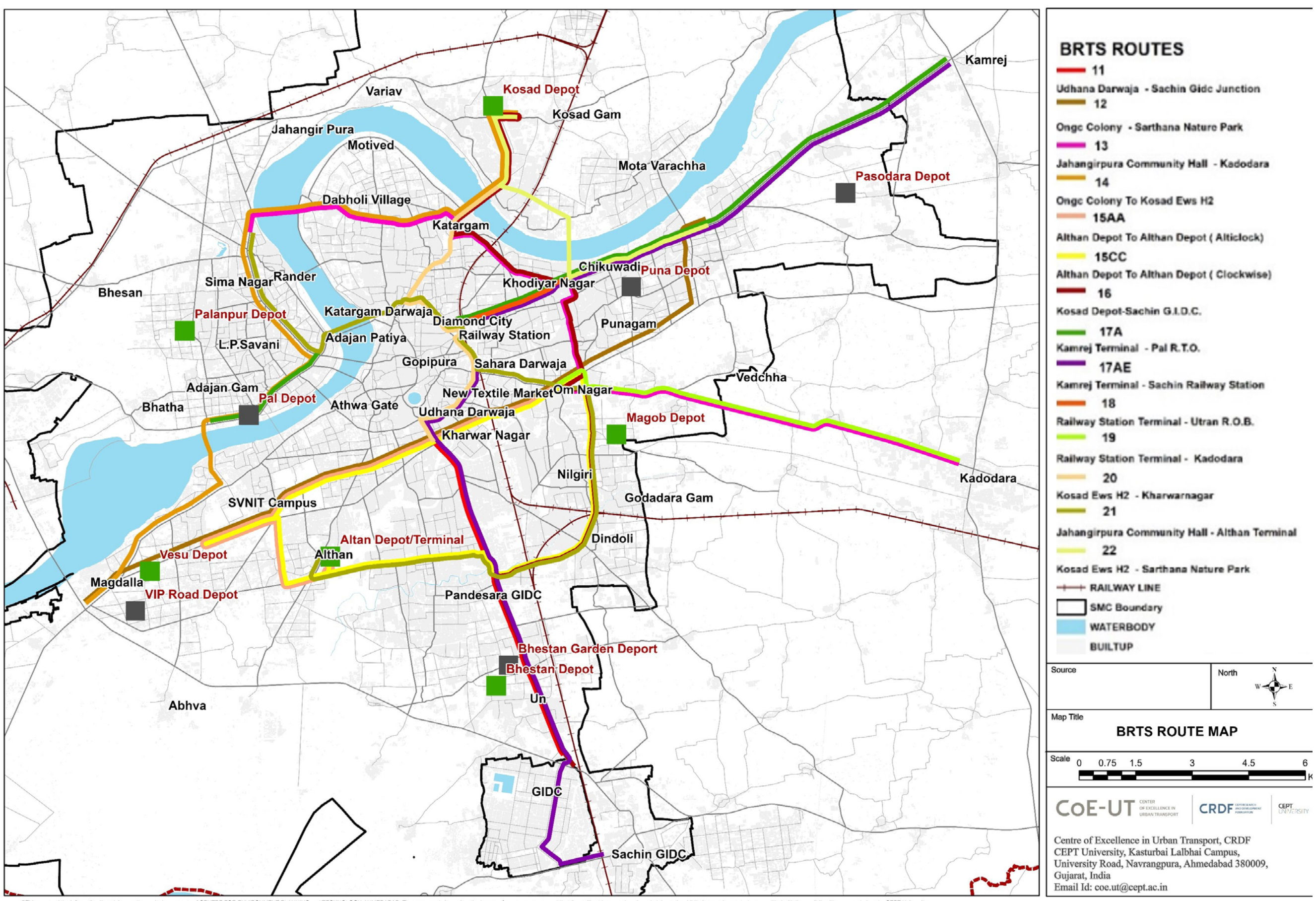
Map 4.1: Existing BRT network and stations

S.No	Route No.	Route Description	Length (km)	Peak Headway (min)
1	11	Udhana Darwaja - Sachin GIDC Junction	10	7
2	12	ONGC Colony - Sarthana Nature Park	20	5
3	13	Jahangirpura Community Hall - Kadodara	23	6
4	14	ONGC Colony - Kosad EWS H2	24	6
5	15AA	Althan Depot - Althan Depot (circular)	27	8
6	16	Kosad Depot - Sachin G.I.D.C.	24	5
7	17A	Kamrej Terminal - Pal R.T.O.	24	5
8	17AE / 23	Kamrej Terminal - Sachin Railway Station	32	9

9	18	Railway Station Terminal - Utran R.O.B.	6	15
10	19	Railway Station Terminal - Kadodara	14	10
11	20	Kosad EWS H2 - Kharwarnagar	13	10
12	21	Jahangirpura Community Hall - Althan Terminal	25	6
13	22	Kosad EWS H2 - Sarthana Nature Park	10	12

Table 4.1: Existing BRT route details

Source: Sitilink, SMC, December 2024



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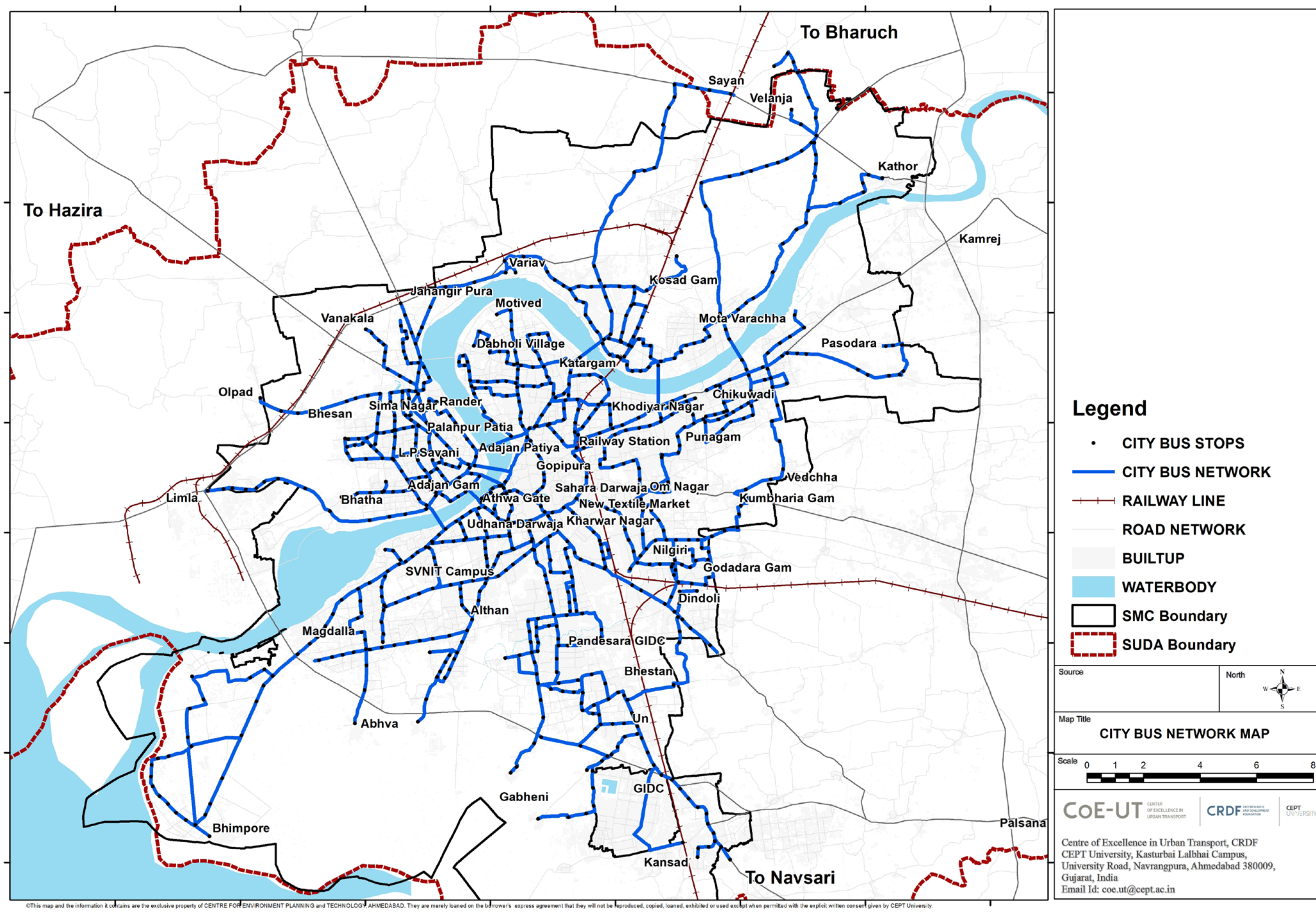
Map 4.2: Existing BRTS routes

4.2 City bus service

The city bus operation under Sitilink was initiated in the year 2017 with a fleet size of 236 buses. The fleet size has now increased to 448 buses amongst which 26 e-buses and 422 are diesel buses (as of December 2024). The city bus network covers around 417 km through 53 bus routes. Currently, only 338 buses are operational due to maintenance issues mainly in diesel buses. Resulting, the fleet utilisation is about 75%, which is relatively low.

The diesel buses are run by two operators namely, Hansa and Maruti with about 350 total buses and 72 buses respectively operated from the four depots i.e. Kosad, Puna, VIP, and Bhestan Garden. Recently, Adajan Pal depot (converted from diesel depot into e-bus depot) has been allocated to the JBM Ecolife Mobility Surat Pvt Ltd.

In terms of headway distribution, the city bus operates only two routes with less than 10 mins headway, 27 routes with a headway of 10-30 mins and rest 24 routes have a headway greater than 30 mins. This reveals that the passenger has longer waiting time in city bus as compared to BRT services. The average speed of city bus is around 17 kmph.



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Refer Annexure I for city bus routes details.

Map 4.3: City bus network and bus stops

4.3 Bus depots

The city has a total of 14 depot locations of which are shown in the Map 44. Out of these 14 depot locations, four of them are electric depots - Palanpur, Althan, Mogab and Vesu, located in western, southern and eastern parts of the city. Each depot can accommodate around 75 buses, Althan and Palanpur are depot cum terminals.

Since the city is adding more e-buses to its fleet, two existing depots at Bhestan (100 buses capacity) and Pal - near Star Bazar (50 buses capacity), have been converted into e-depots to accommodate the newly procured e-buses.

In addition, two new electric depots are under construction; Pasodara and Kosad. As of March 2025, the OEM for these depots has not yet been appointed.
The city also has four diesel bus depots with a total capacity of 422 buses, mainly operated by Hansa (350 total buses) and Maruti (72 total buses). However, two diesel depots (i.e. Pal near LP Savani and Kosad near fire station), previously operated by Chartered, are currently not in operation as their contract has been expired (Figure 41).

Below figure classifies the operational and non-operational depot with the fleet size and operator details.

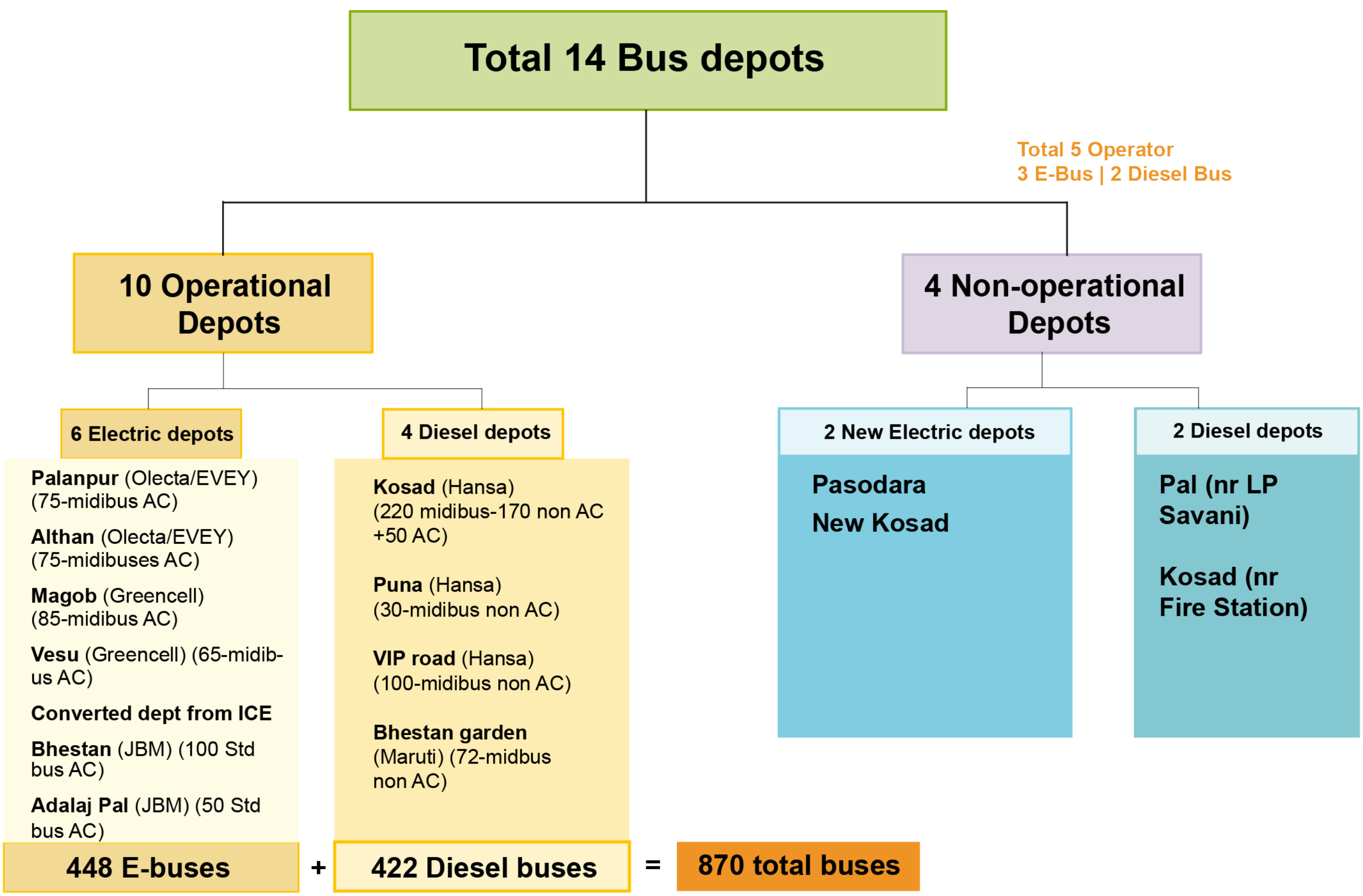


Figure 4.1: Status of existing number of bus depot in Surat

Source: Compiled data from Sitilink, SMC, December 2024

Three depots have been assigned for city bus services, namely, Kosad, Puna and VIP, Kosad depot serves as the primary depot, operating total 23 routes and undertaking major bus repair works. Puna and VIP depots are utilised for bus parking, with few routes assigned depending on the daily schedule. All three depots, are operated by single operator (i.e. Hansa Vahan India Pvt. Ltd.)

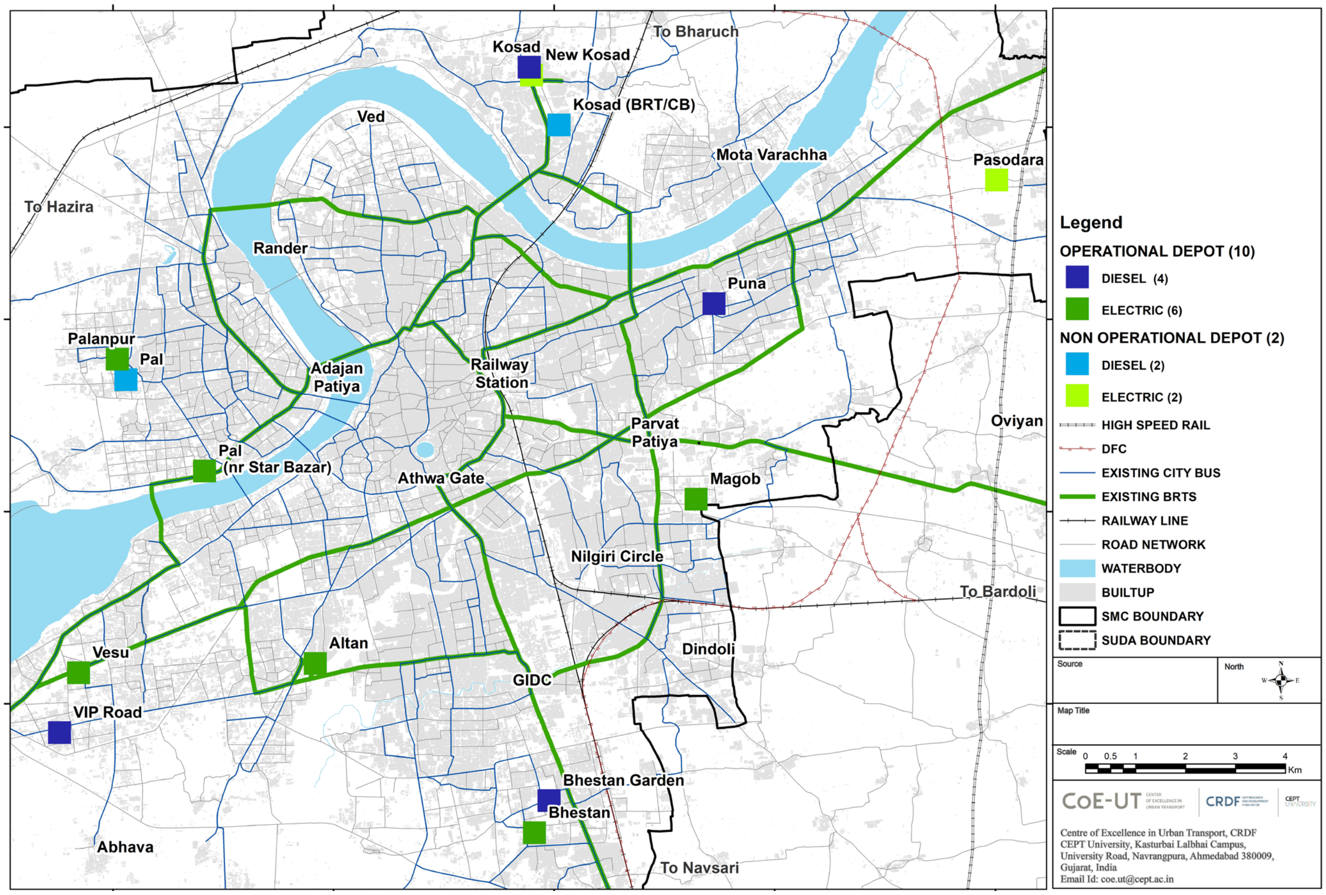
Figure 4.1 show the operators assigned to each depot for both BRT and city bus routes. As per the contract, under the FAME II scheme, 300 e-buses (midi AC) were procured in two lots of 150 e-buses each in 2020 and 2022. In 2023, 150 additional standard (i.e. 12m) e-buses were procured under NEBP. The contract period with private operators is 12 years. It has been observed that capacity of e-bus depot is smaller, accommodating around 75 buses therefore each operator has been assigned two depots.

Sr. No	Depot Allocated	Total Buses	On Road Buses	Type of Bus/ Fuel Type	Name of the Operator	Contract Period	Service Type	Current Rate Rs/km
1	Althan	75	72	Midi (9m) Electric (AC)	Olectra / Evey Trans (SMC) Pvt. Ltd.	February 2021 to February 2031 (FAME II)	BRT	55.26
2	Palanpur	75	72				BRT	
3	Magob	85	70	Midi (9m) Electric (AC)	Green Cell Mobility	February 2023 to February 2033 (FAME II)	BRT	48.87
4	Vesu	65	56				BRT	
5	Bhestan	100*	71	Standard (12m) Electric (AC)	JBM Ecolife Mobility Surat Pvt Ltd.	January 2024 to January 2036 (NEBP)	BRT	59.29
6	Adajan Pal	48* *	46				BRT + City Bus	
7	Kosad	50	26	Midi Diesel (AC)	Hansa Vahan India Pvt. Ltd.	May 2018 to April 2025	City Bus	43.01
8	Kosad	170	127	Midi Diesel (Non-AC)	Hansa Vahan India Pvt. Ltd.	November 2018 to November 2025	City Bus	
9	Puna	30	27					
10	VIP	100	66					
11	Bhestan Garden	72	66	Midi Diesel (Non-AC)	Shri Maruti Travels	May 2017 to May 2024 (Ext 2026)	City Bus	40.01

Table 4.2 Summary of type of buses and operators contract period by depot

Source: Compiled data from Sitilink SMC, March 2025

*Total 25 buses are currently not in operations; ** Total two buses not yet delivered due to operational issues



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Map 4.4: Location of existing bus depots

4.4 Fare structure

Surat has implemented a distance-based common fare structure for both, city bus and BRTS. Since 2018, an integrated and AFCS has been in place and is managed by NEC Corporation India Pvt. Ltd. under Surat Smart City Development Ltd. (SSCDL), SMC. This system enables passengers to travel across the entire public transport network using a single ticket.

The system offers both, paper ticket and mobile app-based ticket options to commuters. The fare for the paper ticket and mobile ticket differs. The mobile ticket is Rs 1 to Rs 5 cheaper as compared to the paper ticket, depending on the fare slab. Furthermore, it is observed that the average distance travelled by a passenger is approximately 6 km, which results in a fare of Rs 12-15 for a journey: the average Rs 2 per km. For passengers using passes and concessional tickets, the effective fare is much lower.

To enhance convenience, the Surat Money Card -an open loop smart card - facilitates payment for transit and non-transit services, such as bill payments, shopping malls, tax payments, etc. Additionally, the city also offers Safe Accessible Reliable Advanced and Low-carbon (SARAL) pass scheme, unlimited travel passes issued on annual, quarterly, and monthly basis. These initiatives allow passengers to travel across the city conveniently and cost-effectively.

Sr. No	Distance Range (km)	Fare for Paper Ticket (Rs)	Fare for Mobile Ticketing (Rs)
1	<2	5	4
2	2-4	10	8
3	4-6	10	8
4	6-8	15	12
5	8-10	15	12
6	10-12	20	16
7	12-14	20	16
8	14+	25	20

Table 4.3: Existing integrated fare structure in bus based public transport

Source: Sitilink, SMC, December 2025

As of April 2024, there are about 25,800 active passes including 62% by students, 17% by women, 10% by senior citizen and the remaining issued to government officials, differently abled persons, and other categories.

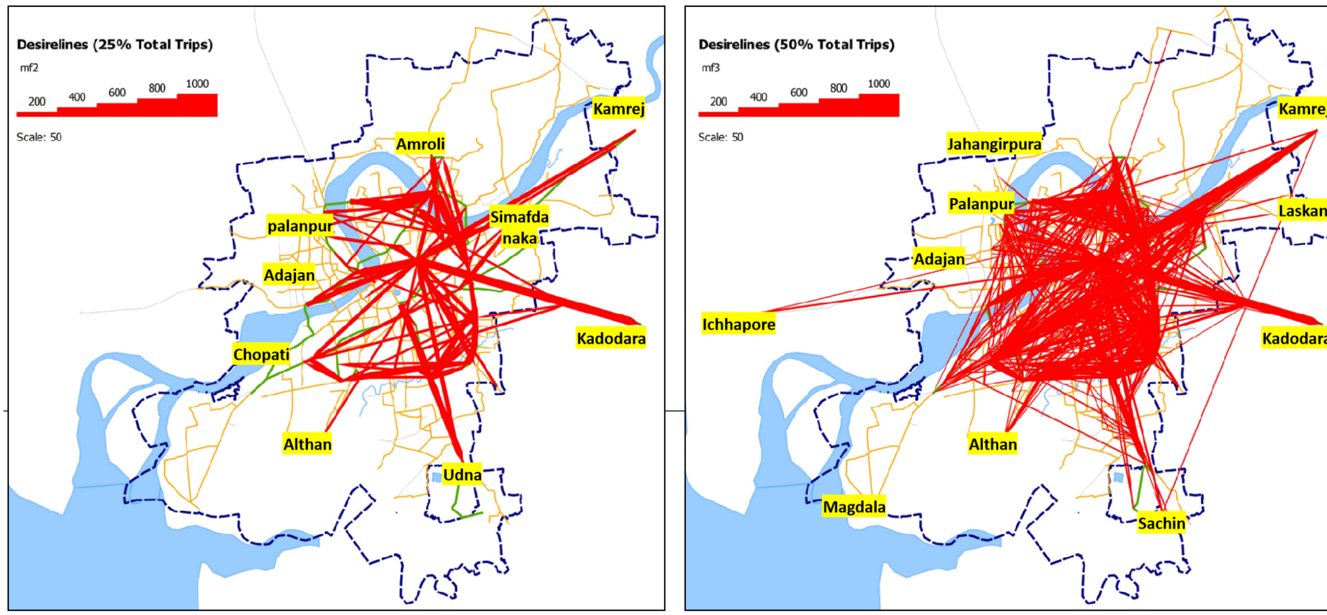
No	Pass Category	Discounts offered
1	Student, Women, Senior citizen, Institutional, others Shramik	Student, Women, Senior citizen, Institutional, others Shramik
2	Student	Surat money card- 40% discounts per journey
3	Women	Surat money card- 25% discounts per journey
4	Senior citizen	Surat money card- 25% discounts per journey
5	Blind	Surat money card- 100% discounts per journey
6	Differently abled	Surat money card- 100% discounts per journey

Table 4.4: Different passes and concessions on Sitilink bus services

Source: NEC, Sitilink SMC (December 2024)

4.5 Passenger travel pattern

Based on the Electronic Ticketing Machine (ETM) data of February 2024, the daily ridership on public transport bus services is about 1.8 lakhs. Notably, that the ridership has increased from 0.8 lakhs to 1.8 lakhs from 2017 to 2024. The city has been able to achieve its pre-Covid ridership levels. The travel pattern of top 25% and top 50% passenger trips is highlighted in the figures below.



Trips : 46,821 (25% Trips)
Total Trips : 1,83,514

Trips : 93,458 (50% Trips)
Total Trips : 1,83,514

Top 25% Passenger trips and Top 50% Passenger Trips Pattern

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Figure 4.2 : Passenger travel pattern (ETM data February 2024)

Source: Map generated based on ETM data, February 2024

Surat is recognised as a city of short trips, with an average trip length of approximately 5 km as per CMP 2018. According to the 2024 ETM data, the average trip length for public transport users in Surat is 6 km, which is shorter when compared to major cities like Ahmedabad and Pune.

The temporal distribution of passengers based on the ticketing information, reveals travel peak for public bus transport. The morning peak hours are observed from 8:00 am to 11:00 am, while the evening peak hours are observed from 5:00 pm to 8:00 pm, respectively (refer to Source: Compiled based on ETM data February 2024, Sitilink, SMC Figure 4.3). This analysis can help to prepare bus schedules more efficiently.

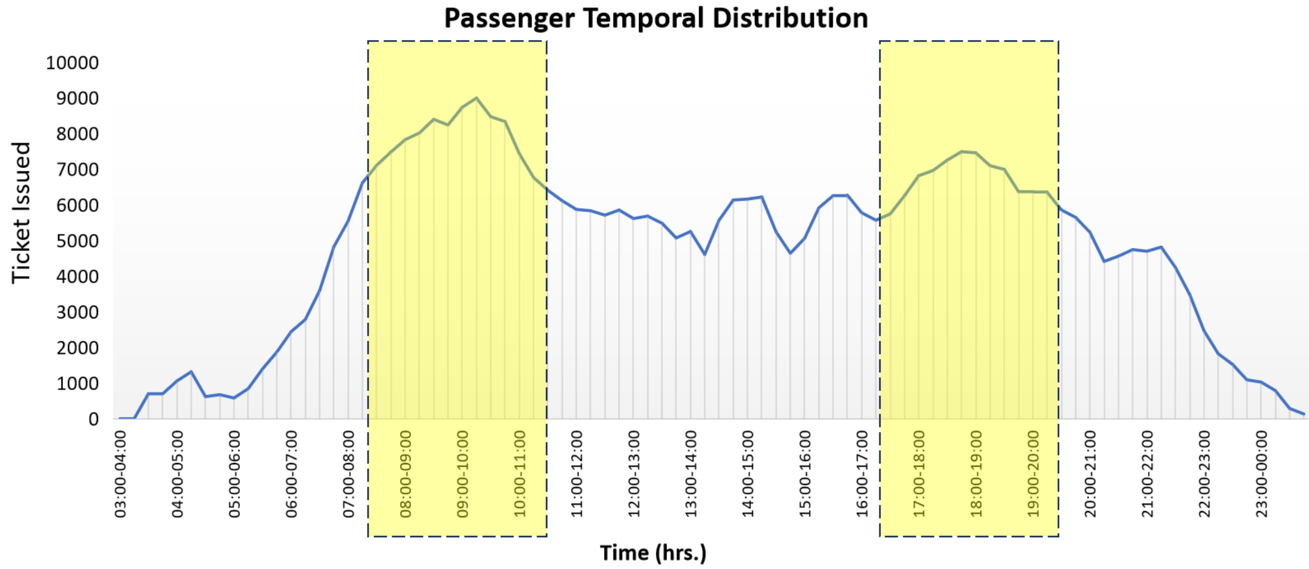


Figure 4.3: Temporal distribution of passenger trips

Source: Compiled based on ETM data February 2024, Sitilink, SMC

4.6 Performance assessment

An overall assessment of public bus transport service levels using Ministry of Housing and Urban Affairs (MoHUA) Service Level Benchmarks (SLB) in urban transport and other operational indicators has been presented in this section.

4.6.1 Service supply and coverage

4.6.1.1 Bus supply in the city

The total number of buses required in the city is assessed based on the number of buses per 1000 population. The estimated population in SMC is about 75.79 lakhs in 2024, with the total fleet size is about 870 (as of December 2024). The ratio obtained is about 0.12 (LOS 4), which is much lower than the recommended standard. This indicates the need for an increase in buses to cater to the growing population.

	SLB Indicator (MoHUA)	Unit	No	LOS	LOS Ranges
a	No. of buses available in the city(December 2024)	No.	870	LOS 4	1- >=0.6 2- 0.4-0.6 3- 0.2-0.6 4 <0.2
b	Population in the city (2024) *	No.	75,79.000		
	Extent of bus supply/1000 population	Ratio	0.12		

*CoE-UT, CRDF estimates

Table 4.5: Availability of public bus transport

4.6.1.2 Bus service coverage

The passenger wait time is influenced by the service headways and service reliability, with higher headways, resulting in longer wait times. Table 46 represents the route distribution by headways for BRT and city bus services. It is recommended that headways for urban bus services should be less than 20 minutes. The BRTS acts as a trunk service operating at high frequency with headways typically ranging from 5 to 10 minutes. In city bus services, approximately 55% of the routes have headways less than 30 minutes. This shows that the overall service frequencies are satisfactory in the city.

Peak Headway Ranges (of routes)	Total No. of BRTS Routes (%)	Total No. of CBS Routes (%)	Total No. of Bus Routes (%)
< 5	0	0	0 (0%)
5-10 Min	10(77%)	2 (4%)	22 (18%)
10-20 Min	3 (23%)	8 (15%)	11 (17%)
20-30 Min		19 (36%)	19 (29%)
30-45 Min		5 (9%)	5 (8%)
45-60 Min		4 (8%)	4 (6%)
60-100 Min		9 (17%)	8 (14%)
>100 Min		6 (11%)	4 (9%)
Total	**13 (100%)**	**53 (100%)**	**66 (100%)**

Table 4.6: Distribution of bus routes by headways

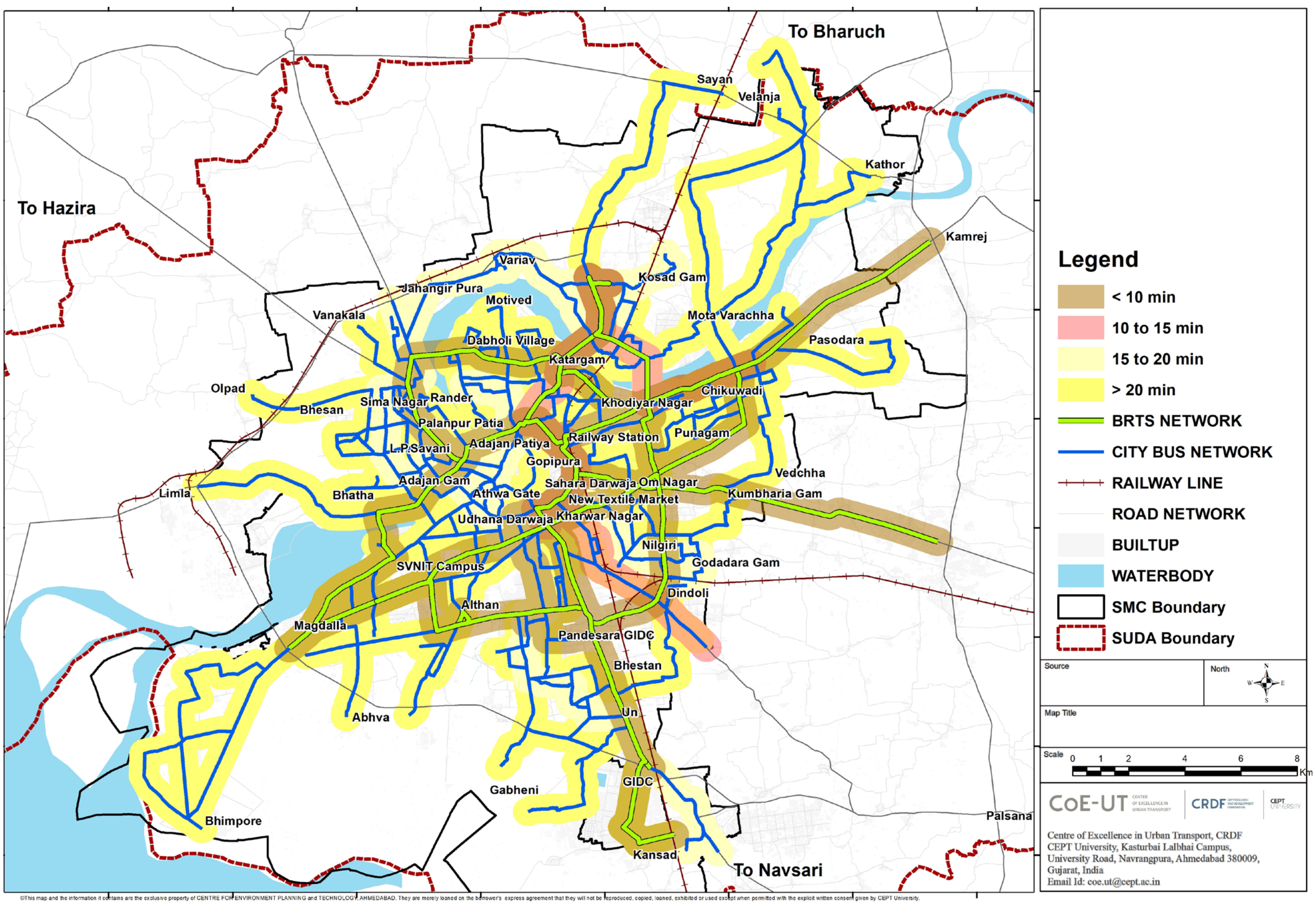
Source: Bus schedule data, Sitilink, SMC, April 2024

The network coverage with high frequency services are significant factors from the passengers' point of view. The total built-up area in SMC is around 221 sq. km, of which 192 sq. km is covered by public bus transport network, resulting in an overall bus service coverage of about 87% of the built-up area considering a catchment area of 500 m. However, the high frequency bus network coverage drops to 71%, taking 20 mins headways as a threshold. This indicates the need for improving bus service coverage in different parts of the city.

Headway Ranges	Built-up area (sq. km)- SMC	% Distribution
<10 Min	60	36%
10 to 15 Min	17	10%
15 to 20 Min	42	25%
>20 min	41	24%
Overall	192	100%

Table 4.7: Built up coverage of public transport network by service headway

Source: Bus schedule data, Sitilink, SMC, April 2024 and build up area, google based analysis, 2024



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Map 4.5: Existing public transport network coverage

4.6.2 Fleet and vehicle utilisation

Fleet utilisation indicates the daily performance of buses based on the total number of bus fleet used in daily operations relative to the total fleet size. It is desirable to have the fleet utilisation as 95% or above. From Table 48 the percentage of fleet utilisation by depot, it is observed that e-buses are performing well with the range of 82%-96% utilisation, whereas for diesel buses the ratio is too low, within the range of 70 -92%. This is because, the diesel buses are 6-7 years old which are not fit enough for operations and would require regular maintenance.

Sr.No	Depot	Types of Buses	Total No of buses	On Road Buses	Fleet Utilisation
1	Altan	electric	75	72	96%
2	Palanpur	electric	75	72	96%
3	Magob	electric	85	70	82%
4	Vesu	electric	65	56	86%
5	Bhestan	electric	100*	71	71%
6	Adajan pal	electric	48	46	96%
7	Kosad/ Puna/ VIP	Diesel	350	246	70%
8	Bhestan Garden	Diesel	72	66	92%
Total			870	699	80%

Table 4.8: Bus fleet utilisation by depot

Source: Sitilink, SMC (December 2024)
* Total 25 buses are not in operation currently; as separate land is provided for parking and charging facility at Althan depot; which is under construction.

The average vehicle utilisation is also an important bus performance indicator that highlights the total daily operated kilometres. It is essential to monitor, as operators are paid based on the daily operated kms as per the contractual agreement. The average vehicle utilisation observed in e-bus is around 193 km/bus/day, whereas the diesel buses is around 194 km/bus/day (May 2024).

4.6.3 Dead kilometre

Efficient bus scheduling and route allocation are critical components of operational planning that can have a significant impact on overall system and bus performance. Figure 44 represents the percentage of dead kilometres in BRTS and city bus routes. The results indicate that BRTS routes, which are predominantly serviced by e-buses, have dead kilometres within a range of 5-7%, which appears feasible. However, diesel buses have a higher percentage of dead kilometre in range of 8% to 10%.

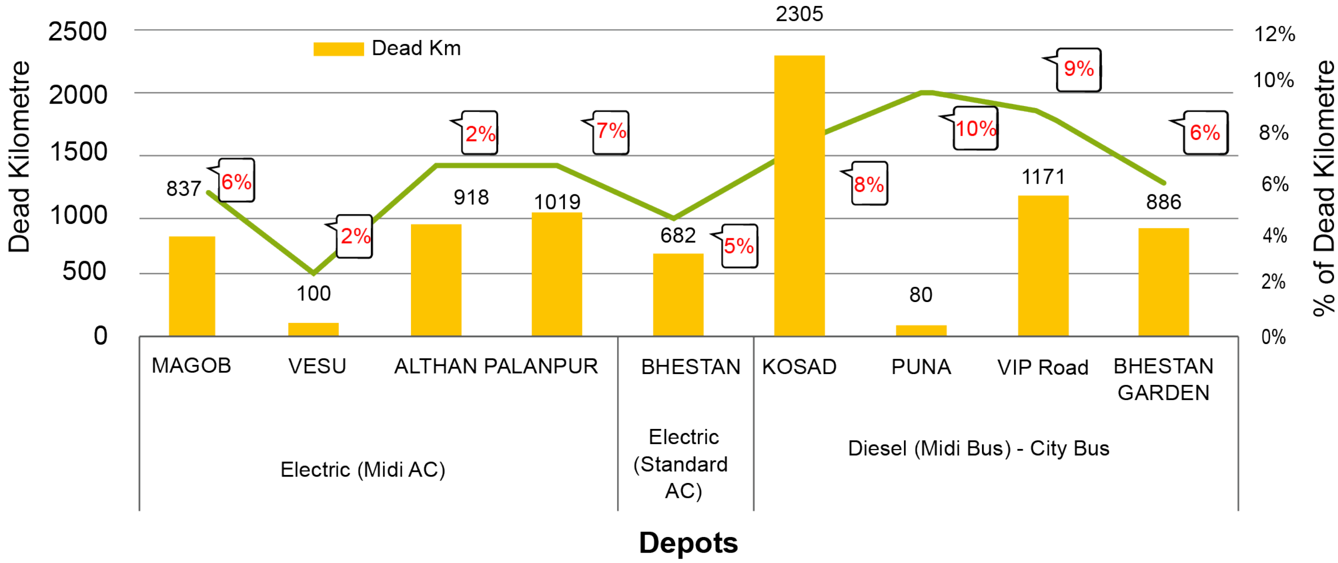


Figure 4.4: Depot wise total dead kilometre by s e-buses and diesel buses

Source: Analysis based on E-bus registry data and bus schedule, April 2024, Sitilink, SMC

4.7 Summary

The city's public transport system appears to be functioning satisfactorily, although there is a need for additional buses to meet the increasing travel demand in the city. Since 2017, Surat has implemented well-planned integrated transportation services, with approximately 1.8 lakh passengers traveling daily, having an average trip length of 6 km in public transport. Notably, the share of auto-rickshaw (3W) account for approximately 11% of passenger trips in the overall mode share, indicating a requirement for additional buses to cater to the city's overall demand and for extended public transport services' coverage. It has been observed that the fleet utilisation of e-buses is optimal because of new buses, but diesel buses utilisation is slightly low, necessitating better maintenance.

The city authority aims for achieving 100% electrification in buses going forward. The allocation of buses on routes by depot will be critical in the comprehensive operational planning process. This approach will help enhance overall bus performance and reduce costs, with promoting sustainable city transportation.

05

Understanding of the Fundamental Difference between E-buses vs ICE buses

The features and composition of e-buses differ significantly from those of conventional ICE buses. E-buses operate on batteries, while ICE buses run on fuels such as diesel and CNG. These differences in vehicle composition represent key operational challenges that authorities must understand to ensure seamless bus operations.

5.1 How do E-buses differ from ICE buses?

E-buses offer several advantages over ICE buses, including environmental benefits, improved passenger comfort, and reduced noise pollution. However, their adoption requires substantial investment in charging infrastructure, skilled personnel for safe operations, and efficient scheduling accommodate battery charging needs and mitigate range anxiety. Although e-buses have a higher initial cost, their maintenance expenses are considerably lower compared to ICE buses. Figure 5.1 highlights the key components that differentiate e-buses from conventional buses in detail.

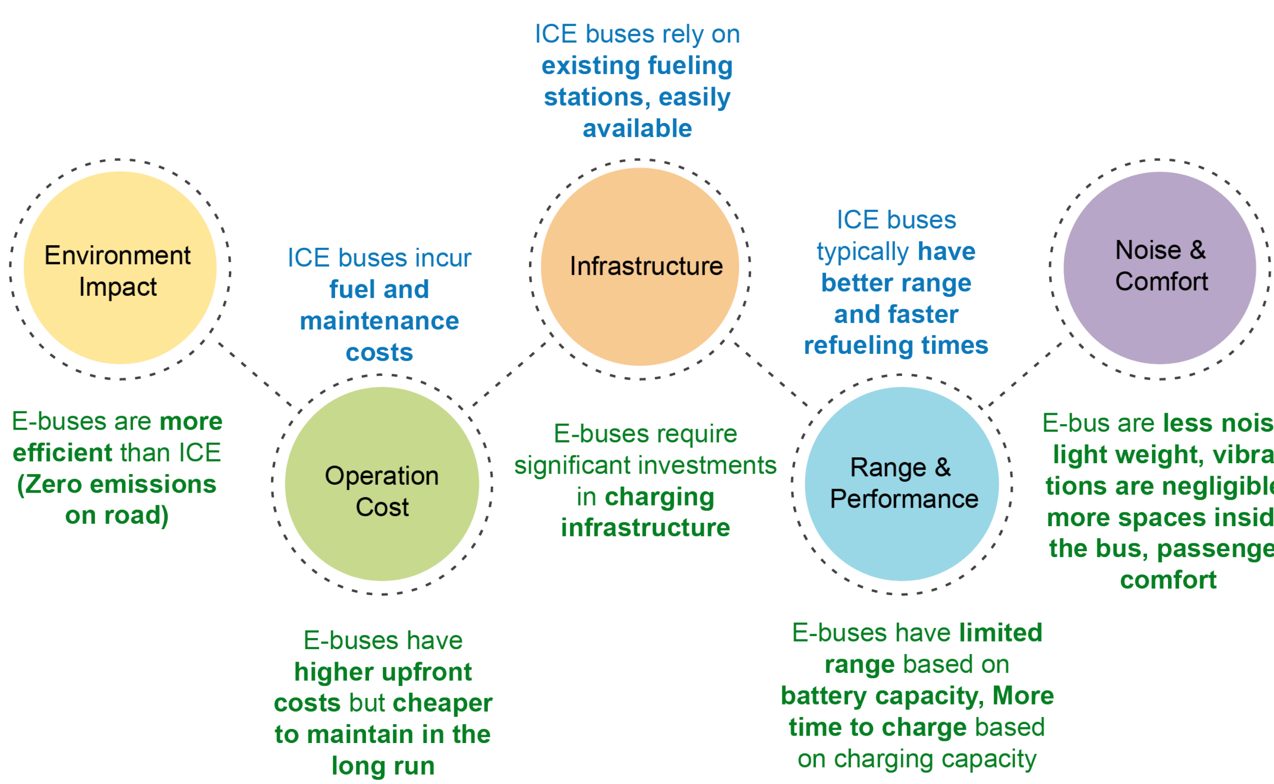


Figure 5.1: Difference in e-bus and ICE bus

5.2 Key challenges in e-bus operations

Despite their advantages, e-bus operations face several key challenges, as illustrated in Figure 5.2. One of the major challenges is there a limited kilometre range per charge, which depends on battery capacity. To complete a full day of service, most e-buses require at least one intermediate charge, making route planning and depot placement critical for operational efficiency. Key performance indicator such as energy consumption (kWh/km) and battery levels or Status of Charge (SOC) must be carefully monitored to optimise operations. Additionally, external factors such as passenger load, bus temperature, driver behaviour, road condition, and traffic congestion also impact energy consumption.

Another significant challenge is managing depot operation during day and at night to minimise delays in bus operations. Understanding the charging time required for different battery capacities e-buses and charger type enables better scheduling and depot efficiency.

Lastly, power utilisation from the electrical grid can be costly, increasing the need to explore alternative sources of electricity. Safety is also a critical concern in bus operations. Therefore, e-buses are equipped with advanced Battery Management System (BMS) that monitors temperature and charge levels, is crucial.

These challenges can be addressed through various strategies and innovations in e-bus technology and operations.

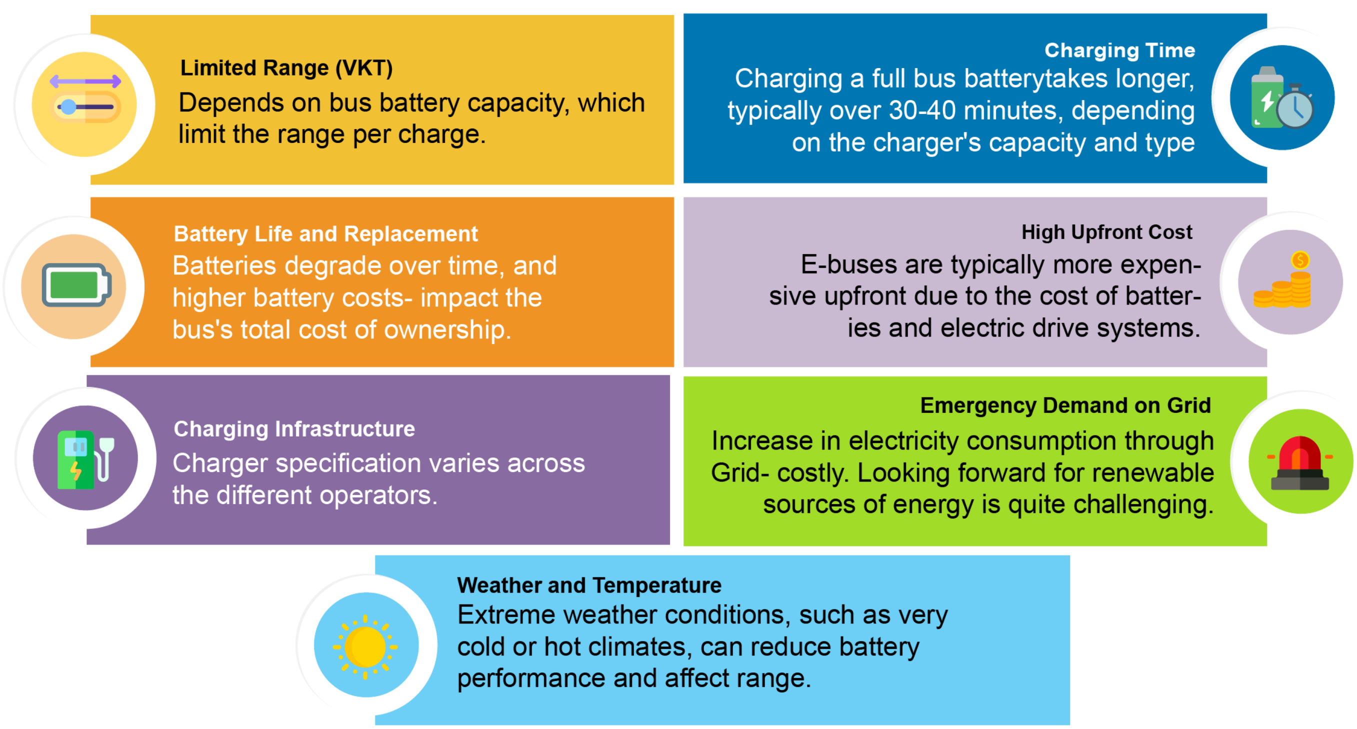


Figure 5.2 : Key challenges in e-bus operations

A crucial aspect of transitioning from ICE buses to e-buses is determining the replacement ratio- how many e-buses are needed to replace a single ICE bus. This depends on factors such as the battery range and energy consumption. Understanding the replacement ratio is essential for assessing the number of e-buses required to maintain service level effectively replace ICE buses. Addressing these challenges through technological advancements, strategic planning, and policy support will be key to successfully integrating e-buses into urban transport systems.

06

Existing E-Bus Operations Performance

Surat operates the largest segregated BRT network in India, currently utilising 450 electric buses (as of March 2025). The city aims to position this network as the largest green BRT operation by further expanding the e-bus fleet.

As e-buses are an evolving technology, and their operations and maintenance require a different approach compared to traditional ICE buses. Key challenges, such as range limitation and the need for opportunity charging, can affect overall scheduling and vehicle utilisation. Unlike ICE buses where refuelling is quick and straightforward, e-buses must be strategically deployed to mitigate range anxiety and optimise charging cycles.
The e-bus operations in Surat have been in place for three years providing valuable insights into their performance. This section outlines the key learnings from current operations, offering strategic recommendations to enhance the overall efficiency of the city's public transport system.

6.1 E-bus and charger specification

Sitilink currently operates e-buses equipped with various battery sizes, prompting the need for research to determine the optimal battery size for future operations. Battery size plays a significantly role in influencing both the range and cost economics of the e-buses. While larger batteries offer a reasonably good range, but it also results in a higher upfront cost due to the increased battery expenses. On the other hand, buses with smaller battery-sized may adequately cover the required average daily distance, however the percentage of non-revenue kilometres must be evaluated. Additionally, larger battery sizes lead to a higher Gross Vehicle Weight (GVW), which can result in increased energy consumption.

The number and capacity of chargers requires at the depot depends on the fleet size and the battery capacity of the e-buses. Table 61 compares the specifications of existing e-buses, their battery capacities, charger specifications, and power requirements. The table showcase in Surat bus battery size varies across the different operators, with the similar fleet size (i.e. 150 e-buses of each operator). Typically, each depot manages around 75 buses, with an observed charger-to-bus ratio of 5-6 DC chargers per bus and 2-3 AC chargers per bus. The choice between AC and DC chargers, along with usage of single or dual charging guns, affects the total charging time and overall operations of the bus.

Charger connector type is critical for an interoperable charging system. In Surat, early e-bus procurements under FAME II did not specify connector types due to the sector's developing stage, therefore, Olectra and Greencell chargers have GB/T connector type. With technology advancement and need for standardisation, later CESL contracts mandated specific connector types. As a result, JBM deployed chargers with CCS2 connectors, as per contract requirements. However, variation in connector types among operators remains a challenge for interoperability charging mechanism in Surat (refer to Table 68).

The E-bus depots with High Tension (HT) power connection of either 11 kVA or 22 kVA for e-bus charging, both during the day and nighttime has been procured, based on the requirement. According to the contract (i.e., GCC model), the power connection is provided by the authority, while the operator is responsible for purchasing the charger and developing the charging and civil infrastructure within the depot. Additionally, the operator oversees bus operations and depot management.

Category	Component	OEM – Olectra Operator – EVEY TRANS Year of Operation Starts: 2020 (FAME II)		OEM – PMI Operator – Greencell Year of Operation Starts: 2023 (FAME II)		OEM & Operator – JBM Year of Operation Starts: 2024 (NEBP)	
Depot	**Name**	**Palanpur**	**Althan**	**Magob**	**Vasu**	**Bhestan**	**Pal***
Rate	Rs. per-km (GCC)	55.26		48.87		59.29	
Bus	No of buses	75	75	85	65	75*	50
	Types of bus (min /midi /standard	Midi	AC	Midi	AC	Standard	AC
	Bus weight	13.5 T		14 T		19 T	20 T
	Actual vehicle utilisation (km/ bus/ day)	226 km		188 km		215 km	
	Range in single charge (actual)	133 km		105 km		163 km	
Battery	Battery capacity	195 kWh		151.55 kWh		261kWh	302 kWh
	80% SOC	156 kWh		121 kWh		209kWh	242kWh
	Battery Type	Lithium-ion NMC		Lithium-ion NMC		Lithium-ion NMC	
Charging	No of chargers	36 (31AC + 5DC)	32 (26AC + 6DC)	12DC	12DC	15DC	12DC
	Charger Capacity	80 kWh (AC) | 180 kWh (DC)		180 kWh (DC)		240 kWh (DC)	
	Type of charger	DC - CCS2, AC - GB/T		GB/T		CCS2	
	Charging time required for full charge (AC/ DC)	2.5 hr. with AC charger dual guns; 1.5 hr. with DC charger single guns charge one bus at a time		60-70 min with dual guns, 90 min with single gun		50 min with dual guns	
Power Demand	Discom power connection line capacity)	11KVA		22KVA		11KVA	
	No of transformers	3		3		3	
	Transformer capacity	1250 KVA each		1200 KVA each		1600 KVA each	

Table 6.1: Existing e-bus and charger specifications by depot

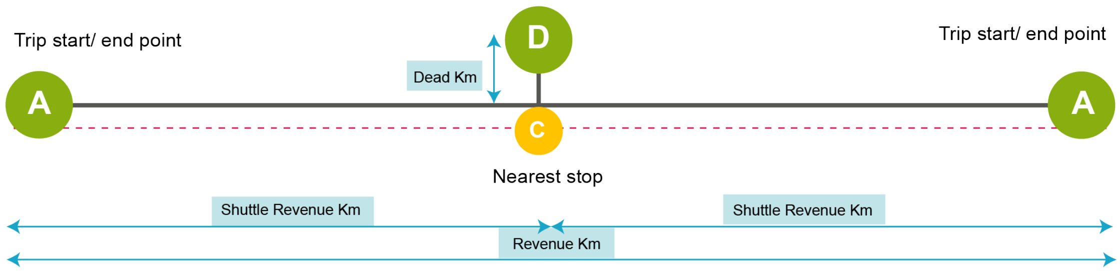
Source: Data compiled from each depot, Sitilink, SMC, December 2024

*Total 25 buses are not in operation currently; as separate land is provided for parking and charging facility at Althan depot; which is under construction.

6.2 Dead kilometre assessment

In bus route planning, minimising the dead kilometres is crucial for efficient bus operations, as it directly impacts the operating costs. This challenge is heightened for e-buses, which needs to return to the depot for opportunity charging throughout the day to meet their required kilometres.

The conceptual planning of routes in Surat is illustrated in the figure below.



Revenue km – Actual route kilometre from start to end points of the route.

Non-revenue km (Dead-km) – Distance from the depot to the nearest stop from where revenue km starts.

Shuttle revenue km – A short trip or a curtail trip from intermediate stop (on the route) to the start/ end terminal. Such short trips happen for the first and last trip of the day as well as when the bus comes for an opportunity charging at the depot during the day. In BRT system, there is an advantage to use this trip as revenue

Figure 6.1: Conceptual diagram of trips variation -Surat

Figure 6.1, depicts the various trip categories in the route planning. Currently, all e-buses operate within the BRT corridor. When these buses return to the depot for an opportunity charge, their trips are curtailed at the nearest stop (i.e., shuttle revenue kilometres), requiring passengers to transfer at the intermediate stop. In the case of BRT services, this transfer is relatively convenient, due to the closed station system; however, for city bus services, this may cause inconvenience for passengers and raise safety concerns.

Depot, Operator and Battery size	On-road Buses	Total Vehicle km	Revenue km (full trips)	Revenue km (Shuttle trips)	Dead km (non-revenue km)	Annual amount for dead km
Magob - Greencell - 151kW	71	13,571	9486 (70%)	3248 (24%)	837 (6%)	Rs 1.49 Cr (€ 0.15M)
Vesu - Greencell - 151kW	21	4,193	3063 (73%)	1030 (25%)	100 (2%)	Rs 0.18 Cr (€ 0.01M)
Althan - Olectra - 195kW	72	13,968	10452 (75%)	2598 (19%)	918 (7%)	Rs 1.85 Cr (€ 0.19M)
Palanpur - Olectra - 195kW	72	15,421	13676 (89%)	726 (5%)	1019 (7%)	Rs 2.06 Cr (€ 0.21M)
Bhestan - 260kW	71	14,354	11325 (77%)	2764 (19%)	682 (5%)	Rs 1.90 Cr (€ 0.19M)

Table 6.2 Daily dead kilometre and shuttle kilometre by depot

Source: Computation from bus schedule and e-bus registry data, May 2024

Table 6.2 shows that, across different depot and battery sizes, the proportion of dead kilometres is about 6-7% of total revenue kilometres. However, the share of shuttle revenue kilometres is highest in Greencell buses with 151.55 kWh battery size at Magob and Vesu depots, accounting for about 24-25%. In comparison, Olectra buses with a 195 kWh battery in Althan and JBM buses with a 261 kWh battery in Bhestan have approximately 19% shuttle kilometres. Notably, at the Palanpur depot, the shuttle kilometres account for only 5%, due to the strategic location of the depot, which enables some routes to start from or near it, minimising unnecessary trips. This indicates that the location of the depot plays a critical role in minimising both dead and shuttle kilometres, which in turn increases actual revenue kilometres and significantly impacts service quality.

Furthermore, a substantial amount spent on dead kilometres has the potential to be converted into revenue kilometres, thereby enhancing operational efficiency. Typically, the share of dead kilometres ranges from 4-6% of the overall vehicle kilometres run. Therefore, proper spatial placement of depot infrastructure is essential for e-bus operational planning, as it helps reduce shuttle trips/ curtail trips.

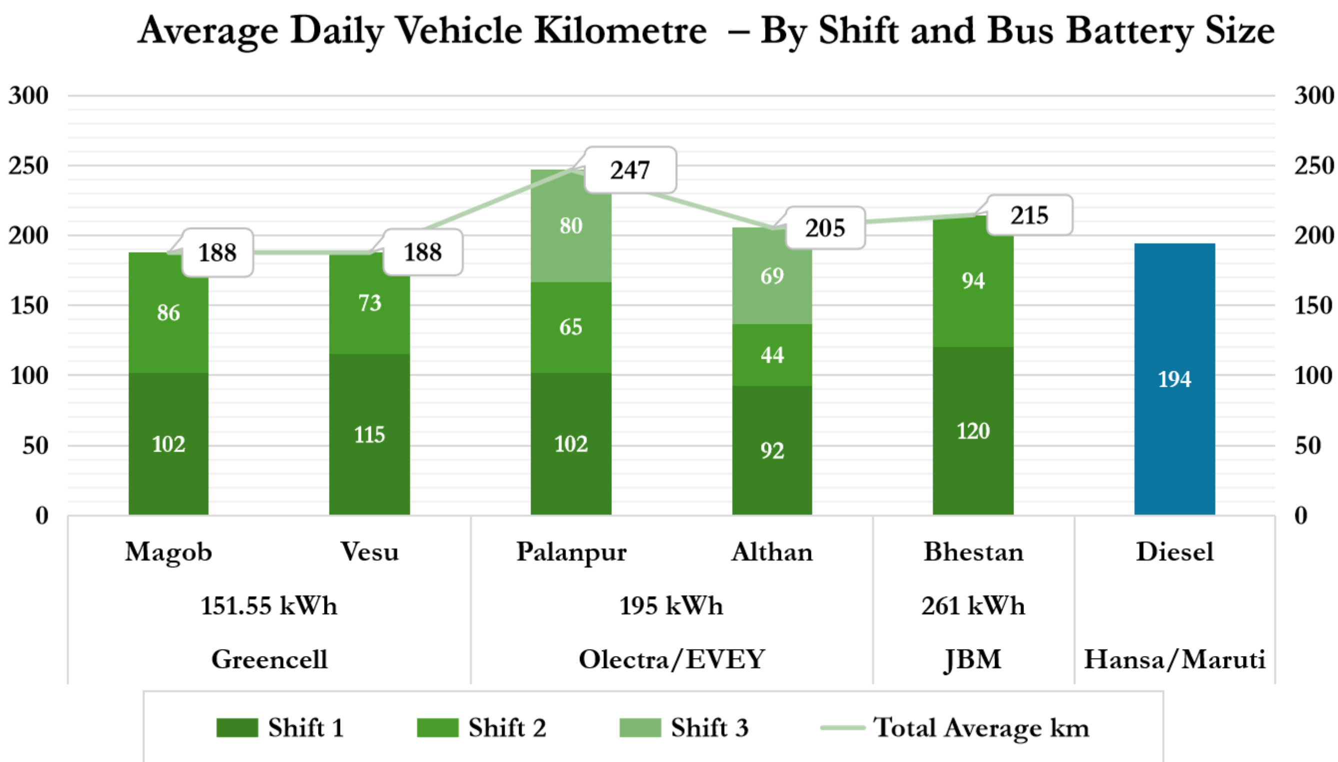
6.3 Vehicle utilisation and battery size

Currently, each operator has designated two depots within the city, which appears to be an effective strategy planning for e-bus operations. Sitilink Ltd. prepares an operational e-bus schedule considering the depot location, battery size, range in a single charge and desired average vehicle kilometres. This strategy enables operators to charge their buses at one depot while using the other during opportunity charging, wherever possible, which helps to minimise dead kilometres. The average route length is about 20 km with a maximum up to 32 km. An in-depth assessment was conducted to understand the efficiency of vehicle utilisation across different shifts[Shift: Bus on road before Opportunity charging 1 is Shift 1. Bus on road after Opportunity charging 1 is Shift 2, and bus on road after Opportunity charging 2 is Shift 3.] and battery sizes, highlighting potential areas for improvement.

Table 6.4 depicts that Greencell buses with 151.55 kWh battery, achieve an average of 188 km daily. The vehicle utilisation is slightly less compared to the assured kilometres mentioned in the contract i.e. 192 km per day. Therefore, these buses are operated on shorter routes. Whereas JBM buses, with the highest battery size of 261 kWh, operates with an average of 215 km per day. Both Greencell and JBM buses operate with a single opportunity charge. Meanwhile, Olectra buses with 195 kWh battery size, operate for an average of 247 km and 205 km respectively from Palanpur and Althan depot with two-time opportunity charging (refer to Table 6.3).

Figure 6.2 represents that during Shift-1, the buses run kilometres is between 102-120 km, whereas in Shift-2 the vehicle operates less kilometres than in Shift-1. In the case of the Althan and Palanpur depots, the schedule has been adjusted such that the vehicle run between 44-55 km in Shift 2 and 65-85 km in Shift 3-both below 100 km. This is because the route length from these depots is about 25 -30 km long and buses have larger battery size (195 kWh) than the Greencell buses (151.55 kWh). Despite JBM buses having a larger battery size of 261 kWh (12 m standard) design limits their operation to the BRT corridor due to road width constraints.

Similarly, Figure 6.2 also presents the maximum vehicle utilisation across the battery sizes operated. This shows that for buses with 195 kWh battery, it is possible to achieve 287 km per day with multiple opportunity charging. This suggests that battery capacity significantly has an impact on its range and overall performance, with higher-capacity batteries enabling greater operational flexibility and efficiency. As compared with diesel buses, the average daily vehicle utilisation is about 194 km and maximum up to 264 km, e-buses demonstrates comparable mileage. This suggests that, with proper infrastructure planning, e-buses can match diesel buses in range.



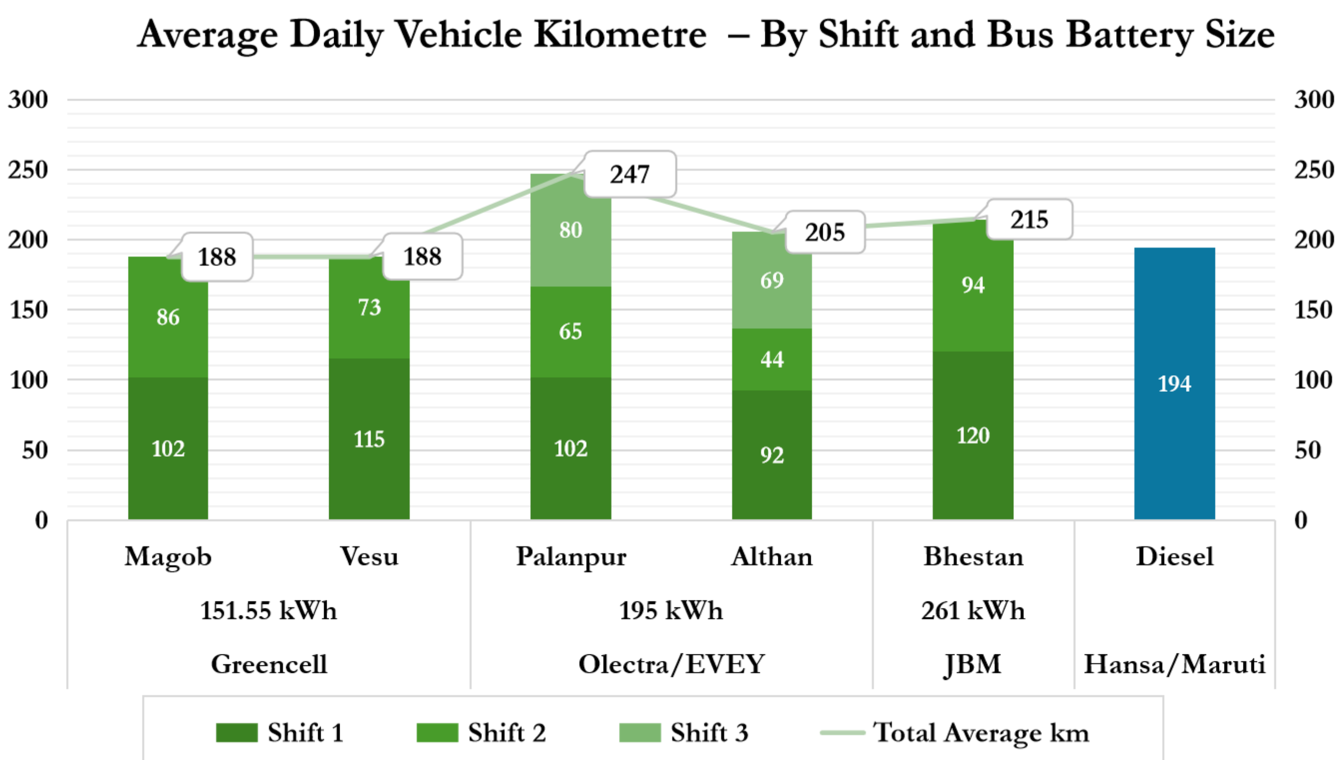


Figure 6.2: Average and maximum vehicle utilisation by battery size and by shift

Source: Computed from E-Bus Registry data - Daily Operator Report (April- May 2024), Sitilink, SMC

Table 6.3 represents the proportion of buses arriving at depot one or two times in day for opportunity charge. The result depicts, that two times opportunity charging provides a higher vehicle kilometre range, as observed in the case of Palanpur and Althan depots. These findings emphasise that efficient bus route scheduling with opportunity charging can significantly enhance daily vehicle kilometres per bus, improving overall cost efficiency.

	DEPOT				
	Palanpur	Althan	Magob	Vesu	Bhestan
Total number of buses	75	75	75	60	75
One time opportunity charging	70%	62%	100%	100%	100%
Two times opportunity charging	30%	38%			

Table 6.3 Percentage of buses opts for number of opportunities charging

Source: Computed from E-bus registry data - Daily operator report (April- May 2024), Sitilink, SMC

A route-level and bus-level performance assessment is provided in Annexure II

6.4 Energy consumption

In e-buses, electricity consumption is a crucial indicator for evaluating the performance and efficiency of the bus system. Energy consumption refers to the amount of power used by the vehicle to travel one kilometre, which also includes additional electricity consumption from air conditioning, lights, load, etc.

Figure 6.3 illustrates the vehicle kilometres travelled and energy consumption by depot, highlighting the variation of energy consumption with different battery sizes. It is observed that the energy consumption increases with the increase in battery capacities. For example, the e-buses operated from Bhestan depot with a battery capacity of 261 kWh (JBM), displays the highest energy consumption rate of 1.28 kWh/km. In contrast, the e-buses with comparatively smaller battery capacity, like e-buses operated from Magob and Vesu depot, with 151.55 kWh (Greencell), have lower energy consumption rates of 0.96 kWh/km and 0.93 kWh/km, respectively. This suggests that while larger batteries provide greater range, they may also lead to higher energy usage per kilometre.

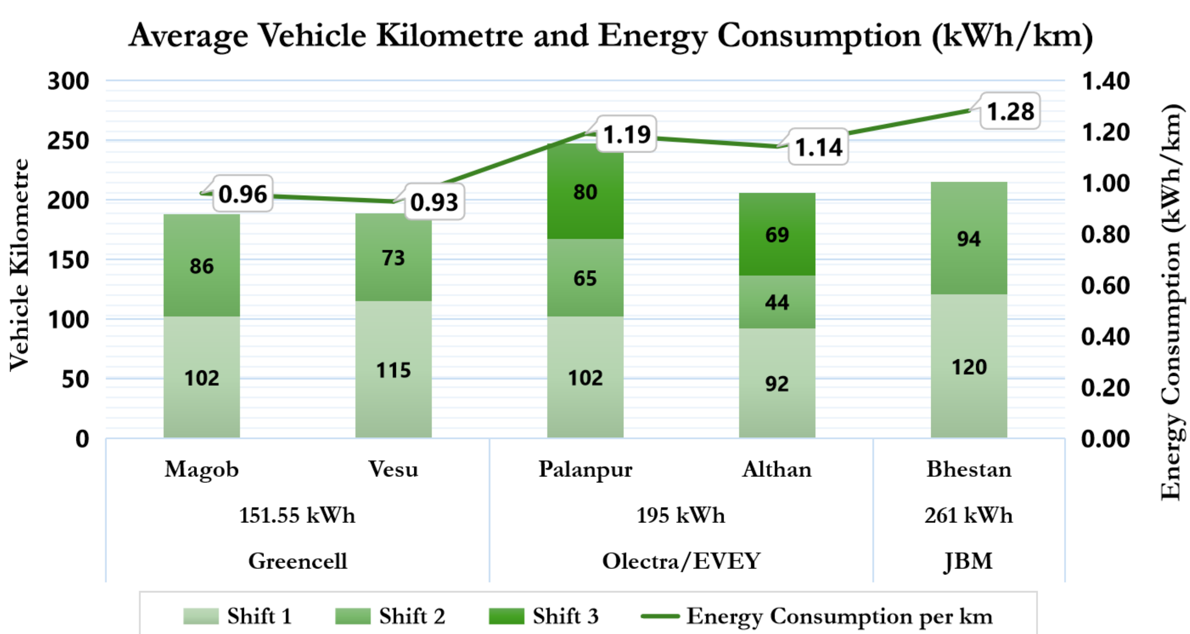


Figure 6.3 : Average vehicle kilometre and energy consumption (kWh/km)

Source: Computed form e-bus registry data - Daily operator report (April- May 2024), Sitilink, SMC

The efficiency of the e-buses varies across different locations. For instance, the e-buses operating from Palanpur depot, equipped with a 195 kWh battery (Olectra/EVEY), has a relatively moderate energy consumption rate of 1.19 kWh/km but achieves a total average distance range of 247 km, indicating a balance between energy usage and operational efficiency. Meanwhile, the e-buses operating from the Althan depot, with a 195 kWh battery (Olectra/EVEY), has a slightly lower energy consumption rate of 1.14 kWh/km but only achieves a total distance range of 205 km. This highlights the potential operational inefficiencies that needs to be addressed.

The table below summarises the differences in the actual kilometres operated by buses compared to their expected kilometres on a full charge across various battery sizes. It indicates that, with the smaller battery sizes, route structures are planned based on the fixed depot locations. Consequently, the percentage of shuttle revenue is higher at depots like Magob and Vesu (i.e. 24%) when compared to other depot locations.

Depot	Battery Size (kWh) Bus Size	Average Vehicle Utilisation (km/day)	Ideal Range with single charge (80% SoC)	Avg. 1st shift km (Actual)	% Non-revenue km	% Shuttle km	Energy Consumption (kWh/km)
Magob	151.55 (9m bus)	188	126	102 (81%)	6%	24%	0.96
Vesu	151.55 (9m bus)	188	130	115 (88%)	2%	25%	0.93
Palanpur	151.55 (9m bus)	247	131	102 (78%)	7%	5%	1.19
Althan	195 (9m bus)	205	137	114 (83%)	7%	19%	1.14
Bhestan	261 (12m bus)	215	163	120 (74%)	5%	19%	1.28

Table 6.4: Summary of ideal vs actual vehicle utilisation and energy consumption

Source: Computed from e-bus registry data - Daily operator report (April- May 2024), Sitilink, SMC

Deploying higher-capacity buses on longer or high-demand routes, like from Bhestan and Palanpur depots, leads to enhanced bus range and efficiency. However, it is essential to monitor the energy consumption closely to manage operating costs effectively. The lower energy consumption per kilometre of buses with smaller batteries, like at Magob and Vesu depots, suggests potential cost savings and environmental benefits, making them suitable for shorter routes with predictable demand.

6.5 Charging pattern and time to charge

In e-bus operations, charging infrastructure and scheduling are essential components for optimising energy usage, time management, and resource efficiency. The charging time required depends on the specifications of the charger and the battery size of the bus. Accurately assessing these factors is crucial for determining the required number of chargers and power demand. Additionally, it is important to continuously monitor the charging patterns and time duration required to charge the buses to enhance the operational efficiency.

To gain a better understanding of these factors, e-bus registry data from each depot was analysed. Daily charging reports were recorded, including details such as bus charging time, the SoC at which the buses arrive at and depart from the depot, the number of buses charged, the energy consumed, and more. Magob, Palanpur, and Bhestan depots were assessed due to the variation in e-bus battery sizes and each depot managing a total of 75 e-buses. The charger type and battery capacity also differ across the depots based on the operator. For instance, Magob depot is equipped with 180 kW DC chargers, Palanpur depot has both 80 kW AC and 180 kW DC chargers, and Bhestan depot is outfitted with 240 kW DC chargers (refer to Table 6.1).

Figure 6.4 illustrates the variation in charging patterns over a 24-hour period for three depots, highlighting peak usage times for chargers and the number of buses charged during those periods. In Magob depot, the charger capacity is larger than the battery size of e-buses, enabling a full charge in approximately 60 minutes with a single gun (overnight) and 45 minutes with a dual gun (daytime opportunity charging). This practice should be adopted to sustain battery life over the long term. All the 75 e-buses get fully charged by 4:00 AM using 12 DC chargers, when charged at 8:00 PM, a day before.

In contrast, in Palanpur depot, the presence of 31 AC chargers and only 5 DC chargers result in a longer charging time for all e-buses—approximately 2 hour and 50 minutes with an AC charger (dual gun charges one bus at a time) and 1 hour and 50 minutes with DC chargers (only one bus charge with a single gun at time), completing the process by 6:00 AM. The chargers are typically occupied throughout the day, from 12:00 PM until the next morning at 5:30 AM, primarily due to the 80 kW AC chargers. For Bhestan depot, with a larger battery capacity, charging a full e-bus with a battery of 261 kWh using the dual gun takes 50 minutes. The graph below showcases the opportunity charging period from 11:00 AM to 6:00 PM, while night charging occurs from 11:00 PM to 5:30 AM. Although the e-buses are charged with dual guns, this practice is not advisable for optimal battery life.

In general, buses should be charged with dual guns (fast charging) during opportunity charging and a single gun (slow charging) for overnight charging to extend the battery life. Understanding charging patterns is crucial for optimising energy use and chargers deployment, leading to more effective bus operational schedules and better resource management.

Table 6.5 represents the proportion of buses arriving at depots at various SoC levels. It is observed that, predominantly, buses arrive for opportunity charging within 20-40% SoC range, particularly in the cases of Magob (71%) and Palanpur (64-68%) depots. However, about 15% of buses at Palanpur depot arrive at less than 20% SoC during the first and second opportunities for charging. This indicates that most buses are fully utilised, as the routes start closer to the depot. In Magob depot, due to the smaller battery size, complete trips are not possible, necessitating that buses return to the depot with a SoC of 30-40%. Meanwhile, at Bhestan depot, 24% of buses arrive within the 20-30% SoC range, 35% within the 40-50% SoC range, and 21% within the 50-60% SoC range. This highlights the underutilisation of batteries, where 19% of the kilometres driven constituting shuttle revenue kilometres.

Bus arrives at % SoC	Magob BS – 151.55 kWh CC – 180 kW DC (12 Chargers)		Palanpur BS – 195 kWh CC – 80 kW AC |180 kW DC (32 AC | 5 DC)			Bhestan BS – 261 kWh CC –240 kW DC (14 Chargers)	
	Opp 1	Night	Opp 1	Opp 2	Night	Opp 1	Night
<20	1%	1%	15%	14%	41%	-	-
20-30	39%	23%	37%	51%	44%	10%	23%
30-40	32%	36%	27%	17%	8%	24%	38%
40-50	16%	32%	8%	0%	5%	35%	28%
50-60	7%	5%	13%	11%	1%	21%	11%
>60	4%	3%	1%	6%	0%	10%	-
Total	100%	100%	100%	100%	100%	100%	100%
No of Buses	74	73	79	35	73	71	71
Legend		>40%		>30%		>20%	

Table 6.5: Proportion of buses arrives at depot with SOC level

SoC- Status of Charge; BC – Battery Capacity; CC- Charger Capacity

Source: Computed from e-bus registry data - Daily charging report (April- May 2024), Sitilink, SMC

Therefore, the study suggests that the appropriate battery size for midi-buses should be in the range of 190-220 kWh, coupled with effective planning of charging and depot infrastructure. Whereas in case of longer routes, larger battery sizes can be preferred.

Additionally, the graph below showcases the utilisation of chargers in relation to the number of bus days charged within a 24-hour period.

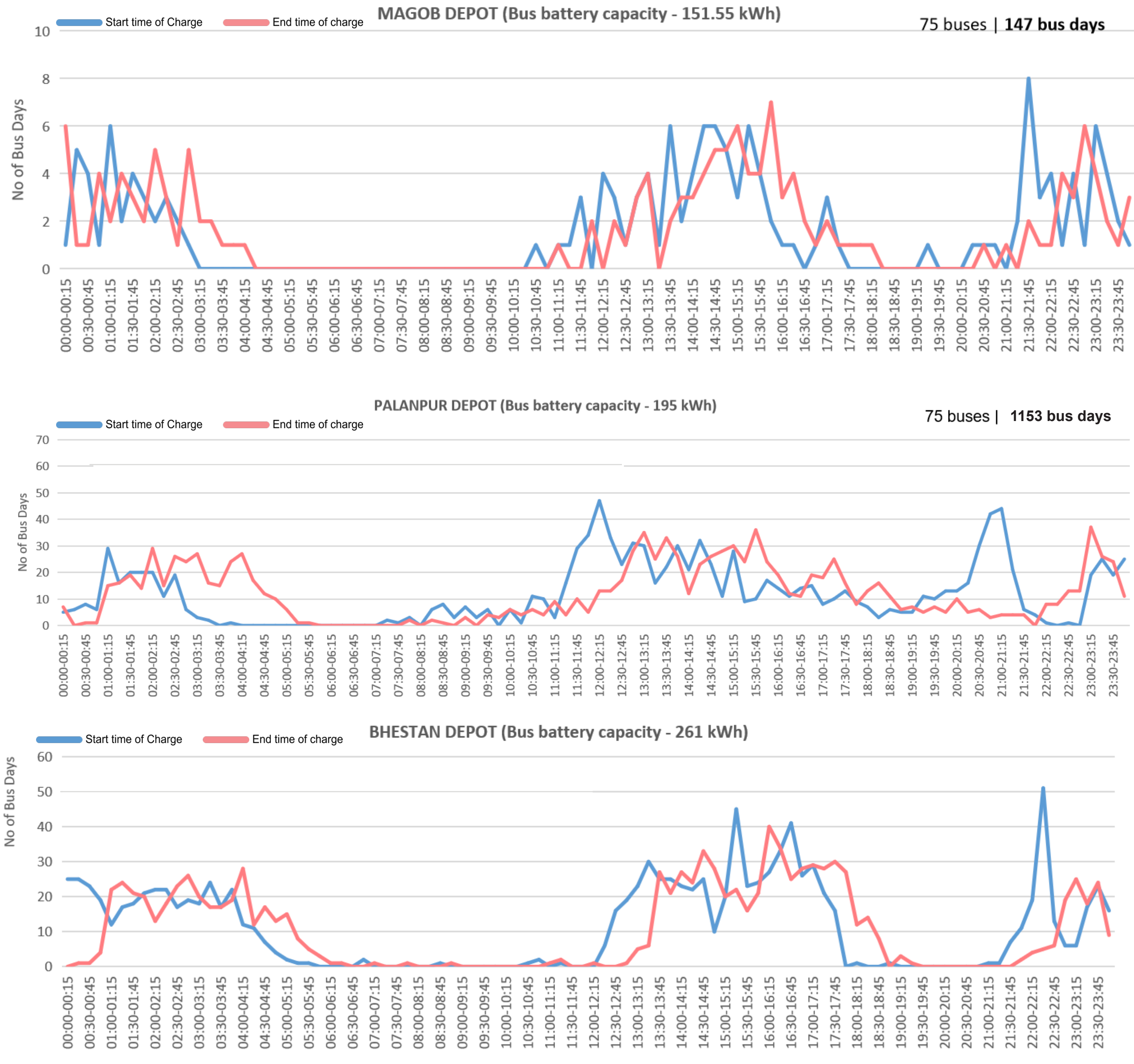


Figure 6.4: Temporal distribution of charging pattern by depot

Source: Computation from e- bus registry, daily charging report, April (Palanpur), July (Magob) and May (Bhestan) 2024, Sitilink,

6.6 Replacement Ratio (RR)-E-bus vs ICE bus

There is a significant difference between the operational planning of e-buses and ICE-buses due to the necessity of opportunity charging. Generally, it is believed that more e-buses are needed to cover the same distance as ICE buses; however, this depends on the battery size of the e-buses.

This section provides a rationale for the requisite number of e-buses compared to ICE buses, considering different battery sizes across various route and depot. The assessment was conducted for selected routes operated by different battery sizes. The existing e-bus schedule was further broken down into runtime, halt time, and charging time. Similarly, for the same routes, an ICE bus schedule was prepared maintaining the total revenue kilometres and ensuring the same frequency during peak and off-peak times, while also providing sufficient halt time for drivers.

Table 6.6 delivers a comprehensive comparison between ICE buses and e-buses.

Bus type and Route No.	E-Bus Existing Schedule			ICE Bus Schedule (prepared)*			Replacement Ratio (e-bus vs ICE)
	Total trips (Full | shuttle)	Vehicle KM (Full |shuttle)	Fleet	Total trips (Full)	Vehicle KM	Feet	
Greencell - 151kWh (Route no. 13, 16, 19)	748 (456 | 292)	13,914 (10,423| 3,491)	71	584	13,972	59	**1.20**
Olectra – 195 kWh (Route no. 13P, 14, 17, 21)	676 (597| 79)	15058 (14,434 | 624)	71	642	15,748	66	**1.09**
JBM – 261 kWh (Route no. 11, 12 & 15)	676 (597| 79)	13742 (11,333 | 2,409)	71	774	15,748	67	**1.06**

Table 6.6: Replacement Ratio (RR) assessment by bus battery size

Source : *CoE-UT CRDF calculation

Note: ICE bus schedule prepared with a similar bus supply (VKT) as the e-bus schedule (maintaining the same frequency in different peak periods)

It has been observed that as the battery size decreases, the replacement ratio of e-buses to ICE buses increases, and vice versa. For example, JBM requires an additional 6% e-buses when using a 261 kWh battery size, 9% more for Palanpur with a 195 kWh battery, and a 20% more for Greencell, which has a 151.55 kWh battery size, compared to ICE buses.

Additionally, the average runtime on routes varies based on battery sizes (refer to Table 6 7). ICE buses require fewer units to maintain the same frequency, and their average runtime for revenue kilometres significantly higher as compared to the current e-bus schedule. Since e-buses are considered a sustainable option for the future, a detailed route-level analysis was conducted to understand the time breakdown for various battery sizes.

Battery size	Route no.	E-Bus vs. ICE Buses	No. of Buses Required	Avg. on Route Time	Avg. Halt Time %	Avg. Charging Time	Avg. Run Time on Route for Revenue km
Greencell - 151 kWh	Route no. 19: Railway station to Kadodara	Existing e-Bus schedule	15	14.65 hr	30%	12%	58% (8.5 hr)
		Comparative ICE bus schedule	12	15.13 hr	27%	-	74% (11.2 hr)
Olectra – 195 kWh	Route no. 14: ONGC colony to Kosad EWS H2	Existing e-Bus schedule	18	13.5 hr	15%	14%	71% (9.5 hr)
		Comparative ICE bus schedule	16	15.2 hr	18%	-	82% (12.5 hr)
JBM – 261 kWh	Route no. 15: Althan Depot- Althan Depot	Existing e-Bus schedule	21	14.7 hr	17%	11%	72% (10.75 hrs)
		Comparative ICE bus schedule	20	15.1 hrs	26%	-	73% (11.05 hr)

Table 6.7: Total run time break-up: Existing e-buses vs. ICE buses

Source: Computation from schedule, May 2024 and ICE buses schedule prepared by CoE-UT, CRDF for analysis

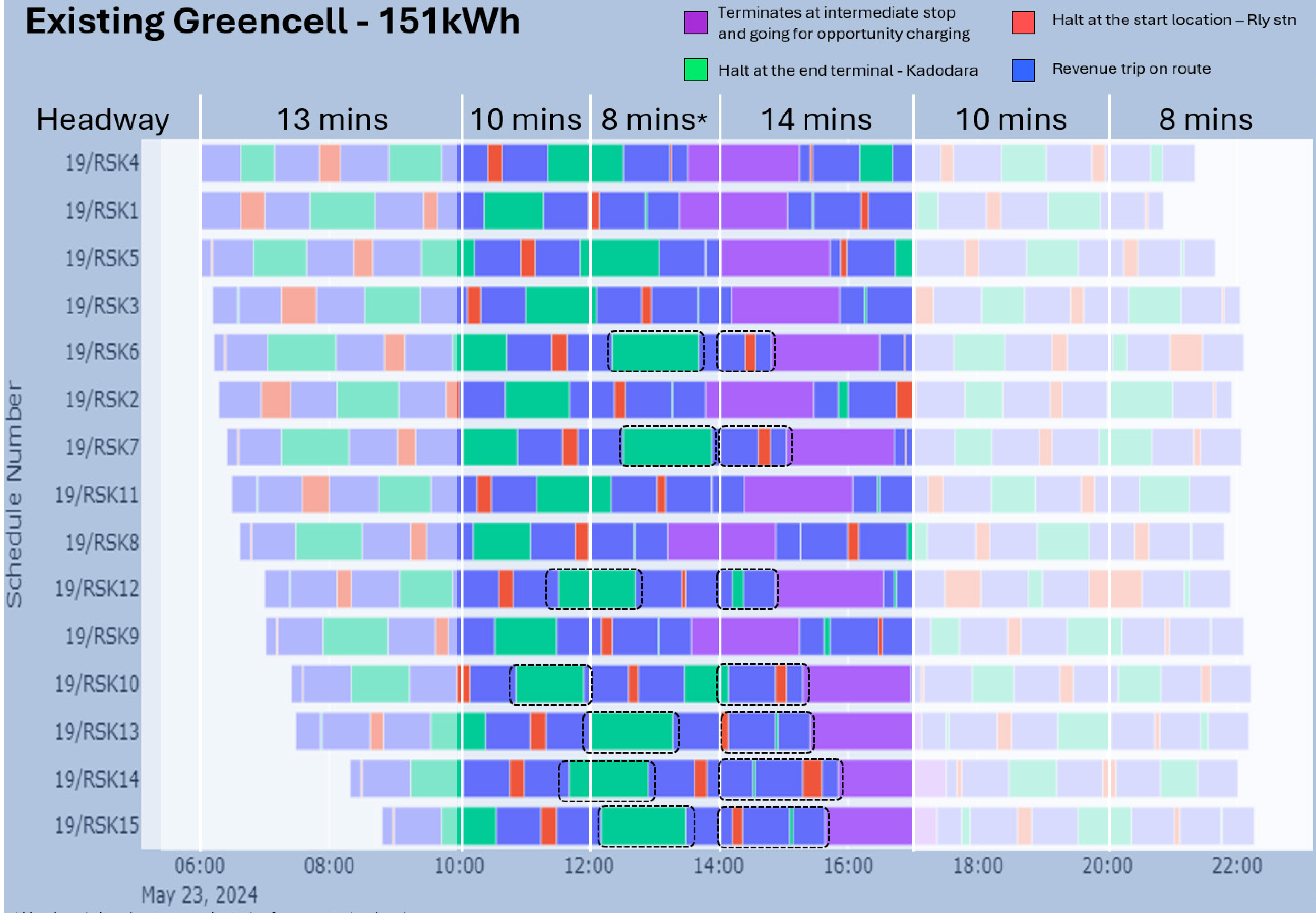
The figures below provide a graphical representation of the schedules formulated for current e-buses and ICE buses on three routes, each utilising different battery sizes. This graph illustrates that on Route 19 (Railway Station to Kadodara), where the bus with the lowest battery size, i.e., Greencell 151.55 kWh is used, a few buses depart early from the depot and planned to halt at the terminal during peak times to operate during off-peak periods. For instance, the halt time observed at Kadodara was approximately 1.5 hours, while other buses proceeded for charging in the subsequent hour. As a result, during non-peak hours, the bus frequency while returning to the depot for opportunity charge is approximately 8 minutes (around 12:00 pm -2:00 pm). This indicates an underutilisation of revenue kilometres, which can result in cost overruns due to the insufficient flexibility in efficiently utilising resources (drivers and conductors).

In planning e-bus operations, it is imperative to effectively coordinate duty cycles for drivers and conductors, as these costs comprise approximately 30%-35% of the total cost of ownership.

The figure below exhibits a Gantt chart that illustrates an example of the Greencell bus with the lowest battery size. A similar analysis has been conducted for other battery sizes, which are shown in Annexure III and Annexure IV.

Route 19: RAILWAY STATION to KADODARA

Existing Greencell - 151kWh



Bus	Halt time	Run time	Total time	Halt time %
RSK4	06:34	08:47	15:21	42.78%
RSK1	05:52	09:00	14:52	39.46%
RSK5	06:43	08:56	15:39	42.92%
RSK3	06:31	09:20	15:51	41.11%
RSK6	07:21	08:32	15:53	46.27%
RSK2	06:41	08:56	15:37	42.80%
RSK7	07:19	08:20	15:39	46.75%
RSK11	06:18	09:06	15:24	40.91%
RSK8	05:46	09:25	15:11	37.98%
RSK12	06:03	08:51	14:54	40.60%
RSK9	05:42	09:23	15:05	37.79%
RSK10	06:27	08:21	14:48	43.58%
RSK13	05:41	09:01	14:42	38.66%
RSK14	06:01	07:41	13:42	43.92%
RSK15	05:34	07:53	13:27	41.39%
Avg.	**06:18**	**08:46**	**15:04**	**41.80%**

** Headway is low due to more short trips for opportunity charging.*

Route 19: RAILWAY STATION to KADODARA

ICE Buses

Bus	Halt time	Run time	Total time	Halt time %
B1	04:14	11:15	15:29	27.34%
B7	04:14	11:15	15:29	27.34%
B2	04:09	11:15	15:24	26.95%
B8	04:09	11:15	15:24	26.95%
B3	04:04	11:15	15:19	26.55%
B9	04:04	11:15	15:19	26.55%
B4	03:59	11:15	15:14	26.15%
B10	03:59	11:15	15:14	26.15%
B5	03:54	11:15	15:09	25.74%
B11	03:54	11:15	15:09	25.74%
B6	03:49	11:15	15:04	25.33%
B12	03:49	11:15	15:04	25.33%
Avg.	**04:01**	**11:15**	**15:16**	**26.34%**

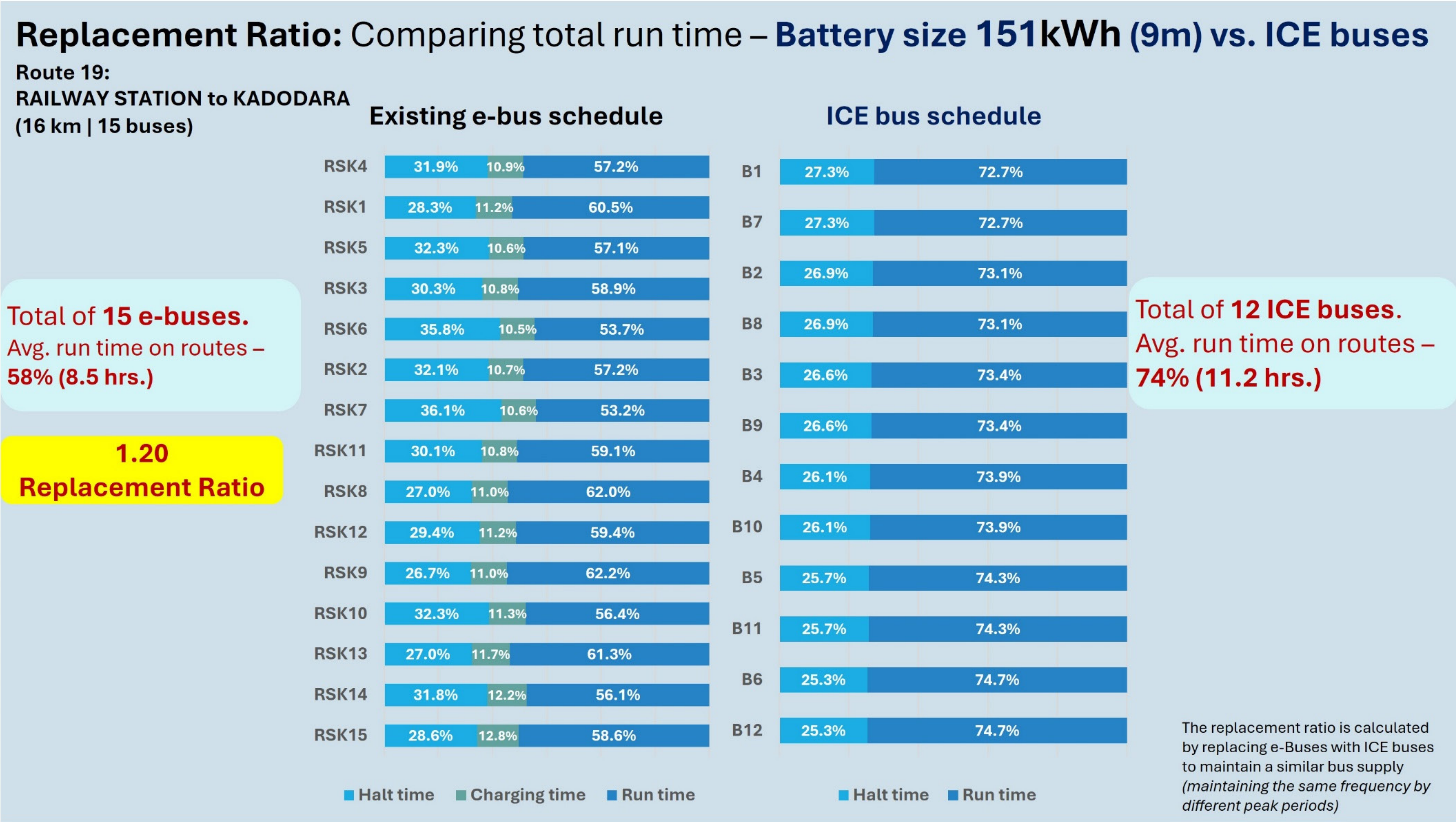


Figure 6.5: Schedule of e-buses vs. ICE buses – (Illustration – Greencell Route 19)

6.7 Understanding of contract conditions

Surat was one of the first cities to adopt e-bus operations in 2021. Currently, it operates the largest fleet in the state, managed by three different operators, each utilising various battery sizes and charging specifications, as discussed in previous sections. The buses are managed under a Gross Cost Contract (GCC). Two of these operators, Olectra/Evey Trans (SMC) Pvt. Ltd. and Green Cell Mobility, were procured under the FAME II scheme, with the tender prepared by the city authority. The third operator, JBM Ecolife Mobility Surat Pvt. Ltd., was procured under the NEBP, with tender prepared by CESL, incorporating modified conditions based on insights gained from previous e-bus deployment challenges.

Table 6.8 provides a comparison of contract conditions related to fleet and vehicle utilisation, bus operations (including opportunity charging and energy consumption), and charger specifications. Significant differences have been observed amongst the three operators. Notably, for Olectra and Greencell, the operators must cover the costs of dead kilometres within a 10 km radius; this condition does not apply to JBM. It encourages operators to install chargers at opportunity charging locations outside designated depots. Currently, the contract lacks clear conditions regarding opportunity charging locations beyond the allocated depots, which should be a focus for future initiatives promoting inter-depot opportunity charging. Addressing this will help minimising the dead kilometres and enhancing the operational efficiency.

The types of chargers used are not standardised, which hinders interoperability amongst them. Furthermore, there are no provisions regarding the sharing of depot infrastructure Behind The Meter (BTM) or the power sharing during the opportunity charging, both of which could provide better scheduling and operational flexibility.

In conclusion, standardisation especially regarding the charging mechanisms would facilitate smoother and more flexible operations while enhancing vehicle utilisation by minimising the dead kilometres and improving cost economics over the long term.

Particular	**Olectra/ Evey150 buses** (9m bus – 195 kWh battery size)	**PMI/ Greencell 150 buses** (9m bus – 151.55 kWh battery size	**JBM – 150 Buses** (100 buses - 12m bus with 261 kWh battery size 50 buses – 12 m bus with 302 kWh battery size)
GENERAL CONTRACTUAL AND OPERATIONAL DETAILS			
Contract period	Year 2021 – 2031 (can be extended up to 16 years)	Year 2023 – 2033 (can be extended up to 12 years)	Year 2024 – 2036 (up to 10 lakhs km)
Scheme from GoI	FAME II – Tender was prepared by city.	FAME II – Tender was prepared by city.	NEBP – Model tender was prepared by CESL
Fleet availability %	=> 94%	=> 94%	=> 95%
Average vehicle utilisation	Avg. 70,000 km annually per bus – for total (100%) buses	Avg. 70,000 km annually per bus – for total (100%) buses	Avg. 70,000 km annually per bus – for total (100%) buses
Per km rate (2024) – excl. GST	Rs.55.26/km	Rs.48.87/km	Rs.59.29/km

E-BUS OPERATIONS			
Night charging timing (specify with single gun/ dual guns)	~12 PM to morning 5 AM.	~12 PM to morning 5 AM	Minimum 50 min
Opportunity charging timing (single gun/ dual guns)	Maximum 75 min. (Opp charging can be done at the change in driver shift)	Maximum 75 min. (Opp charging can be done at the change in driver shift)	Maximum 45 min
Number of opportunity charging per bus per day (one/ two times)	Once/ day	Once/ day	Once/ day
Veh. km (range) in single charge	~135-140 km	~125-130 km	200 km at 80% SoC
Avg. Veh. km in a day with opportunity charging	-	-	225 km
Average energy consumption per km	Not provided in the RFP	Not provided in the RFP	=<1.3 kw/km
Battery life/ replacement	OEM to replace the battery at its own cost	OEM to replace the battery at its own cost	OEMs to replace battery when State of Health (SoH) falls below 80%.
CHARGING INFRASTRUCTURE FACILITIES AND DEAD KM			
Who will bear the cost of dead-km operations and how much km?	OEM bears the cost of dead-km up to 10 km/ bus/ day for opportunity charging	OEM bears the cost of dead-km up to 10 km/ bus/ day for opportunity charging	-
Charger typology	-	-	CCS -2.0 Combine charge system
Sharing of charging infrastructure facilities for inter depot operability	-	-	-
Responsibility for developing opportunity charging facilities at any other depot for interoperability/terminal: • **Who will install chargers & support electrical infrastructure** • **Who would bear the cost** **Who would maintain this facility?**	-	-	• Land, right of way, HT connection & all applicable permits will be provided by authority. • Installation of chargers will be OEM's responsibility.
Sharing of Behind The Meter (BTM) power infrastructure	-	-	-

Table 6.8: Review of contract condition for each operator with respect to Bus Operations

Source: Review of Contract document of various operators in Sitilink bus operations, SMC

6.8 Observations and learnings

In the previous section, the performance of existing e-bus operations has been examined through various components, including the type of e-buses, battery sizes, range, energy consumption and dead kilometres. This section summarises insights gained from the city's current e-bus operations.
Surat serves as a unique example of diversity in battery sizes within its e-bus fleet. This variation raises important questions about the replacement ratio, optimal battery sizes, and the operational strategies the city should adopt in the future to improve overall operational efficiency and extend battery life.

Some of the key observations from the existing e-bus operations are enlisted below:

- Non-revenue kilometres are currently moderate, at around 6%. This situation is managed by operating shuttle trips, which constitute approximately 16% of total vehicle kilometres. However, increasing shuttle trips to minimise non-revenue kilometres may not be a feasible solution for electric bus operations in city bus services. Therefore, it is essential to explore the placement of charging infrastructure for opportunity charging at inter-depot and end-route locations.

- The depot locations have been selected based on the land availability, and existing ICE depots, which have been further transformed into an e-bus depot, resulting an increase in shuttle and dead kilometres. For e-bus operations, strategically placing of depot locations is critical to reduce the dead kilometres and enhance the operational flexibility.

- Selecting the appropriate bus type, particularly the battery size, and deploying it on suitable routes is essential. JBM buses, equipped with a 261 kWh battery, have a higher range, averaging over 220 km on a single charge at 80% SoC. However, their utilisation has been limited because the 12-meter bus size restricts their operations within BRT corridors.

- In contrast, Greencell buses, with a lower battery capacity of 151.55 kWh (9m bus), exhibit a higher percentage of shuttle and non-revenue kilometres (28-30%). These buses often cannot complete a full trip, necessitating their return to the depot for opportunity charging. It affects the operating schedule, increases travel time, and requires additional number of buses to maintain peak service frequencies.

- Olectra buses operating from the Palanpur depot, equipped with a 195 kWh battery (9 m bus) can achieve maximum vehicle kilometres of 287 km with one or two opportunity charging. This highlights that the opportunity charging at terminals can significantly enhance the operational efficiency by optimising vehicle kilometres.

- The study indicates that e-buses with lower battery capacities require additional buses compared to ICE vehicles, leading to higher investment and operational costs. Therefore, selecting the right battery size and bus type is a critical factor.

- The contractual conditions need to be strengthened and standardised across operators to improve the operational efficiency related to charging infrastructure and shared facilities.

07

Proposal for Short-Term Action Areas

The previous chapter reviewed the current challenges encountered in the operations of e-buses in Surat. This section proposes short-term strategies (2025-2028) aimed at enhancing the efficiency of existing e-bus operations and improving service quality.

The proposed strategies concentrate on three main aspects:

- Minimising the dead kilometres and maximising the revenue kilometres by identifying suitable locations for opportunity charging.
- Assessing the required number of chargers at selected locations and estimating power demand.
- Conducting feasibility assessment for the installation of charging infrastructure.

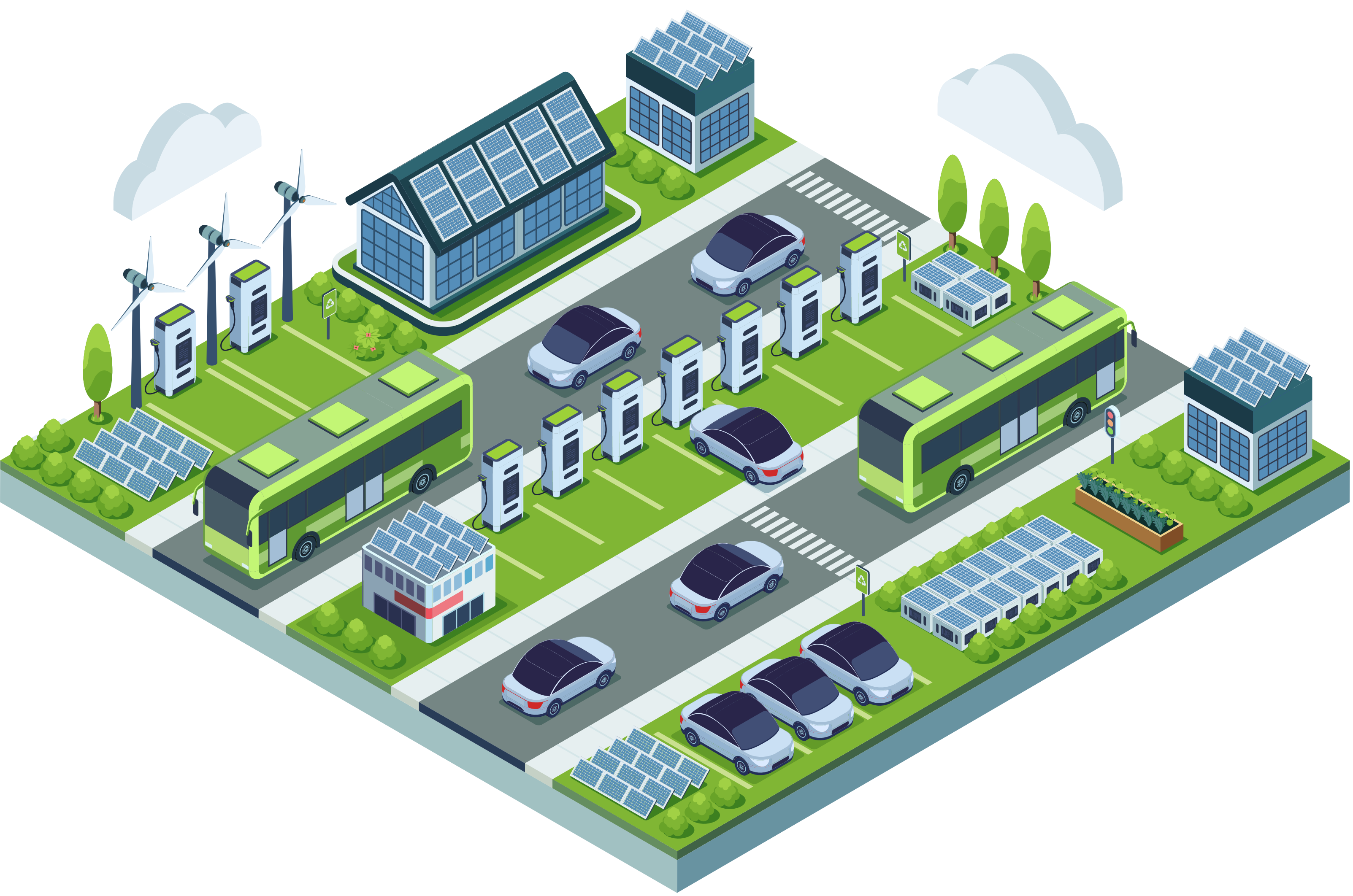
The following figure illustrates the benefits of the proposed strategies, which focuses on opportunity charging both at depot and end-route locations

Strategies	Benefits
Identification of potential depot-based opportunity charging locations	Minimise the dead kilometre and reduce the associated cost
Identifying the terminal-based opportunity charging locations (proposed for Low Tension (LT) connection)	Minimise shuttle trips to improve passenger convenience
Assessment of the number of chargers at opportunity locations and power load assessment	Increase in revenue kilometre – increases bus frequency.
Feasibility assessment for installation of charging infrastructure at the proposed site.	Increase in operational flexibility – Schedule planning

7.1 Assessment for opportunity charging locations

Currently, inter-operable charging technology has not been widely implemented, but there is potential for providing opportunity charging facilities at inter-depot or at end route locations. This approach involves strategically charging e-buses during their downtime between routes, enhancing fleet efficiency and reducing idle time.

Sitilink Ltd. has developed a bus deployment plan of 428 e-buses, as detailed in the table given below. For a more comprehensive understanding, this deployment plan has been analysed meticulously for each route (refer Table 7.1)



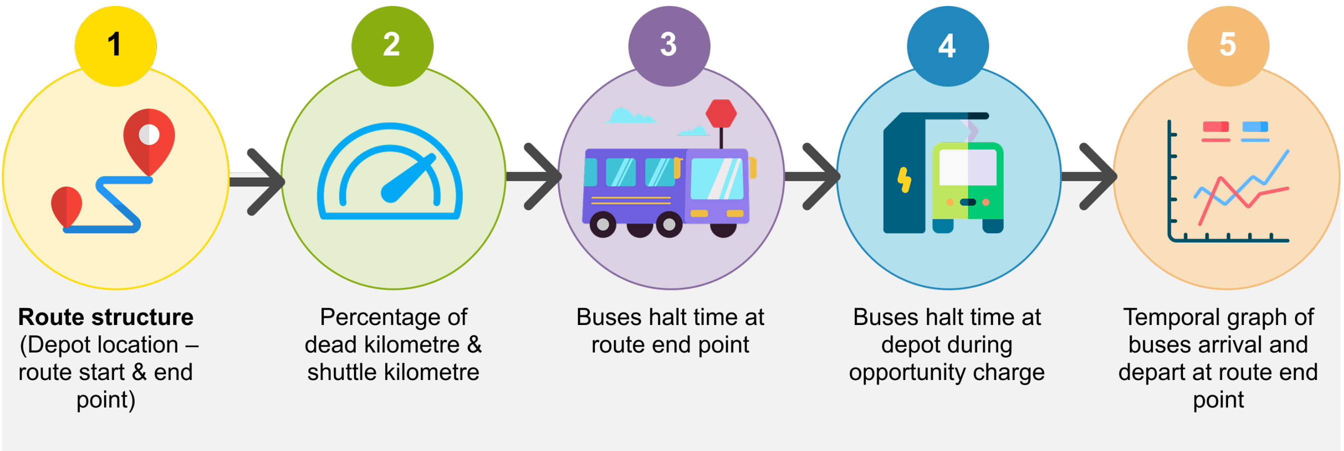
Route No	Route name	JBM Ecolife		Green Cell		Evey Trans (SMC)		Total
		Adajan	Bhestan	Magob	Vesu	Althan	Palanpur	
Bus Rapid Transit Services								
11	Udana - Sachin G.I.D.C		15					15
12	ONGC - Sarthana Nature Park		35					35
13	Jahangirpura Community Hall - Kadodara			6			24	30
14	ONGC Colony- Kosad EWS H2	32						32
15	Someshwar - Amazia - Someshwar loop		46					46
16	Kasod Depot - Sachin GIDC			40			36	40
17A	Kamrej Terminal - Pal RTO					48		36
17E	Kamrej Terminal - Sachin Railway Station							48
18	Railway Station - Utran RoB			9				9
19	Railway Station - Kadodara			15				15
20	Kharwar nagar - Kosad	14						14
21	Jahangirpura Community Hall - Althan Terminal					24	12	36
22	Kosad EWS H2 - Sarthana Nature Park BRTS			10				10
City Bus Services								
706	Jahangirpura - VNSG University				16			16
716	Jahangirpura - Gail Colony				15			15
136	Railway Station - Surat Airport				15			15
106	Railway Station - Abhiva Gam				16			16
Total		46	96	80	62	72	72	428

Table 7.1: Proposed bus deployment plan for e-buses - Sitilink

Source: Sitilink, SMC, 2025

The detailed assessment at route-level has been undertaken to assess the dead kilometre, shuttle kilometre and revenue kilometre. This section showcases the analytical approach adopted for depot and end route locations for opportunity charge.

The figure below illustrates the steps followed for this assessment.



7.1.1 Depot-based opportunity charging (Illustration – Route no 16)

This section provides a detailed assessment of BRT Route No. 16, which runs between Sachin GIDC and Kosad, covering a total length of 24 km. Figure 7 1 illustrates the location of the Magob depot, from which the route originates. The start and the end point, i.e. Kosad and Sachin GIDC are approximately 12-14 km away from the depot.

As of the scheduled data from May 2024, the fleet assigned to this route consists of 42 buses. As shown in Table 7 2, the non-revenue kilometres travelled by the buses fall into three route variations: the route from the depot to both ends (i.e., Kosad and Sachin) and the intermediate stop (i.e., Parvat Gam). This accounts for roughly 397 km, with a fleet of 27 buses. The shuttle kilometres, which included the curtailed route from Parvat Gam to Kosad Depot (and vice versa), utilises 21 buses in each direction, total of approximately 2,217 km. This indicates that the shuttle kilometres account for about 28% of the total kilometres. Passengers are required to transfer at this intermediate point, leading to approximately 6,300 passengers for a total of 180 trips (calculated based on the assumption).

All 42 buses return to the depot for opportunity charging, with each bus completing around four trips per day. This results in an dead kilometre per bus of about 9 km and shuttle kilometre of approximately 53 km. This analysis aims to assess how these shuttles and dead kilometres can be minimised.

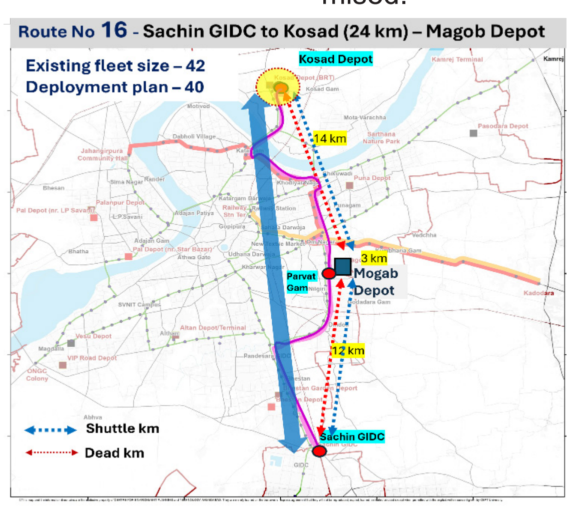


Figure 7.1: Route structure of route 16 (Magob depot

Sr No	Start Location	End Location	Length km	Trip Categories	Fleet size	Total Trips (Both way)	Total km	% Total km
1	Depot	Kosad Depot	15	Dead	11	11	154	5% (397km)
2	Depot	Parvat Gam	1.5	Dead	8	98	147	
3	Depot	Sachin GIDC	12	Dead	8	8	96	
4	Parvat Gam	Kosad Depot	14	Shuttle Revenue	21	90	1260	28% (2217km)
5	Parvat Gam	Sachin GIDC	11	Shuttle Revenue	21	87	957	
6	Kosad Depot	Sachin GIDC	24	Revenue	42	195	5265	67% (5265 km)

Table 7.2: Trip details of route no 16 – Sachin GIDC to Kosad (Magob Depot)

Source: Analyse from schedule data, May 2024, Sitilink, SMC

The time spent by buses in the depot, during the opportunity charging is also very crucial. The graph below indicates that buses start arriving at the depot from 11:00 am and depart around 12:30 pm, spending approximately 1.5 hours in the depot for charging. This total downtime and opportunity charging time could be optimised.

The figure below showcases the temporal distribution of bus inflow and outflow at the Magob depot across all routes.

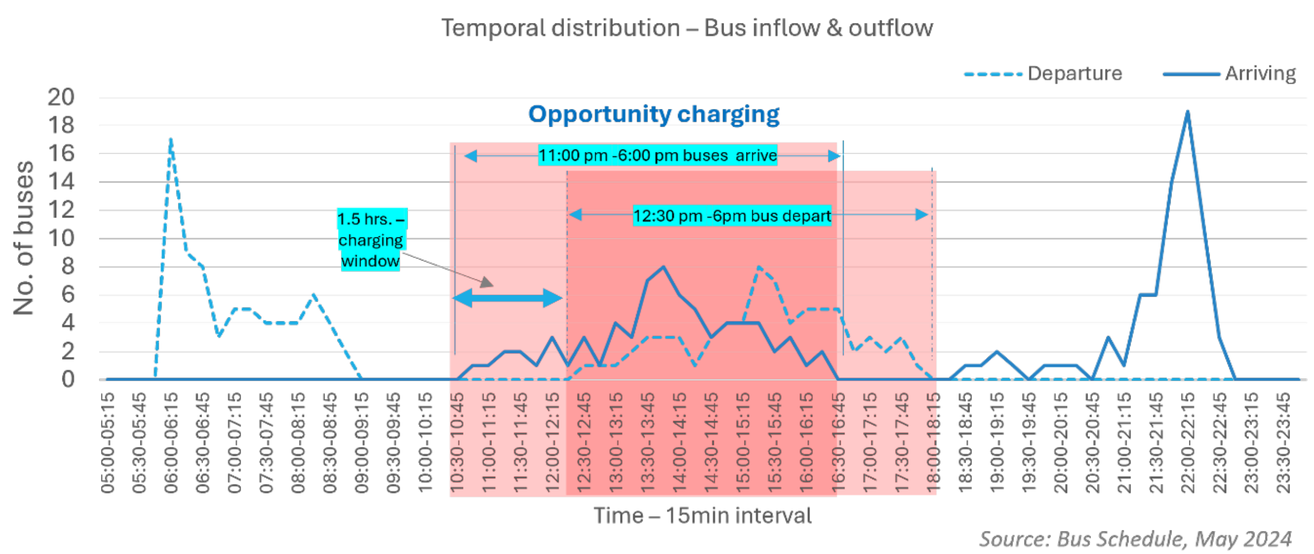


Figure 7.2: Temporal distribution of bus inflow and outflow (Magob Depot)

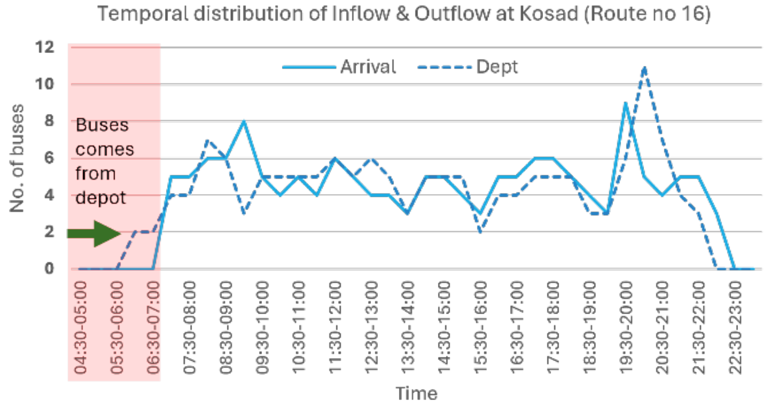
Based on the existing schedule, the number of buses halts at both endpoints and their duration has been assessed. It was observed that a total of 31 Greencell buses had a halt time greater than 30 minutes at Kosad, while around 27 buses halt at Sachin GIDC. The temporal graph represents the arrival and departure of buses from Kosad, showing that buses start their first trip at 6:00 am, starting half an hour earlier from the depot to reach the starting location (refer to Figure 7.3).

The details have been mentioned in the figure below.

No of Buses halt at the Route End (R16)

Halt time (mins)	Kosad	Sachin GIDC
30	-	2
40	2	3
50	10	2
60	3	8
70	-	8
80	-	1
90	8	1
100	5	1
110	2	-
120	1	1
Total no of buses	**31**	**27**

Buses halts > 30 min has been considered



Source: Bus Schedule, April 2024

Figure 7.3: Buses halt time and temporal of bus inflow and outflow at Kosad

As mentioned earlier, a new depot adjacent to Kosad depot, namely New Kosad depot, has been proposed and it is in the planning and implementation stage (refer to Map 4.4). If the space within the New Kosad depot is provided for opportunity charging for Greencell buses, the buses will not need to travel to the existing depot for opportunity charging, thus reduces the dead kilometres. This strategy will enhance operational efficiency and improve passenger convenience. The layout for the new Kosad depot has been planned and is recommended to modify the layout to accommodate six chargers of Greencell.

The following are the implementation areas and expected benefits from the proposal.

Proposal action areas

1. The new Kosad depot layout should be designed to accommodate an additional six DC chargers for Greencell, each with a capacity of 180 kWh, to charge 40 buses of Route 16.

2. It is feasible to conduct opportunity charging at Kosad under the existing schedule; however, it is recommended to create a new schedule that includes opportunity charging time at the Kosad depot, while maintaining required bus frequency.

3. The proposed schedule may need to include one or two time slots of 30-45 minutes each for opportunity charging.

Benefits:

1. Total dead-km savings of 180 km, which would be worth Rs 32 lakh (€0.033 M) annually.

2. Total savings in shuttle-km of over 1,000 km, relieving over 3,000 passengers from unnecessary transfers.

3. Total revenue kilometre will increase from 5,265 km to 6,505 km (+16%).

4. An additional 23 round trips could be planned to increase the frequency on this route, or these kilometres could be utilised in the areas with low frequency.

Category	Existing	Proposed
Dead kilometre	360 (5%)	360 (5%)
Shuttle revenue kilometre	2120 (27%)	360 (5%)
Revenue km	5265 (68%)	360 (5%)
Total kilometre	**7745**	**7745**
Total shuttle trips	178	360 (5%)
Estimated shuttle trips pax needs transfer	6300	3100
Possible revenue (round) trip	195	218 (195+23)
Rs 32 lakh (€0.033 M) of dead-kilometre can be converted into revenue-kilometre annually.		

Table 7.3: Proposal for inter -depot opportunity charging- Benefit summary - (Route 16)

Table 7.3 summarises the total benefits that would result from implementing this strategy. This approach would benefit both operators through increased revenue kilometres and optimised battery usage, as these buses have a smaller battery capacity of 151.55 kWh, enabling them to maintain the required kilometres. According to the contract, operators must bear the costs associated with dead kilometres within 10 km, which ultimately raises operational costs. From the authority's perspective, passenger comfort and convenience are priorities, potentially leading to increased frequency and ridership, thus generating more revenue.

7.1.2 End route-based opportunity charging (Illustration – Route no 13)

This section illustrates the approach to identify potential opportunity charging locations at the end of the route (i.e. route terminating location), using a specific example. Two routes are analysed: R13, from Jahangirpura to Kadodara (25 km), and R19, from Surat Railway Station to Kadodara (16 km). Both routes originate from the Magob depot, operated by Greencell, operates buses equipped with a battery size of 151.55 kWh.

Figure 7.4 displays the route structure for R13 and R19, highlighting both shuttle trips and dead kilometres. Currently, the fleet consists of 14 buses for Route R13 and 15 buses for Route R19. However, in the proposed deployment plan, the fleet size for R19 remains unchanged, while the number of buses in Route R13 is reduced from 14 to 6.

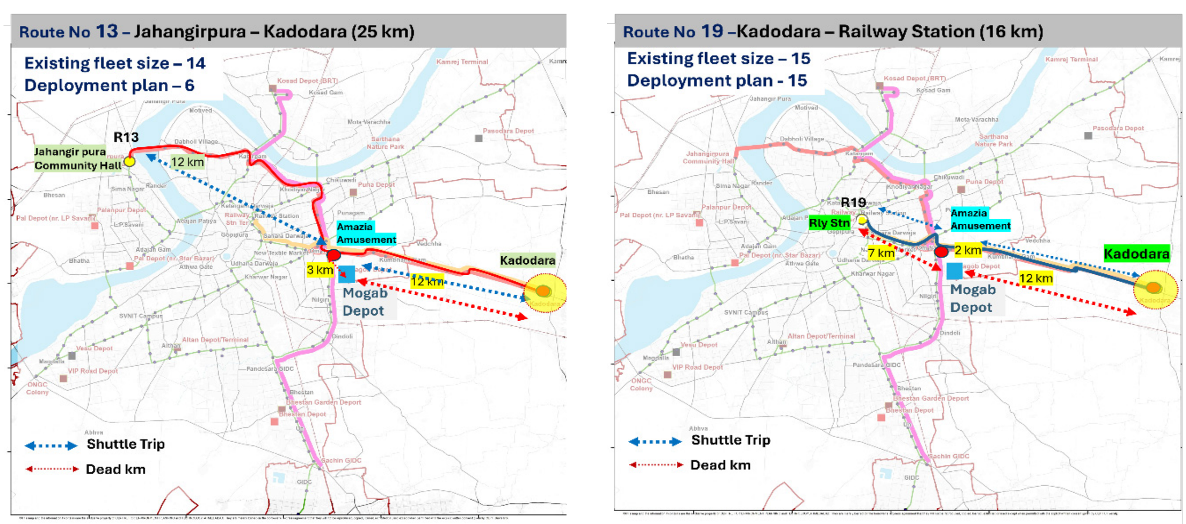


Figure 7.4: Route structure - Route 13 & route 19 (Magob depot)

The figure above illustrates that Amazia Amusement location serves as a midpoint for planned curtail/shuttle routes. The table below summarises trip details by total kilometres. It indicates that the dead kilometres for both routes are approximately 5%. However, the shuttle revenue kilometres range from 12% to 19%, indicating the potential for reduction.

Sr No	Start Location	End Location	Length km	Trip Category	Fleet Size	Total Trips (Both way)	Total km	% km
Route 13- Jahangirpura - Kadodara								
1	Depot	Amazia Amusement Park	3	Dead	11	39	117	5% (153 km)
2	Depot	Kadodara	12	Dead	3	3	36	
3	Amazia Amusement Park	Jahangirpura Community Hall	12	Shuttle Revenue	14	28	336	19% (586 km)
4	Amazia Amusement Park	Kadodara	10	Shuttle Revenue	14	25	250	
5	Jahangirpura Community Hall	Kadodara	25	Revenue Trips	14	85	2268	75% (2,268 km)

Sr No	Start Location	End Location	Length km	Trip Category	Fleet Size	Total Trips (Both way)	Total km	% km
Route 19 – Railway Station - Kadodara								
1	Depot	Amazia Amusement Park	2	Dead	9	35	70	5% (165 km)
2	Depot	Kadodara	12	Dead	5	5	60	
3	Amazia Amusement Park	Railway Station	7	Dead	5	5	35	12% (362 km)
4	Amazia Amusement Park	Kadodara	10	Shuttle Revenue	11	27	270	
5	Jahangirpura Community Hall	Railway Station	4	Shuttle Revenue	9	23	92	83% (2,592 km)
6	Kadodara	Railway Station	16	Revenue Trips	15	162	2592	

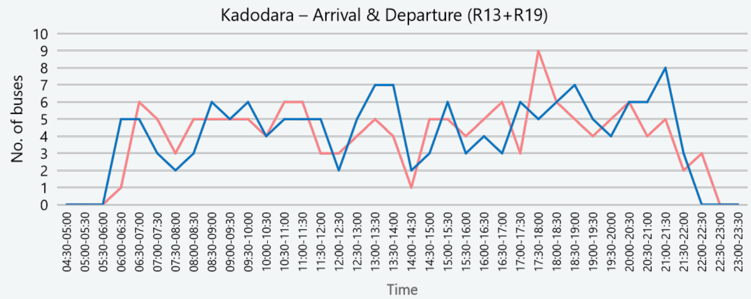
Table 7.4: Trip details of route 13 and route 19 (Magob depot)

As both the routes have it's one end at Kadodara location, the existing schedule of these routes are analysed consequently to understand the total number of buses that halt at the end location. Figure below indicates that around 24 buses halt at Kadodara and 10 buses at Jahangirpura for more than 30 minutes, details have been given below.

No of buses halt at the route end (R16)

Buses halts >30 min has been considered

Halt time (mins)	Kadodara (R13+R19)	Jahangirpura (R13)
30	1	2
40	3	1
50	3	3
60	1	2
70	-	1
80	1	1
90	-	-
100	-	-
110	-	-
120	1	-
130	14	-
Total	**24**	**10**



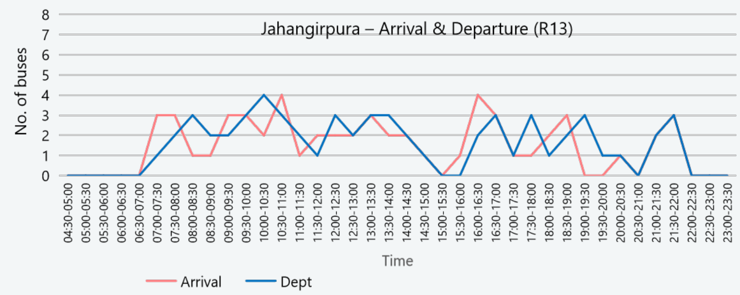


Figure 7.5: Buses halt time and temporal of bus inflow and outflow (Kadodara & Jahangirpura location)

The following outlines the action areas required for the implementation and benefits of the proposal.

Proposed action areas

1. It is proposed to establish four DC chargers of 99 kWh capacity with LT connection to be installed within 50-100 meters (depending on site feasibility and connection available).

2. For Route13 (6 buses) and Route19 (15 buses), charging at the Kadodara location is recommended as an opportunity. According to the current schedule, each bus has an average halt time of 50 minutes at Kadodara, making it feasible to charge 21 buses during their halt time.

3. The new schedule should be prepared considering the charging times for DC chargers with dual guns as given below:

   If buses halt for 30 minutes, they will require two opportunity charges.

   If buses halt for 60 minutes, they will need only one opportunity charge.

Benefits

1. Total dead-kilometre savings account to 170 km, translating to a yearly revenue of Rs 30 lakh (€0.031 M).

2. Total savings in shuttle kilometres exceed 300 km, providing relief to over 1,800 passengers from unnecessary transfers.

3. Revenue kilometres will increase from 3,232 km to 3,727 km, resulting to 15% increase.

4. An additional 15 round trips may be planned, which could increase bus frequency on the route or utilise these kilometres where supply is currently limited.

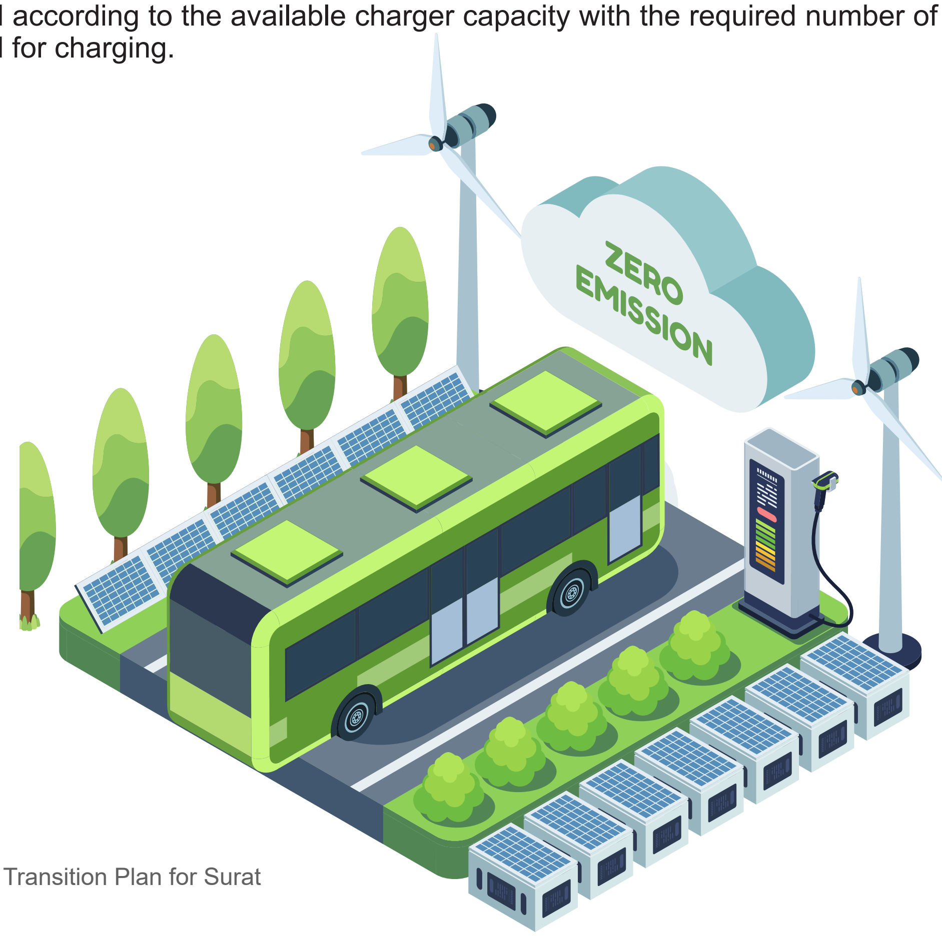
Detailed information has been provided in the table below.

Opportunity Charging Location	As per deployment plan	Proposed opportunity strategy
Total dead kilometre	**345 (8%)**	**173 (4%)**
Total shuttle kilometre	**645 (15%)**	**323 (8%)**
Total revenue kilometre	3232 (77%)	3727 (88%)
Total kilometre	**4242**	**4242**
Total shuttle trips	103	52
Estimated shuttle trips pax needs transfer	3605	1080
Possible revenue (round) trip	198	213(198+15)
Rs 30 lakh (€0.031 M) of dead-km can be converted into revenue-km annually		

Table 7.5: Proposal for end route opportunity charging - Benefit summary (R13 & R19)

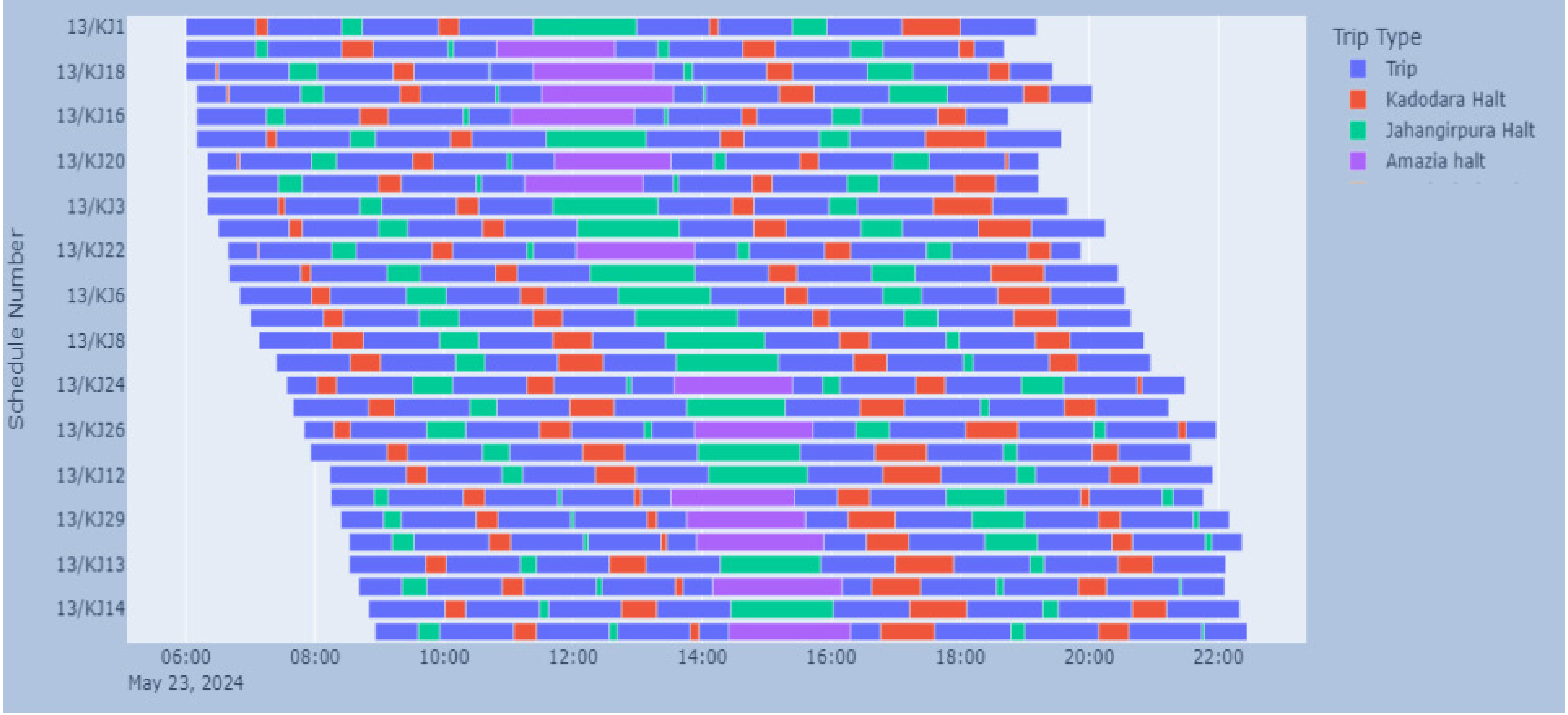
Figure 7.6 illustrates the Gantt chart outlining both the existing and proposed schedules for each bus. This chart indicates that there is a potential to utilise the halt time for charging with sufficient kilowatt to cover the required kilometres, thus avoiding the need to return to the depot for charging.

The proposed schedule is based on DC charging with a capacity of 99 kWh (low-tension connection). However, as per the notification from Gujarat Electricity Regulatory Commission (GERC), charger capacities reach up to 150 kWh from 100 kWh, therefore, it is recommended that the bus schedule shall be prepared according to the available charger capacity with the required number of chargers and the time allocated for charging.



Route 13: JAHANGIRPURA COMMUNITY HALL to KADODARA

Bus schedule



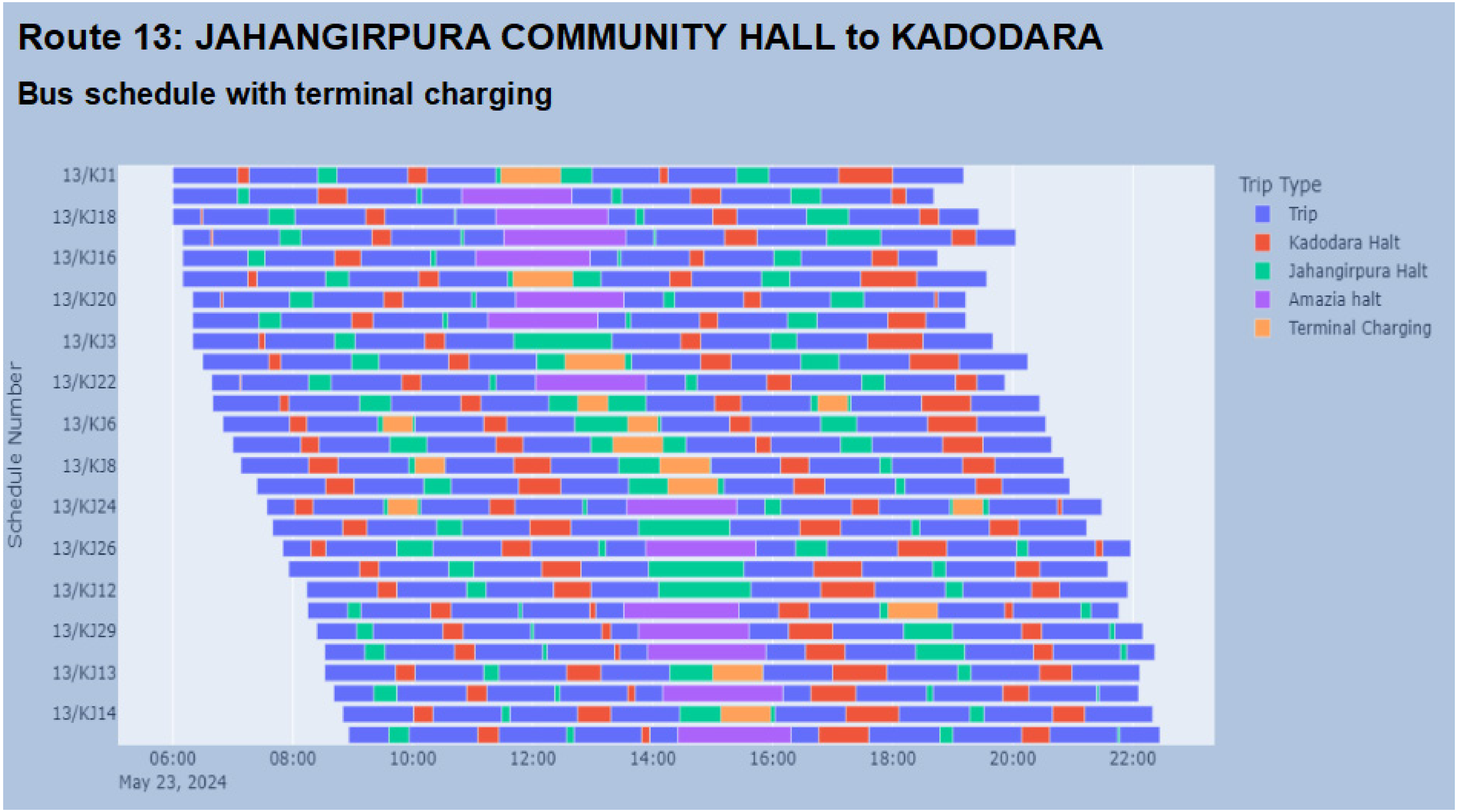


Figure 7 6: Gantt chart of existing and proposed schedule of Route no 13

7.1.3 Summary of proposed action areas for short-term

The short-term action area focuses on minimising dead kilometres and improvises the operational efficiency of e-buses by proposing a route-end and inter-depot opportunity charging strategy. This analysis aims to determine the most suitable routes that would provide maximum benefits in terms of e-bus operational efficiency and financial feasibility.

The proposed plan has identified seven optimal locations for opportunity charging based on the route structure developed for 428 e-buses by Sitilink. As detailed in the previous section, each assessment considered existing operational and charging schedules, the operational feasibility of integrating opportunity charging at the end locations to reduce dead kilometres while maintaining the existing route structure.

The approach to identify these locations are as follows:

1. Identifying routes with higher shuttle kilometres and dead kilometres.

2. If one end of the route is near its own depot, no changes were made.

3. If the depot location is far from the start and end points of the route, those routes were targeted for route end-based opportunity charging or inter-depot opportunity charging.

4. If multiple routes approach the same location, both halt schedules were assessed to avoid bus bunching at that location at the same time.

5. To assess the feasibility, charging schedules were prepared for few ends terminal location to identify the number of chargers required for opportunity charging.

Ultimately, the proposed plan showcases four strategic locations for inter-depot charging and three locations for end-route opportunity charging (refer to Figure 7.8).

The benefits reveal a significant reduction in dead kilometres and shuttle kilometres, with saving of up to 50% for each route. This clearly indicates that buses previously returning for opportunity charging can now be charged at the depot or end route locations, thereby reducing unnecessary trips and saving time. (refer to Figure 7.7)

Additionally, about 35-40% of the savings in dead kilometres and shuttle kilometres can be converted into revenue kilometres, enhancing both operational efficiency and service quality. An improvement in headway of 2-3 minutes can be observed after implementing the charging infrastructure.

Trip Category	Existing	Proposed
Dead km	6%	4%
Shuttle km	16%	9%
Revenue km	78%	87%
Total	100%	100%

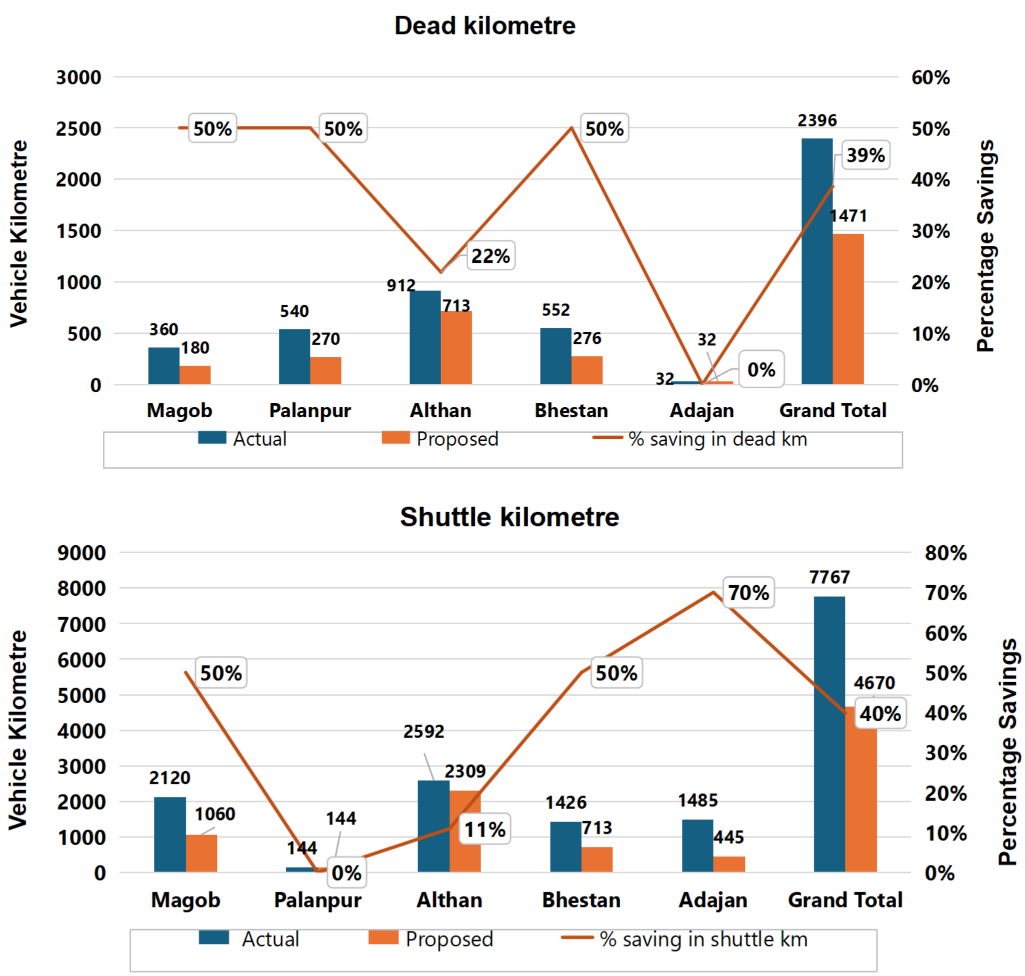


Figure 7.7: Savings in dead km and shuttle km – Short term action area

The following action areas are required to be undertaken, and the benefits from these proposals are discussed below. Table 7.6 provides a detailed summary of benefits associated with proposed route with opportunity charging, including number of chargers, charger capacity, operators and cost estimation.

Summary of overall proposed action areas

i. Inter-depot opportunity charging

- A total of four depot locations have been selected: Althan, Vesu, New Kosad and Adajan Pal.
- A total of 23 DC chargers (180 kW) are proposed to be installed at these locations.
- It is recommended to amend contractual agreement between operators to facilitate the sharing of electric power and billings, along with implementing safety protocols. As per the proposal, the agreements shall be made among the following operators for the respective depots:
- JBM – Olectra (Adajan Pal/Bhestan – Palanpur/Althan depot)
- JBM – Greencell (Bhestan - Vesu depot)
- Greencell - New OEM (Magob – New Kosad depot)
- A total investment require is estimated to be approximately Rs 4.17 crores (€0.433 M) for charging infrastructure (assuming cost of charger to be Rs 15 lakhs (€0.015 M) + 20% additional for submetering, switch gears, panels, cables, etc)

ii. End route opportunity charging

- Total three locations are selected, namely Kadodara, Kamrej, and Sachin Railway Station).

- A total of 12 DC chargers (99 kWh) are proposed to be installed through Low Tension (LT) connections .
- Total investment cost would be approximately Rs. 0.6 crore (€0.062 M) from end route charging. (Assuming a charger cost to be Rs 5 lakh (€0.005 M).

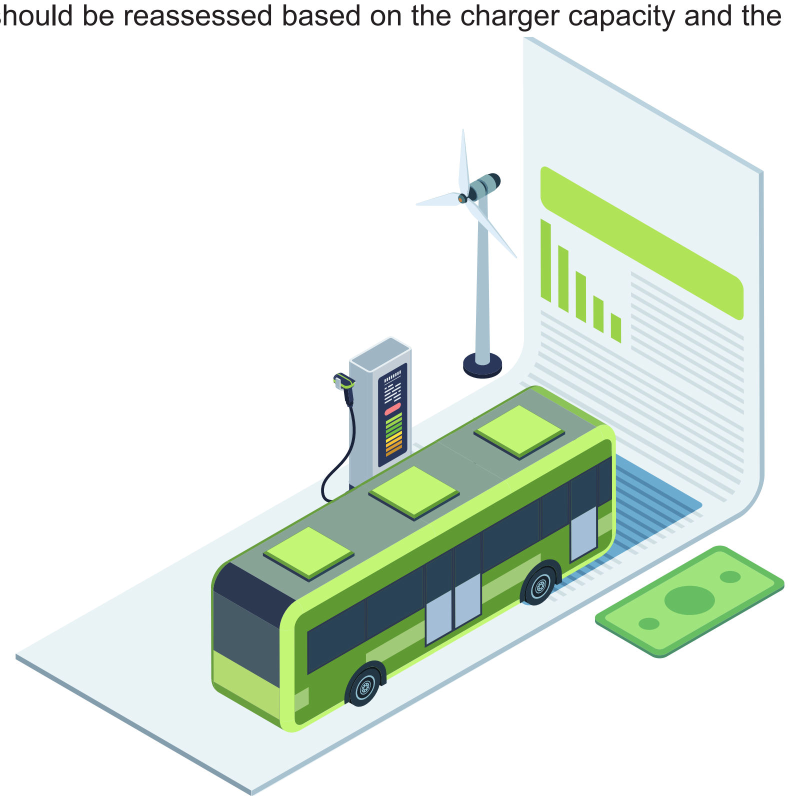
Summary of overall benefits from the proposals

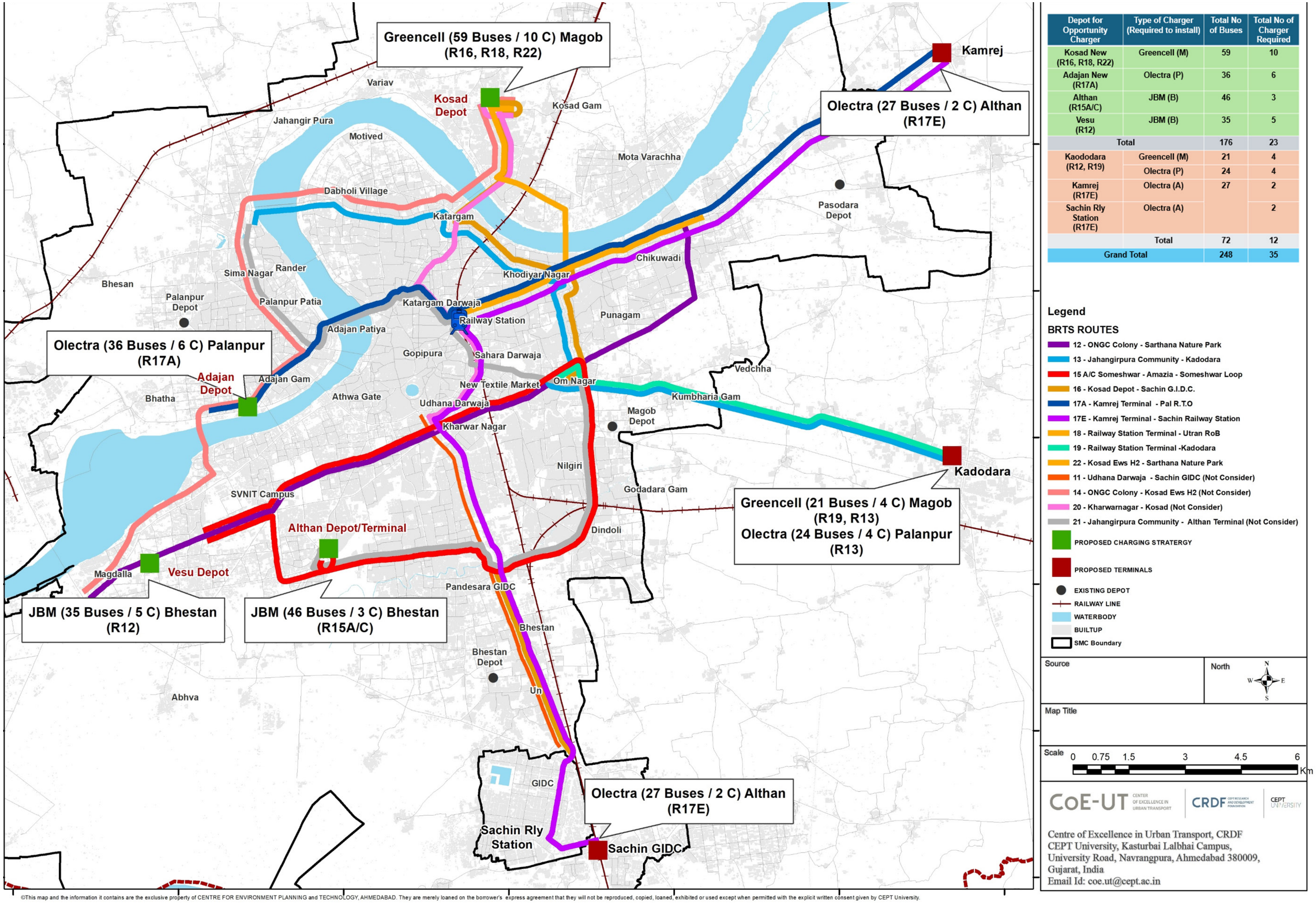
- Total savings will include 1860 km from non-revenue kilometres- savings of over 1000 km from depot-based (interoperable) and over 860 km from end route-based charging.
- The value of Rs 30 crores (€3.09 M) from non-revenue kilometres can be converted into revenue kilometres over 10 years.
- Total savings of over 5000 km of shuttle kilometres, which minimises 40% of shuttle trips, leading to an increase in frequency.
- This provides convenient journeys for over 17,000 passengers by minimising unnecessary transfers due to shuttle trips.
- Increased bus supply will enhance service standards and consequently increase the ridership.

Hence, with this initiative, the one-time investment in chargers are estimated to be approximately Rs 4.75 crores (€0.49 M), while the total savings from reducing dead kilometres is projected to be around Rs 30 crores (€3.09 M) over the next 10 years.

Since interoperable charging is still underway research, the study recommends that operators shall install their own chargers, preferably DC chargers, at the proposed locations. This will help to minimise the dead kilometres, leading to an increase in revenue kilometres and bus frequency.

It is important to note that during implementation, the number of charges required according to the new charging schedule should be reassessed based on the charger capacity and the operational challenges





Depot for Opportunity Charger	Type of Charger (Required to install)	Total No of Buses	Total No of Charger Required
Kosad New (R16, R18, R22)	Greencell (M)	59	10
Adajan New (R17A)	Olectra (P)	36	6
Althan (R15A/C)	JBM (B)	46	3
Vesu (R12)	JBM (B)	35	5
Total		176	23
Kaododara (R12, R19)	Greencell (M)	21	4
	Olectra (P)	24	4
Kamrej (R17E)	Olectra (A)	27	2
Sachin Rly Station (R17E)	Olectra (A)		2
	Total	72	12
Grand Total		248	35

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Figure 7.8: Proposal strategic locations for inter- depot and end-route opportunity charging (Short term action area)

Summary of Inter Depot Opportunity Charging										
Routes (Existing Depot)	Depot for Opportunity Charge Location	Type of Charger (Required to install)	Total No of buses	Total No of chargers required	How much dead km will be minimized	How much Shuttle-km will be minimised	How much revenue km increased (km)	% increase in revenue km	Capital Investment Cost (Rs)	Cost of savings in Dead km annual (Rs)
R19, R13 (Magob)	Kadodara	Greencell (M)	21	4	173	323	495	15%	0.19 Cr (€0.020 M)	0.31 Cr (€0.032 M)
R13 (Palanpur)		Olectra (P)	24	4	180	0	180	4%	0.20 Cr (€0.010 M)	0.36 Cr (€0.037 M)
R17E (R23) (Althan)	Kamrej	Olectra (A)	27	2	513	2025	2538	43%	0.10 Cr (€0.010 M)	0.40 Cr (€0.415 M)
R17E (R23) (Althan)	Sachin Rly station	Olectra (A)		2						
Total			**72**	**12**	**865**	**2348**	**3213**		**0.59 Cr (€0.61 M)**	**1.07 Cr (€1.11 M)**

Table 7.6 : Summary of overall benefits in short term action area

Summary of End Route Opportunity Charging										
Routes (Existing Depot)	End Route for Opportunity Charge Location	Type of Charger (Required to install)	Total No of buses	Total No of chargers required	How much dead km will be minimized	How much Shuttle-km will be minimised	How much revenue km increased (km)	% increase in revenue km	Capital Investment Cost (Rs)	Cost of savings in Dead km annual (Rs)
R16, R18, R22 (Magob)	Kosad New Depot	Greencell (M)	59	10	325	1060	1385	16%	1.71 Cr (€1.778 M)	0.58 Cr (€0.562 M)
R17A (Palanpur)	Adajan New Depot	Olectra (P)	36	6	270	-	270	4%	1.08 Cr (€1.123 M)	0.54 Cr (€0.562 M)
R15A/C (Bhestan)	Althan	JBM (B)	46	8	276	713	989	14%	0.48 Cr (€0.499 M)	0.64 Cr (€0.665 M)
R12 (Bhestan)	Vesu	JBM (B)	35	5	140	963	1103	20%	0.90 Cr (€0.936 M)	0.30 Cr (€0.312 M)
Total			176	23	1011	2736	3747		4.17 Cr (€4.33 M)	2.03 Cr (€2.11 M)

Table 7.6 : Summary of overall benefits in short term action area

7.2 Support for pilot project implementation

Based on the study proposal, the SMC has initiated efforts to implement pilot project for both depot-level and on-road (end route) opportunity charging.

7.2.1 Multi-OEM Electric bus operations from one Depot - Althan, Surat

The operator JBM has been assigned 100 e-buses to operate from the Bhestan depot, which was converted from an ICE bus depot to an electric bus depot. As of June 2024, JBM was operating 75 e-buses from the Bhestan depot, with plans to add 25 more buses.

However, JBM requested additional space, stating that the existing Bhestan depot could not accommodate all 100 e-buses. In response, the SMC has identified a nearby site (approximate 300 m) away from Bhestan depot, covering 3,318 square meters, referred to as Bhestan II depot. The estimated value of this vacant site is between Rs 16 and 18 crores (€16.63 M - €18.73 M).

Infrastructure development, including the installation of electrical lines, transformers and chargers, had commenced at the Bhestan II site. However, due to certain land issues, the construction was halted, and the plan to accommodate the remaining 25 e-buses at Bhestan II was subsequently discontinued.

To reassess the need for additional infrastructure, SMC decided to carry out the site assessment to understand the operational capacity and challenges at Bhestan depot; the following question were assessed.

1. Is there a requirement for additional depot for operating 25 e-buses?

2. Can 100 e-buses accommodate at the Bhestan depot without compromising the functionality?

3. Are there any operational issues that SMC or the operator needs to address while conducting depot activities?

A detailed analysis, including night activity surveys covering bus in-out time, charging capacity, activity sequence, and bus movement patterns, indicated that all 100 e-buses could be accommodated at the existing Bhestan depot with some modifications in the depot layout. Accordingly, two alternative layout options were proposed to optimise the available space (refer to Annexure IX). However, the operators, JBM, was not fully confident about operating the remaining 25 e-buses from Bhestan depot.

Simultaneously, a review of existing route schedules revealed that Route No. 15, although operated from Bhestan depot, functions as circular route starting and ending at the Althan depot cum terminal (refer to Figure 7.9). Total 44 buses are deployed on this route, providing adequate halt time and space for charging. Based on this assessment, SMC proposed a power and space-sharing arrangement at Althan depot with existing operators, Olectra/EVEY.

In this regard, several stakeholder meetings were conducted, with officials from SMC, Sitilink, the operator, and teams from GIZ and CRDF for technical support. Following mutual agreement, SMC allocated approximately 4500 sq. m of unused land within Altan depot to JBM for accommodating 25 e-buses, along with a separate power connection for charging.

Finally, both operators have agreed to the arrangement and the execution of civil works and charging infrastructure began in December 2024. Subsequently, the operation of JBM buses from the Althan depot has been commenced from May 2025. This implementation offers significant advantages:

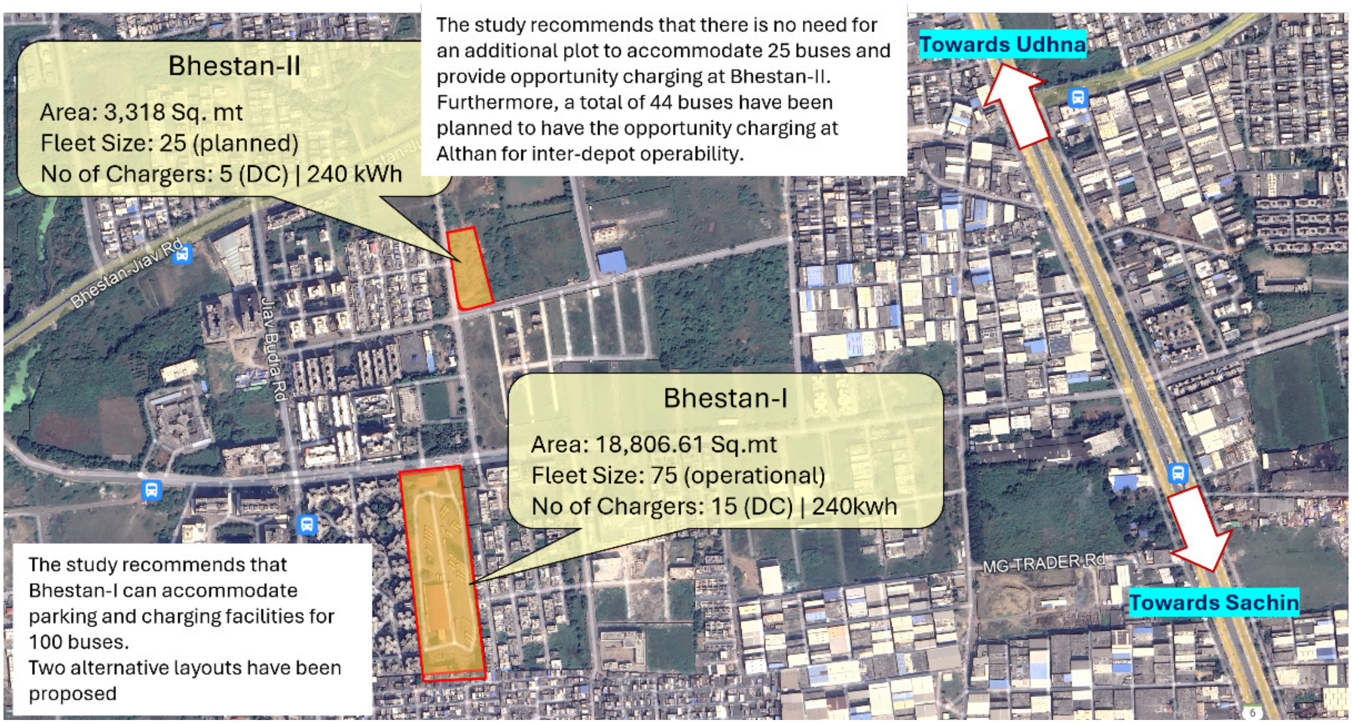
- Cost savings of Rs 16–18 crore (€16.63 M - €18.73 M), as SMC avoided the purchasing additional land for Bhestan II Depot.

- Optimal utilisation of unused land within the Althan Depot for parking and charging.

- Estimated annual savings of Rs 2.13 croresin non-revenue (dead) kilometres, due to reduced mid-day dead mileage for opportunity charging.

- While the development of basic civil infrastructure and power line connection incurred additional costs, the initiative enhances operational efficiency and service quality for both the operator and the authority.

The work progress has been highlighted in the figure below.



Location of Bhestan I and Bhestand II Depot

Meeting on 13th August'24 – to see the feasibility on ground for sub-metering and to decide the scope of work to take this forward. Traffic cell & Sitilink, SMC, JBM, Olectra, CRDF, CEPT

Proposed Location at Althan Depot
Plot size is ~4500 sqm (JBM)

On going civil construction as of
February 2025

Installation of Charging Infrastructure as of March 2025

Operations of JBM buses commenced from Althan depot - May 2025

Figure 7.9 : Highlight of pilot implementation at Althan Depot (Inter-depot opportunity charge)

7.2.2 On-road (end route) opportunity charging infrastructure - Sachin, Surat

The SMC has also taken the initiative to implement an on-road (end route) opportunity charging infrastructure for enhancing the fleet efficiency and reducing idle time by strategically charging e-buses during their downtime between routes.

On December 16, 2024, a site inspection was conducted by representative from SMC, Sitilink, GIZ, and CRDF to assess on-ground challenges and identify the most feasible location for pilot implementation. As a result of the inspection, Sachin location was selected to be the most suitable site for the pilot implementation due to its location near a dead end with low vehicular traffic and availability of unused space beneath the flyover. Although the site experiences high pedestrian flow during peak hour due to the adjoining railway station, the study recommends installing barricades to ensure safe separation between the charging infrastructure and pedestrian movement (refer to Figure 7 10).

The Route no. 23, which operates from Altan Depot with fleet of 48 buses, provides an opportunity charging facility as Sachin railway station. A total 28 buses would be able to charge at this location. Two alternatives were evaluated to assess the appropriate charger capacity and the associated benefits.

1. Alternative 1 – Two 80 kWh AC chargers with one single connection, the power drawn can be adjusted to 75 kWh with 80% power loss that translates to 60 kWh charger capacity. A total of four chargers are proposed with two LT connections at the location with a total capacity of 240 kWh (Proposed layout plan for bus circulation and charger location are provided in Annexure VIII).

2. Alternative 2 – One 150 kWh DC charger with one single connection and 80% power loss translated to 120 kWh charger capacity. A total of two chargers are proposed with two LT connections at the location with a total capacity of 240 kWh (refer to Figure 7 10 for proposed layout for bus circulation and charge location).

The study recommends the implementation of two DC chargers, each with a capacity of 150 kWh at Sachin Railway Station, utilising two LT connections. This setup is expected to maximise the benefits regarding e-bus operations, charging efficiency, and overall long-term investment for both the authority and the operator.

The key benefits of this initiative are as follows:

- A total of 28 buses will benefit from opportunity charging facilities, resulting in daily savings of over 300 dead kilometres.

- Annual savings from reduced dead kilometres are estimated at Rs. 64 lakhs (€0.071 M), which will accumulate significantly over the next 10 years.

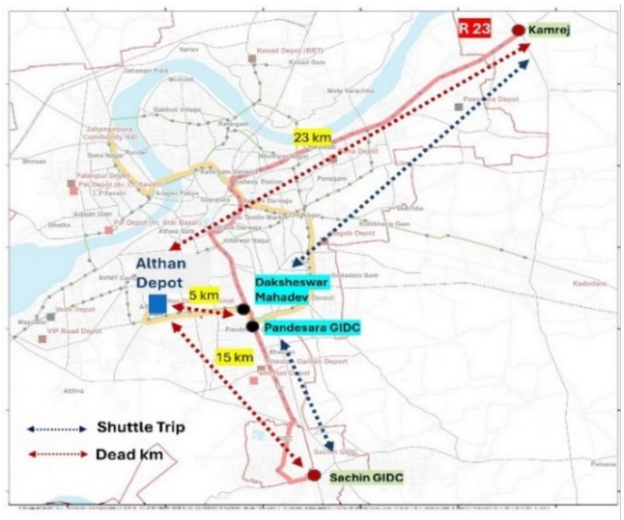
- Reduction in shuttle trips are significant, with approximately 40 shuttle trips saved daily on Route No. 23. This will provide convenience for around 1,500 passengers daily, who will no longer face unnecessary transfers, as some trips previously ended at an intermediate location.

- An increase of over 1,000 revenue kilometres is expected as the bus service frequency improves from 6.5 minutes to 5 minutes during peak hours. This will increase the ridership and revenue for the operator.

This pilot project is intended to be monitored for at least two months to evaluate its results. Additionally, it is important to assess the impact on safety and the operational feasibility of the initiative. This pilot can serve as a foundation for learning and identifying more locations for further action, as suggested in the transition plan study.

- The study indicates that both alternatives are viable. However, as of March 24, 2025, a decision has been confirmed to proceed with the installation of AC chargers. The operator is currently assessing the feasibility of installing two chargers rather than four chargers.

The figure below highlights the glimpse of site location.

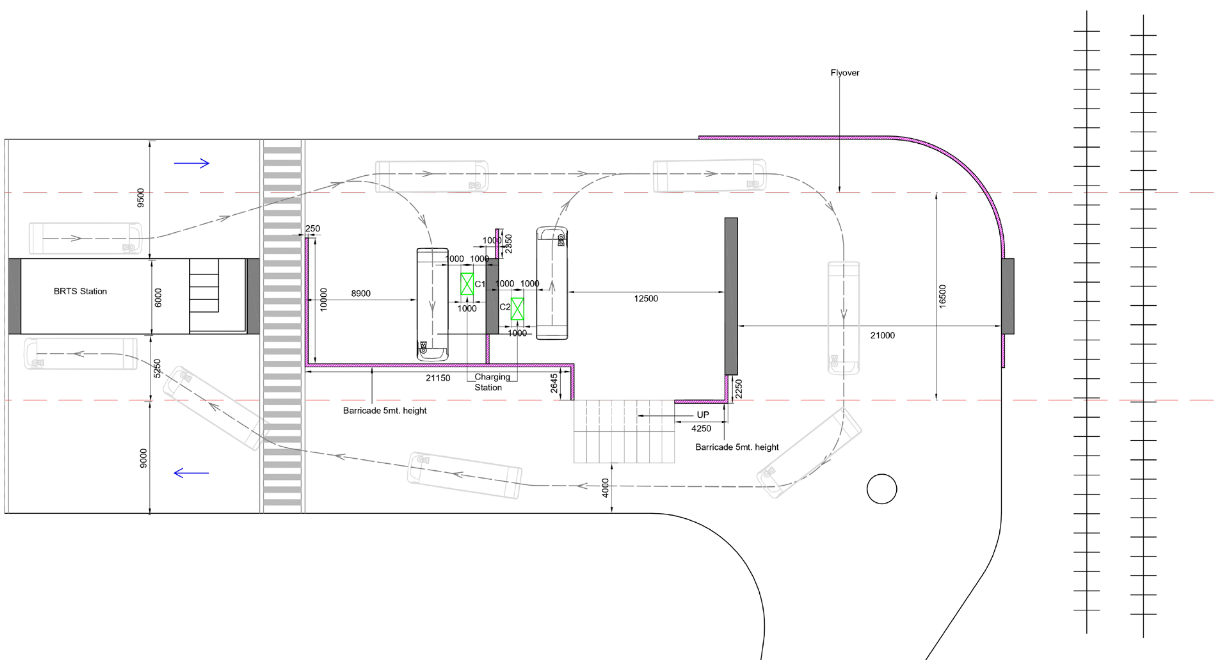


Feasible space for charging

Pedestrian flow

Feasible space for charging (Location 2)

Feasible space for charging (Location 1)



Tentative Alternative – Two DC charger (each 150 kWh) placed on single wall in different direction beneath the flyover (Not yet final- the discussion is in progress)

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Figure 7.10 : Highlight of pilot implementation at Sachin Railway Station (End route opportunity charging)

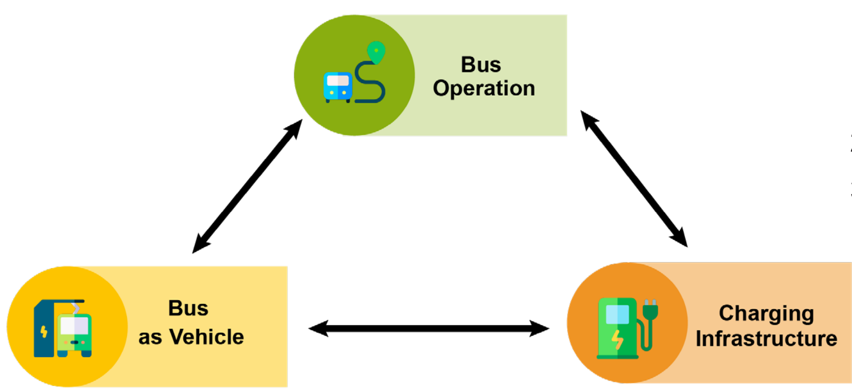
08

Strategies for Adopting E-buses by 2035

Surat city is set to undergo a significant shift towards e-buses in the upcoming years. While this transition promises various benefits, it also presents certain challenges that are more pronounced when compared to traditional ICE buses. To ensure seamless transition, strategic planning is essential that focuses on developing the necessary infrastructure, particularly charging facilities for e-buses. This infrastructure must be evaluated and refined continuously to support the successful integration of e-buses into the city's bus operations. While e-buses typically have a higher upfront cost compared to ICE buses, but e-buses offer a more sustainable alternative in the long term. With advancements in technology, different segments of e-buses are emerging, necessitating a thorough evaluation of their financial and economic viability over time.

This section outlines a strategic roadmap for the long-term transition of Surat towards e-buses, with a target horizon of 10 years. i.e. by year 2035. To ensure a well-planned transition to e-buses before operations commence, the following key questions need to be addressed:

- What will be the total fleet size needed by 2035 to achieve the de sired mode share?
- How many buses should be procured each year and what types of e-buses should be selected?
- How many depots are required and where should they be located?
- What level of investment is needed for depot infrastructure and bus operations?
- What will be the strategy for efficient operations?



1.The vehicle/ bus technology

2.Charging and other infrastructure

3.Operations Plan

The insights gained from existing operations indicate that transitioning to e-buses involve three interconnected elements

Currently, bus operations are planned with fixed consideration for infrastructure and bus battery specification.

For future strategies, bus operations should be designed independently to meet the desired level of service, while infrastructure and vehicle specifications should be adapted to enhance the overall operational efficiency.

8.1 Fleet size estimation – Year 2035

Surat, the eighth-largest city in the country, has been experiencing rapid population growth continuously for over six decades. The estimated population of the Surat metropolitan area is 8.3 million (2024). As per CMP 2018, by 2035, the city is likely to accommodate 9.9 million people. Therefore, a robust public bus transportation system is essential for efficient functioning and sustainable development of the city.

The electrification of public bus transport represents a key strategic approach to advancing the economic and environmental efficiency. The section aims to estimate the size of the electric public bus transport fleet and the supporting infrastructure that can be effectively deployed in the city by 2035. The analysis is intended to support decision-making by determining the number, composition and phasing of the fleet. Additionally, it will facilitate the planning and allocation of land and infrastructure, necessary to accommodate the future electric bus fleet.

The section is structured into three parts. The first part provides an estimate of the size of the public bus transport fleet that can be effectively deployed by the year 2035. The second part outlines a procurement plan, considering the fleet requirements for augmentation and replacement. The third part addresses the infrastructure needs of depots, including the estimated number and location of facilities necessary to support the projected fleet.

8.1.1 Alternative approach to estimate the e-bus fleet size

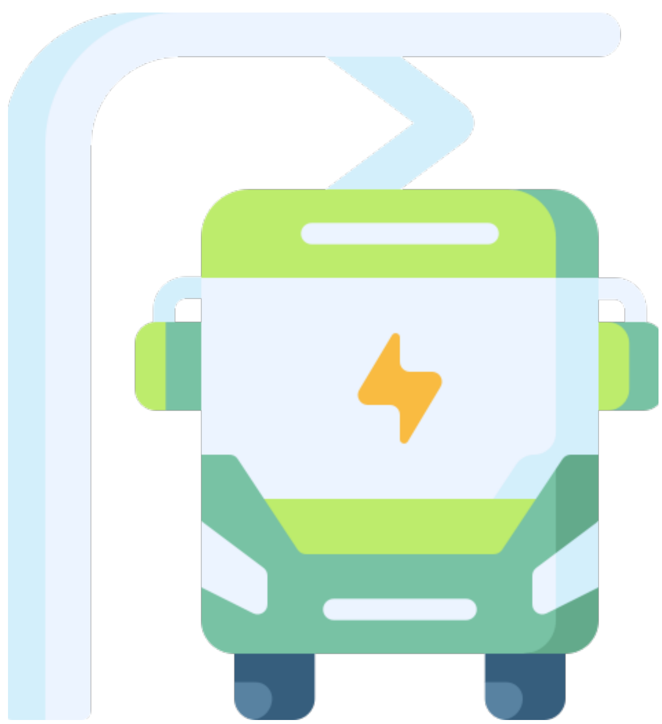
The public bus transport fleet requirements can be derived by adopting three different perspectives:

1. Based on the Service Level Benchmarks (SLB)
2. Based on the travel demand (potential passenger shift based on the trip distance – Trip Length Frequency Distribution (TLFD))
3. Based on the operational viability (fleet deployment on strategic PT network 2035)

8.1.1.1 Fleet size estimate based on the SLB.

In 2010, the Ministry of Housing and Urban Affairs (MoHUA) established a comprehensive framework to measure and monitor urban bus transport performance in India. The SLB framework evaluates the city's Level of Service (LOS) based on the number of per 1000 population, defining targets from LOS 1 (best) to LOS 4 (worst).

The required fleet size for Surat per the LOS are presented in the table below. With a fleet of 875 buses (0.12 buses/1000 population), the current LOS is 4.



Level Of Service (LOS)	Buses per 1000 population as per LOS	Surat Fleet Estimates – (2024) (as per SLB)	Surat Fleet Proposed (2035)	Potential Ridership – 2035 @ 600 Pass/bus	Mode share – 2035 (%)
LOS 1	>=0.6	4500	6000	36,00,000	40.22
LOS 2	0.4 - 0.6	3800	5000	30,00,000	33.52
LOS 3	0.2-0.4	2300	3000	18,00,000	20.11
LOS 4	<0.2	1100	1500	9,00,000	10.06

Table 8.1: Fleet size estimates for 2035

Source: Service Level Benchmark, MoHUA

Note: Currently, 699 of the total fleet of 875 buses are on-road daily, serving 188 thousand passengers (i.e. 3% PT share of total motorized trips). This works out to about 260 passenger/bus/day.

8.1.1.2 Fleet size estimate based on the travel demand

The size of the public bus transport fleet required in urban areas depend on the pattern of demand in space and time, i.e. the total number of trips and their distribution by length. The requirement for the bus fleet can be determined based on the peak hours or the total operational hours of the day. In this analysis, the estimates are based on the projected demand for the total operational hours of the day.

Estimation of the future demand has been undertaken as a four-step process.

Step - 1 - Estimating Total Travel Demand in 2035

According to the 2016 survey, the motorised trip rate was recorded as 0.85. This rate is projected to increase to 0.90 by the year 2035. Based on the estimated public transport service area and a projected population of 9.9 million, the motorised trips are estimated to reach approximately 8.9 million.

Step 2 - Trip Distribution in 2035

The 2016 survey provides the data on the distribution of motorised trips by trip length in Surat. To project future trends, the trip distribution patterns observed in Hyderabad and Ahmedabad, along with average trip lengths in Delhi, Chennai, and Bengaluru, have been considered. Based on the comparative analysis, the future trip length distribution in Surat is estimated to reflect a moderately sprawled urban structure.

Step 3 - Share of Public Bus Transport Trips in 2035

Trip length is a key determinant of mode choice. The probability of users opting for the public bus transport increases with an increase in trip length. In 2016, surveys were conducted to assess users' willingness to shift to public transport. These findings have been applied to project the future distribution of public transport trips.

Step 4 - Fleet Requirement in 2035

Based on the total number of trips and passenger kilometres, the required fleet size was estimated, assuming a composition of 20% standard buses and 80% midi buses. The estimation also considered a daily vehicle utilisation of 200 km, fleet utilisation at 95%, and a load factor of 60%. Under these assumptions, the projected fleet required by 2035 is estimated to be 2200 e-buses.

This fleet configuration is expected to serve approximately 14 lakh (1.4 million) passengers, representing a 16% PT share, with an average trip length of approximately 9 kilometres.

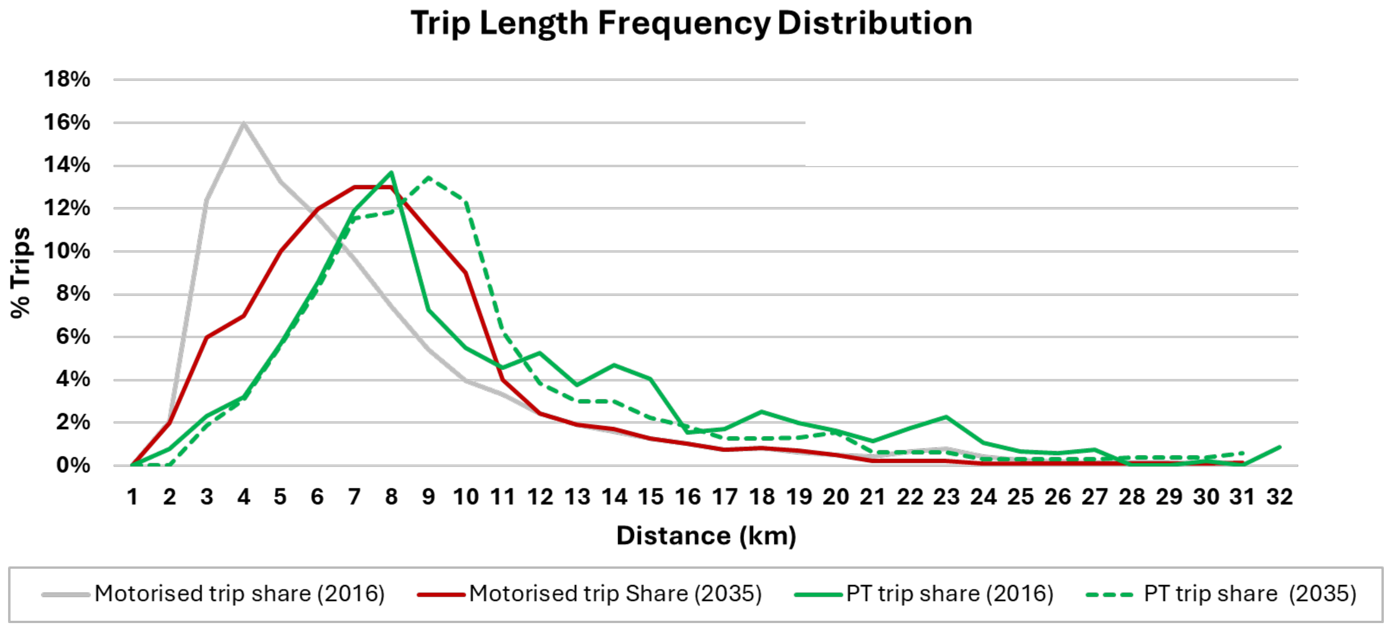


Figure 8.1: Trip Distribution for base 2016 and future 2035

8.1.1.3 Fleet size estimate based on the operational viability

The operational viability is examined based on two major criteria:

- Public transport network and its design, determines the feasible headways and daily vehicle utilisation (constrained by traffic conditions)
- Potential increase in the public transport mode share.

The size of the public transport fleet required in urban areas depend on the user demand pattern.

A.Public transport system design

The overall public transport network and the design of its operations determine the feasible headways, travel speeds (constrained by traffic conditions) and daily vehicle utilisation.

- **Public Transport Network:** Surat is a high-density city, and denser cities are found to require shorter public transport networks.
- **Operational Design:** Operations in mixed traffic conditions against the operations in segregated/prioritised corridors impact headway and daily vehicle utilisation.

In the mixed-traffic conditions, travel speeds tend to be lower, adversely affecting the daily vehicle utilisation. In addition to traffic conditions, frequent junctions negatively impact the travel time reliability, due to bus bunching. Therefore, in mixed-traffic operations, minimum headway achieved are 6 minutes or higher.

In the case of BRT/Bus priority operations, as there is minimal traffic interference, the travel time reliability is comparatively higher, and minimum headway achieved are 2 minutes or higher.

Based on the above principles, a conceptual bus route network expansion plan for BRT and the city bus systems is prepared. This plan includes 14 BRT and 76 City bus routes. A strategic proposed network map and route details for 2035 have been presented in Annexures V and Annexures VI respectively.

Services	No of routes	Headway	Fleet Size	No of routes	Headway	Fleet Size
BRTS (12 m bus)	14	5 to 15 min (Predominately 8-10 min)	870	14	3 to 8 min	1580 (680 + 900)
City bus (9m bus)	53	10 to 150 min (predominantly 15-30 min)		42+7 extension	5 to 10 min	
Proposed new routes (9m bus)	-	-	-	27	10 mins	550
Total	59	-	870	90	-	2100
Pass/bus/day	260 passengers			860 passengers on BRT | 550 passengers on city bus		
PT network length	480 km			900 km		
PT coverage (%) (SUDA region) (population within 500 buffer of high frequency network headway <10 min)	77%			90%		

Table 8.2: Existing and proposal of public transport based on operational viability

B. Potential increase in the public transport mode share

Travel behaviour is firmly established and any shift in patterns tend to be a gradual process. The increase in the share of public transport usage will primarily depend on the existing transport shares and the strategies implemented.

In this context, the analysis considers the operation of standard-size buses on the BRT network and midi buses in the city bus network, both with a daily vehicle utilisation of 200 km and a passenger load factor of 60%, assuming an average trip length of 9 km. Using this approach, the total number of passengers is estimated to be approximately 14.2 lakhs (1.42 million), with buses accounting for about 15% of the PT share relative to motorised trips. This percentage could potentially rise to 20%, considering the future metro ridership.

8.1.1.4 Summary of all three approaches

The figure below summarises three different approaches to estimate the future fleet size required for the city to accommodate future demand.

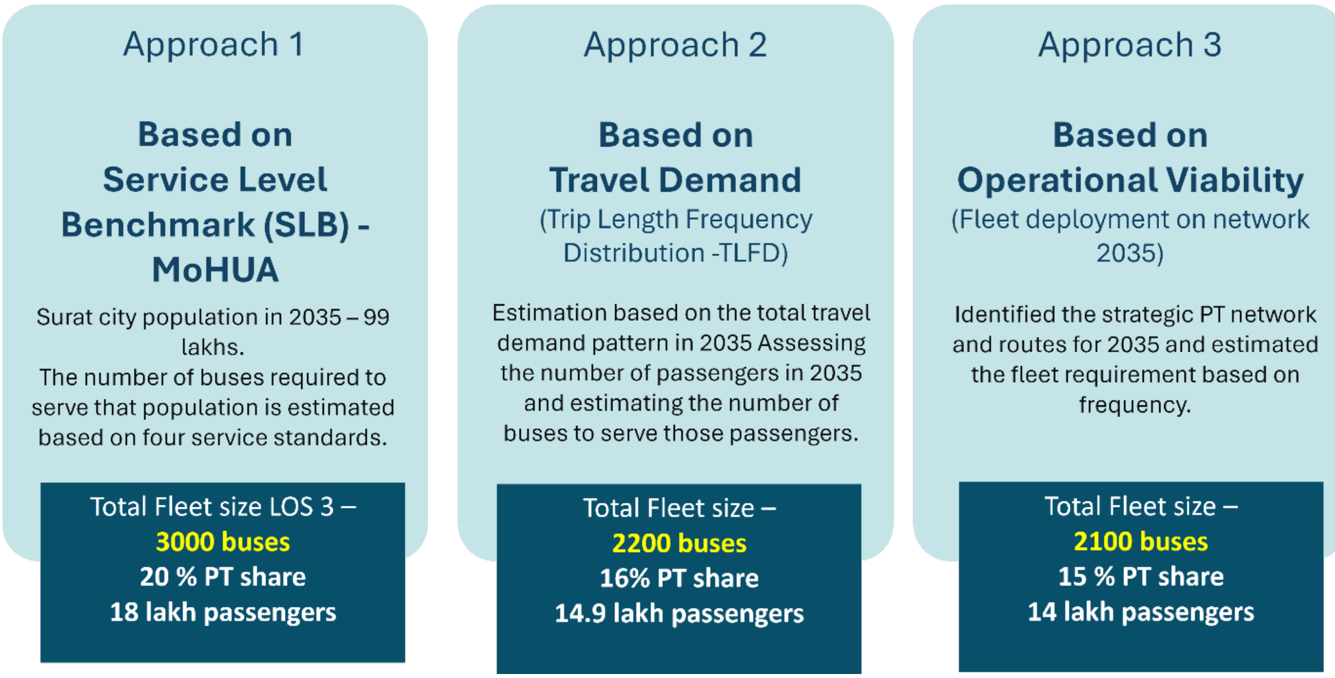


Figure 8.2: Fleet estimation summary of all three approaches for future year 2035

The above section indicates that the population of the city will reach 99 lakhs (9.9 million) by the year 2035. To accommodate this growth, it is estimated that the city will require a fleet size of between 2,100 and 3,000 buses with three different approaches (refer Figure 8 2). The expansion of the fleet size is projected to result in a public transportation (PT) mode share of approximately 15% to 20% of total motorised transportation.

However, adhering to SLB standards suggest that the city should opt for Level of Service (LOS) 3, rather than the more desirable LOS 2 or LOS 1. Therefore, further analysis was conducted to evaluate the feasibility of achieving LOS 2 (i.e. 3,000+ buses) focusing on the city's urban growth structure, road infrastructure, and population densities. This analysis aims to determine whether the city has the infrastructure capacity to support a fleet size of 3,000 buses or more, ensuring that public transportation can effectively meet the future needs of its growing population.

8.1.2 What fleet size and type can the city accommodate?

The section delves into a different approach based on the city's growth structure, road network infrastructure and population density. It is compared with Ahmedabad city, which is similar in size, to understand the impact of these factors on the bus fleet type (standard, midi, and mini) and fleet size.

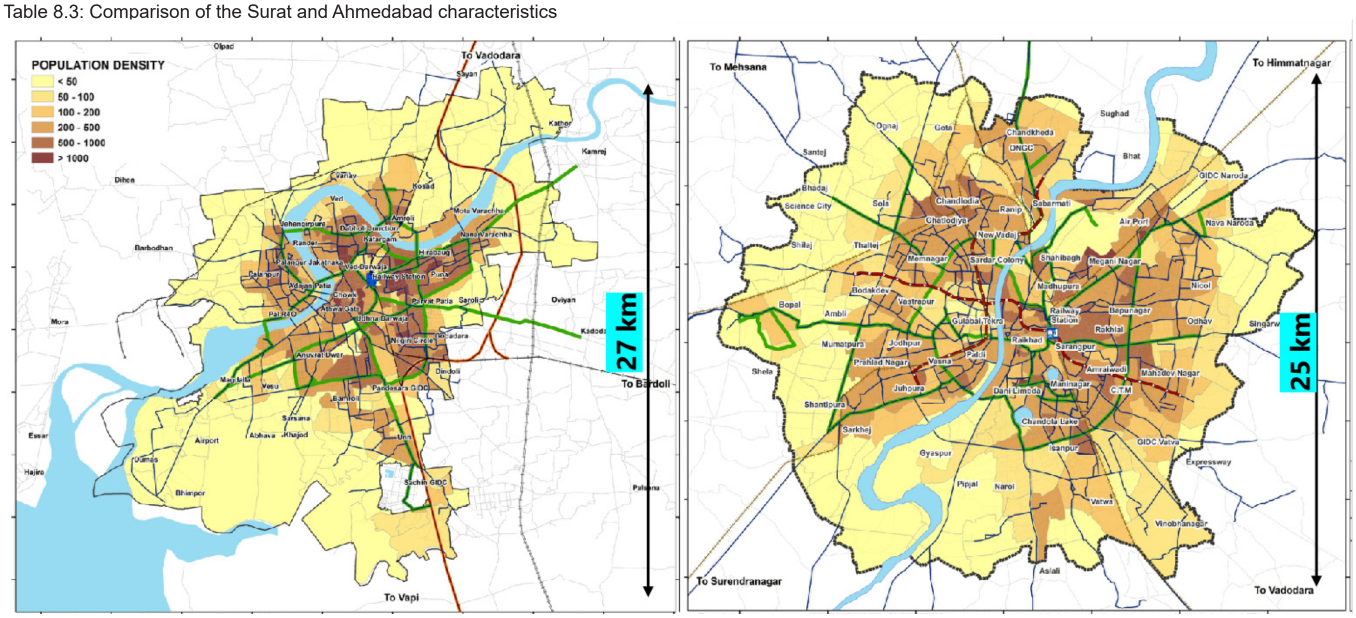
Surat has a ring-radial pattern with an elongated administrative area (Surat Municipal Corporation) covering 462 sq. km. In contrast, Ahmedabad features a circular city structure with a ring-radial road network pattern. Due to these differences, Surat has approximately 850 km of major road network, while

Ahmedabad has about 1,560 km of road network. This indicates that Surat has a lower road density per square kilometre (1.82 sq. km/km) and a lower road network per population (13 km per lakh population) compared to Ahmedabad (refer to Table 8.3).

The table and figure given below, represents that Surat has a higher population density of approximately 213 person per hectare (PPH) compared to 192 PPH in Ahmedabad within the 500-meter PT buffer area, indicating more compact development. However, while calculating the PT coverage with respect to the major road network, Surat covers about 54%, in comparison to 40% in Ahmedabad. This highlights the significance of considering city structure, population density, and road capacity when planning for bus fleet deployment.

Parameter	Surat	Ahmedabad
Municipal area	462 sq km	488 sq km
City’s shape and dimensions	Elongated shape (27 km X 15km)	Circular shape (25 km X 25 km)
Population density within PT buffer area	213 PPH	192 PPH
Major road network	842 km	1556 km
PT network	454 km	619 km
PT network covered (%) wrt major road network	54%	40%
Road network density	1.82 km/sq km	3.18 km/sq km
Road network/ lakh population	13 km /lakh population	21 km / lakh population

Table 8.3: Comparison of the Surat and Ahmedabad characteristics



Surat

Ahmedabad

Disclaimer: This geographical map is for informational purposes only and does not constitute recognition of international boundaries or regions; GIZ makes no claims concerning the validity, accuracy or completeness of the maps nor assumes any liability resulting from the use of the information therein.

Figure 8.3: Map of road network and densities - Surat and Ahmedabad

Based on the current assessment, it has been observed that the standard (12m) buses are suitable for operating primarily on the BRT corridor, which offers a sufficient Right-Of-Way (ROW)of about 24 to 30 m. However, deploying these buses on non-BRT roads will be challenging due to limited ROW and higher congestion levels.

The study recommended that Surat should adopt a diversified e-bus procurement strategy to effectively serve its current and future public transport needs. It is advised that a mix of different e-bus types should be procured, primarily 9 m (midi) e-buses for inner-city routes and 12 m (standard) e-buses for routes connecting the outer peripheral areas and the BRT corridor.

Additionally, the deployment of e-buses should be assessed based on the passenger demand and the available road width.

8.1.3 Recommended future fleet size

The analysis highlights that Surat city faces challenges in road capacity due to its high population density, compact structure and lower road density. It is recommended that the city should have 2,000-2,200 buses. This recommendation aligns with a Service Level Benchmark (SLB) of LOS3, with a bus-to-population ratio ranging between 0.22 and 0.25 buses per 1,000 population. The future study suggests that the methodology used to assess the fleet size was at a broad level. However, for a detailed assessment of fleet requirements and phasing of procurement plan, along with comprehensive route planning, the city will necessitate to prepare a report on the service and business plan for the city bus operations.

8.2 Proposed depot location

The study estimates that Surat will need approximately 2100 buses by the year 2035. To accommodate these buses, the total number of depots required were assessed assuming 75 buses per depot (as per existing ratio of buses per depot). This translates to a total requirement of 29 depots. The city currently has 14 existing depots, which are anticipated to be converted to electric bus depots in the future. Therefore, an additional 15 depot locations will be needed by 2035.

Proactive planning for depot locations is critical due to potential challenges in land acquisition in later phases. Depot location plays a pivotal role in electric bus operations, particularly given the need for daily opportunity charging. Strategic identification and reservation of land for depots at this stage will mitigate future logistical and financial issues.

This section outlines a strategic approach for planning depot locations.

Approach for Identification of Depot Locations

The identification of strategic depot locations followed a three-step methodology:

Step1: Mapping the future expansion of the PT network, connecting the peripheral major growth centres and villages to strategically plan the routes. The approach is based on the operational feasibility. (refer section 8.1.1.3)

Step 2: Identifying the locations, that serve as major start or end point of all these routes to determine suitable depot locations.

Step 3: Finalising the depot locations based on spatial distribution across the city, ensuring depot can serve 4-5 directional routes. Locations were prioritised based on existing and anticipated population density and urban growth area. This strategy will provide opportunities for inter-depot charging infrastructure development.

Strategy adopted for planning of depot location:

- It is recommended that each depot should be designed to accommodate approximately 75–85 buses, which is more suitable for Surat when compared to the **conventional standard of accommodating 100 buses. Depots should be evenly distributed across the city, ideally located at major road intersections or within a 500-meter buffer from major corridors,** to reduce dead kilometres and support inter-depot charging, enhancing the operational efficiency.

Such spatial planning of depots will also facilitate greater operational flexibility and improve overall service efficiency.

Figure 8.4 represent the map of proposed strategic depot locations and Annexure VII shows the details of the depots

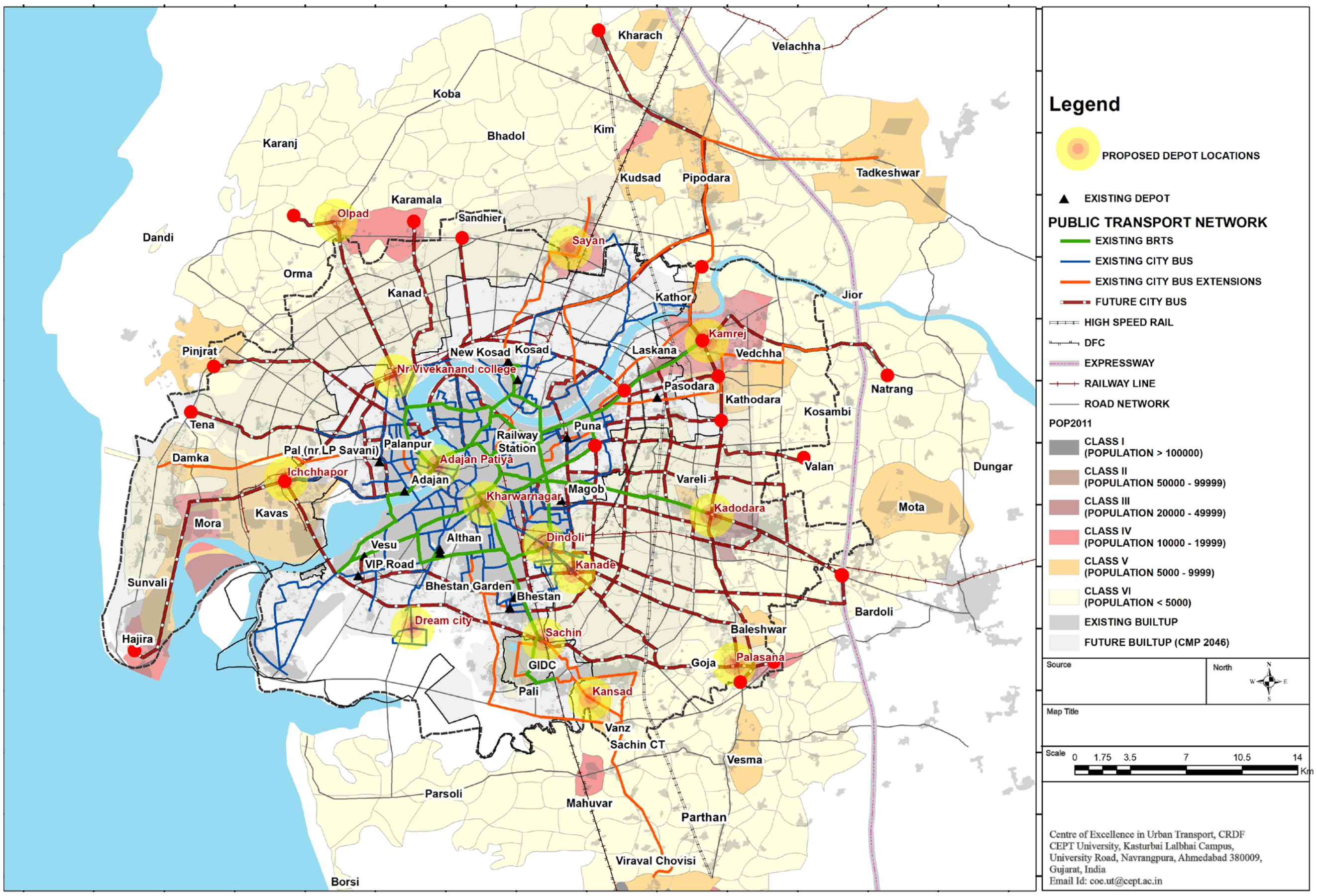


Figure 8.4: Proposed strategic map of depot location - 2035

Disclaimer: This geographical map is for informational purposes only and does not constitute recognition of international boundaries or regions; GIZ makes no claims concerning the validity, accuracy or completeness of the maps nor assumes any liability resulting from the use of the information therein.

8.3 Financial assessment

Nearly a decade has passed since the GoI initiated the promotion of electric buses through the FAME I policy, launched in 2015. However, the e-buses are still perceived as a more expensive option due to their higher capital costs compared to ICE buses. As a result, the financial performance remains a significant concern for transit agencies and city authorities.

This section outlines the financial assessment for the city of Surat over the next ten years, up to 2035. It includes:

- A fleet procurement plan for the year 2035
- A comparison between ICE bus vs. e-bus operations.
- The investment requirements for depot infrastructure to support the future fleet
- The financial implications for the city

8.3.1 Fleet procurement plan – Year 2035

As discussed, the city currently has a PT share of approximately 3%, which has remained stagnant for an extended period. To increase the PT share from 3% to 15%, the city will need to procure 2100 buses by 2035, focusing on enhancing the quality of bus services. Achieving a total of 2100 buses by 2035 will require a phased procurement plan to distribute the fleet over the years. This approach will also help manage the financial requirements and prepare necessary depot infrastructure within the city.

At present, Surat's bus fleet comprises approximately 150 standard buses (12m), with the remainder consisting of midi buses (9m). The standard buses are primarily deployed on high-demand BRT corridors, whereas the midi buses serve on a moderate and low-demand routes across the city. Therefore, it is assumed that 20% of the total fleet, equivalent to approximately 420 standard buses, will be allocated to high-demand BRT routes by 2035. The e-bus procurement plan for 2035 has been developed addressing both the replacement of aging bus fleet and the procurement of additional buses to expand the service coverage.

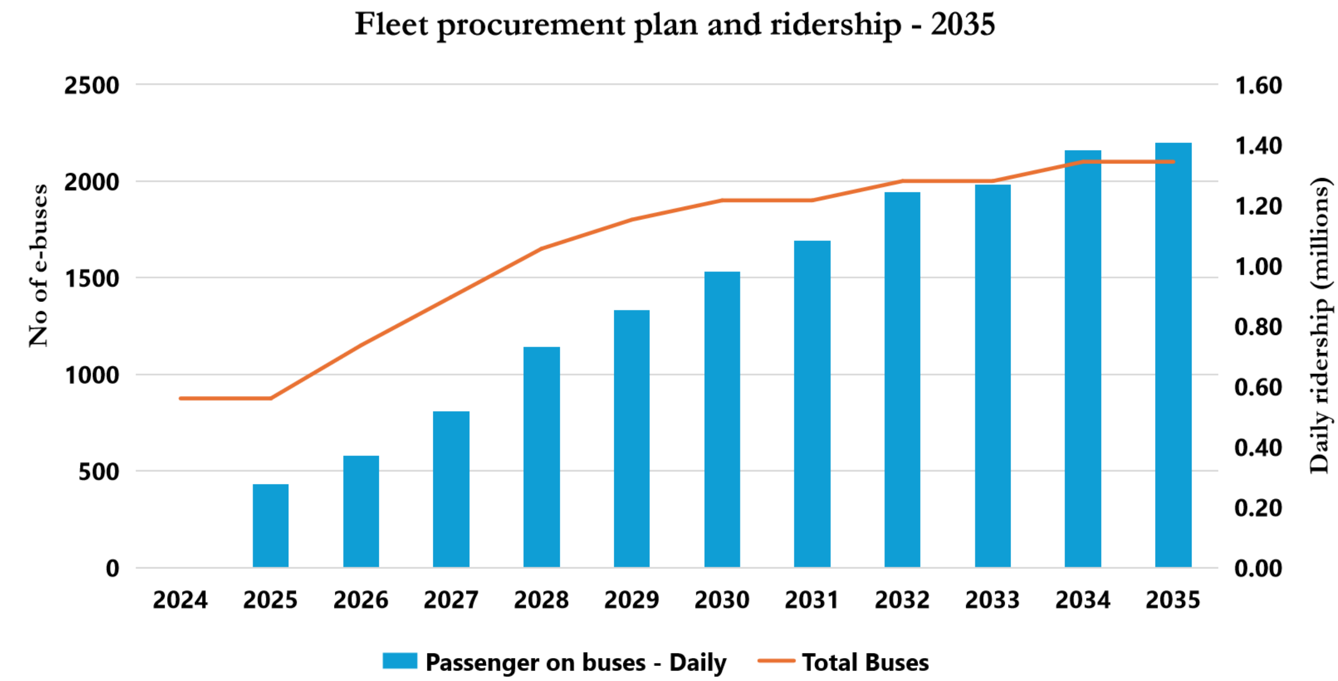


Table 8.4: Fleet procurement and ridership forecast

The proposed target for the city is to achieve a 15% modal share for public transport by the year 2035, approximately 15 lakh daily bus passengers. To achieve the target, rapid augmentation has been recommended in the initial four years from 2025 to 2028, to enhance the service frequency by attracting more passengers and improving the service quality. To support this growth, it is estimated that the city will need to procure approximately 1,200 e-buses within the first four years. Of these, 425 buses will serve as replacements for aging vehicles, while 775 buses will be net additions to the fleet. These buses are proposed to be acquired under the PM e-Drive scheme.

Year	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Total fleet size	875	875	1150	1400	1650	1800	1900	1900	2000	2000	2100	2100
Procurement against replacement	0	350	75	0	0	0	0	150	0	150	0	150
Bus augmentation – Net addition	0	0	275	250	250	150	100	0	100	0	100	0
Buses to be procured – Gross addition	0	350	350	250	250	150	100	150	100	150	100	150
12m buses (20% of total fleet – Only for BRT)		175	230	280	330	360	380	380	400	400	420	420
9m buses (80% of total fleet – BRT & City)		700	920	1120	1320	1440	1520	1520	1600	1600	1680	1680

Table 8.5: Fleet procurement plan by year 2035

SMC aims to procure only electric buses to promote green and sustainable urban transport, which raises questions about the financial assessment of the system.

8.3.2 Cost estimates of ICE bus vs E-bus operations

This section presents a comparative analysis of overall cost estimates for both ICE bus and e-bus operations through 2035. Various cost components have been examined to provide a comprehensive estimate for each option.

Historical trends in per-kilometre payments to bus operators have been assessed over five years for diesel and e-bus operations. The analysis reveals that the per-kilometre rate for diesel buses has increased at a Compound Annual Growth Rate (CAGR) of 4.4%, while for CNG buses, the rate has grown by 6.9%. In contrast, for e-buses have shown much lower growth, ranging from 1.4% to 1.7% CAGR.

Table 8.6 summarises the per-kilometre rates for different existing bus operators, such as AMTS and AJL in Ahmedabad. It is assumed that these rates reflect the Total Cost of Ownership (TCO), suggesting that a separate TCO analysis may not be necessary for estimating the aggregate costs of e-bus operations.

Bus Operator (AJL & AMTS)	Bus Type and Size	Rate (Rs) / km							CAGR
		2018	2019	2020	2021	2022	2023	2024	
CSPL	Diesel - 12m	52.65	55.36	57.19	64.70	63.85	65.08	68.27	4.4%
SMT	Diesel - 12m	52.65	55.36	57.19	64.70	63.85	65.08	68.27	4.4%
Travel Time	CNG - 12m			60.21	62.86	68.40	75.36	78.54	6.9%
Ashok Ley	EV - 9m				62.86	64.40	66.53	70.30	3.7%
Ashok Ley	EV - 9m				63.12	42.05	43.00	45.54	3.7%
VT e-Mobility (JBM)	EV - 9m				40.80	54.90	57.18	53.73	1.7%
Tata Motors	EV - 9m				54.90	54.90	54.90	57.19	1.4%

Table 8.6: Per-km rate trend for diesel and CNG bus operations, AMTS & AJL Ahmedabad

Note: Per-km rates of Surat are not compared because the cost of the diesel is being borne by the city authority, and hence, the operators are being paid at a lower rate.

Additionally, the overall unit rates for diesel, CNG, and electricity in Gujarat have been compared to analyse their rate of increase over the past decade. Diesel and CNG prices have risen by 5.4% and 7%, respectively, while electricity tariffs have increased by 1% to 1.3%. Using the rates trend observed in AJL and AMTS buses, the total cost for Surat fleet size has been calculated for 2035.

Below are the current unit rates for diesel and CNG in Gujarat, as well as the electricity tariff rates in Ahmedabad.

Year	Diesel/ litre (Rs)	CNG/ kg. (Rs)
2013	53.00	40.00
2014	55.49	43.49
2015	50.00	45.00
2016	56.00	47.00
2017	59.28	50.28
2018	63.32	52.32
2019	65.00	55.00
2020	70.68	55.00
2021	85.38	70.00
2022	86.38	75.00
2023	89.54	79.00
CAGR (2013-2023)	**5.38%**	**7.04%**
CAGR (2020-2023)	**8.20%**	**12.83%**

Source: Fuel rate, Gujarat, all the rates are in Rupees

Year	Rate in Rs (First 200 units)	Rate in Rs (Above 200 units)
2024-25	4.1	4.8
2023-24	4.1	4.8
2021-22	4.1	4.8
2018-19	4.1	4.8
2012-13	3.6	3.6
2011-12	3.5	4.25
CAGR	**1.3%**	**1.0%**

Source: Torrent power ltd., Ahmedabad

The purpose of this comparison is to understand the differences between diesel/CNG and electricity tariffs. The rates in Surat and Ahmedabad are expected to be almost equal, as currently observed.

Table 8.7: Unit rate of diesel, CNG and electricity tariff

Below is a detailed comparison of cost estimates for operating 2,100 diesel buses versus e-buses. The per-kilometre rates for both 12-meter and 9-meter diesel and CNG buses have been estimated based on trends computed from past data, as presented earlier in this section. According to the procurement plan, the total expense for operating 2,100 diesel buses is projected to be Rs 1,423 crores (€147 M), compared to Rs. 1,090 crores (€113 M), for electric buses in the year 2035. Interestingly, while e-bus operations initially appear more expensive, the lower growth rate in electricity tariffs has altered the future estimates. As a result, e-bus operations are projected to be 23% more economical compared to diesel bus operations.

Years	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Total Buses (procurement plan)	875	875	1150	1400	1650	1800	1900	1900	2000	2000	2100	2100
Buses to be procured		350	350	250	250	150	100	150	100	150	100	150
A. Cost for 12 m buses (Rs)												
Diesel buses (Rate /km)	68.27	71.29	74.45	77.75	81.18	84.77	88.52	92.44	96.53	100.83	105.26	109.92
E-Buses (Rate /km)	65.00	66.10	67.21	68.35	69.51	70.68	71.87	73.09	74.32	75.58	76.86	78.15
Total cost of operation (in Cr.) - Diesel buses		91.07	124.99	158.90	195.56	222.78	245.57	256.43	281.87	294.35	322.74	337.02
Total cost of operation (in Cr.) - E-Buses		84.44	112.85	139.71	167.44	62.77	199.38	202.75	217.02	220.69	235.64	239.62
B. Cost for 9 m buses (Rs)												
Diesel buses (Rate/km)	55.00	57.43	59.98	62.63	65.40	68.30	71.32	74.47	77.77	81.21	84.80	88.56
E-Buses (Rate/km)	57.73	58.61	59.70	60.71	61.73	62.77	63.84	64.91	66.01	67.13	68.26	69.41
C. Cost of Operations (Rs)												
Total cost of operation (in Cr.) - Diesel buses		293.49	402.79	512.06	630.20	712.92	791.34	826.35	908.34	948.53	1040.03	1086.06
Total cost of operation (in Cr.) – E-Buses		299.98	400.93	496.33	594.85	659.89	708.31	720.28	771.00	784.03	837.14	851.28
D. Total Cost (Rs)												
Total Cost (in Cr.) - Diesel Buses		384.56	527.79	670.96	825.77	940.77	1036.90	1082.79	1190.21	1242.88	1362.77	1423.08
Total Cost (in Cr.) - E-Buses		384.43	513.78	636.04	762.28	845.63	907.69	923.03	988.03	1004.72	1072.78	1090.90
% Difference between Diesel & E-Buses		100%	97%	95%	92%	90%	88%	85%	83%	81%	79%	77%

It is to be noted that the cost estimates only account for operator payments; excluding expenses related to AFCS, ITMS, or the depot and terminal infrastructure necessary for the bus operations.

Table 8.8: Future bus procurement plan with cost estimates - Diesel vs e-buses

8.3.3 Depot infrastructure cost estimates

Depots are the supporting infrastructure for bus operations and must be planned with careful consideration. Currently, each depot accommodates approximately 75 to 80 buses, which is considered an optimal fleet size per depot. This benchmark is projected to be maintained for future planning to ensure operational manageability and cost-effectiveness.

Since e-bus depots require both electrical and civil infrastructure, their costs differ from conventional depot. For the deployment of 2,100 e-buses, the city would require around 29 depots

The estimated cost of constructing one depot is Rs 21 crore (€2.33 M) as per current year figures, with references drawn from cities of PM e-Bus Sewa Scheme, Gujarat Urban Development Mission (GUDM), and the Government of Gujarat. Of the total estimated cost, 25% to 30% is allocated to Behind the Meter (BTM) power infrastructure. The cost estimates consider both new depot construction and the conversion of existing ICE depots to support e-bus operations.

The table below presents the breakdown of cost estimates for the power infrastructure BTM and civil infrastructure.

Years	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Total Buses (procurement plan)	875	875	1150	1400	1650	1800	1900	1900	2000	2000	2100	2100
Buses to be procured		350	350	250	250	150	100	150	100	150	100	150
Number of e-depot required)	11	14	15	17	19	21	23	25	26	27	28	29
Buses/ depot	80	63	77	82	87	86	83	76	77	74	75	72
Additional e-depots (no.)		3	1	2	2	2	2	2	1	1	1	1
Total cost for e-bus depot (Rs in crore)		60.00	21.00	44.10	46.31	48.62	51.05	53.60	28.14	29.55	31.03	32.58
Behind the Meter Power Infrastructure (Rs in crore) (DISCOM, Substations, HT-LT panels, the foundation for sub-station, etc.)		15.60	5.46	11.47	12.4	12.64	13.27	13.94	7.32	7.68	8.07	8.47
Depot civil infrastructure (Rs in crore) (Admin building, pits, CC floor for parking, washing yard, water tank, fire safety, driver training room, etc.)		44.40	15.54	32.63	34.27	35.98	37.78	39.67	20.83	21.87	22.96	24.11

Table 8.9: Future year - Cost estimates for depot infrastructure (2025-2035)- 2025 to 2035

8.3.4 Financial impact assessment

A financial impact assessment was conducted with cost and revenue estimates. A financial model has been developed that considers all types of costs associated with operations, as well as the revenues generated, to understand the significant burden on the city authority.

In the case of Surat, the operation of e-buses will be a cost-effective alternative to diesel-powered buses in long run. The city will be benefitted from two types of funding support:

- Capital subsidy through PM e-DRIVE
- Operations Viability Gap Funding (VGF) from the Government of Gujarat (GoG) under the Chief Minister Urban Bus Scheme (CMUBS).

This approach contrasts with the TCO analysis. In this approach the per-kilometre rate paid to the operator has been compared and planned to expand the fleet size over the years. This expansion is expected to provide broader coverage and more frequent services. As a result, it is expected to increase the ridership and revenue, estimates based on the planning principles.

Key financial performance parameters in this context are explained below:

- **Cost of e-bus operations:** Instead of conducting a detailed TCO analysis, the study uses the trend of the per-kilometre payment made to the operator as a baseline. The trend is used to forecast future cost and derive aggregate estimates for e-bus operations. An additional 15% is added to the operator's payment rate for Automatic Fare Collection System (AFCS) and Intelligent Transportation Management System (ITMS) on a per-kilometre basis to determine the total operational costs.
- **CPKM:** The total per-kilometre rate for vehicle operations is referred to as Cost Per Kilometre (CPKM). This has also been projected using an escalation rate derived from the past trends.
- **Load Factor (LF):** The load factor (LF) is defined as the ratio of passenger kilometres supplied to passenger kilometres demanded. A load factor of 60% is considered indicative of a sound public bus transport system. It is assumed that the city will achieve a load factor of 55%-60% by 2035, improving from the current 20% over the next ten years through enhanced service quality.
- **Trip length:** This refers to the average distance travelled by passengers using public transport. It is significant parameter, as it influences fare and revenue estimates. Given the city's development, the average trip length is expected to grow from 7 km to 9 km by 2035, although at a slow pace.
- **EPKM:** Earning per km (EPKM) is calculated as the ratio of total revenue collected to total vehicle kilometres operated. It is calculated based on total ticketing revenue. It is assumed that fares will increase by 10% every two years to reduce losses, considering the city's affordability.
- **EPKM/ CPKM ratio:** This ratio compares EPKM and CPKM, illustrating the recovery of total costs incurred in the system.
- **Gap per kilometre:** After revenue collection, any remaining gap that needs to be covered for operational costs is represented as gap per vehicle kilometre.
- **Viability Gap Funding (VGF) per km:** The GoG provides operational support through VGF per kilometre under the CMUBS. This VGF is capped at Rs 30 of the gap per kilometre or 60% of the gap per kilometre, whichever is lower. The total gap will be funded by GoG under the CMUBS for the city authority.

Table 8.10 below presents the financial impact assessment for e-bus operations from 2025 to 2035. Additionally, as noted earlier, the city will need to invest in depot infrastructure, including BTM power infrastructure and civil infrastructure. It has been observed that with the increase in fleet size and improvements in service quality, public transport ridership, and consequently revenue, are expected to rise. The financial impact assessment of overall e-bus operations indicates that the city's outlay will decrease to approximately Rs 115 crore (€12.78 M) annually, assuming the VGF criteria remain unchanged and public transport service quality improves.

Furthermore, it is recommended that the city should prepare a comprehensive Service and Business Plan (SBP) for bus operations. This plan will address efficient service planning, strategies to enhance service quality, and a framework for monitoring service performance to ensure that that the service standards are consistently improved.

Years	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Total Buses (procurement plan)	875	875	1150	1400	1650	1800	1900	1900	2000	2000	2100	2100
Buses to be procured		350	350	250	250	150	100	150	100	150	100	150
Cost (Rs in Cr) - Payment to operators		384.43	513.78	636.04	762.28	845.63	907.69	923.03	988.03	1004.72	1072.78	1090.90
Total cost (Rs in Cr) of operations – E-Bus(Including additional 15% cost on ITMS, AFCS, and other maintenance)		453.62	606.26	750.53	899.49	997.85	1071.08	1089.17	1165.87	1185.57	1265.88	1287.27
CPKM (Cost/km)		71.02	72.22	73.44	74.68	75.94	77.22	78.53	79.85	81.20	82.58	83.97
Load factor		0.22	0.23	0.27	0.33	0.36	0.40	0.45	0.50	0.52	0.55	0.57
Trip length – km (assumed for future year)		7.00	7.15	7.30	7.45	7.60	7.75	7.90	8.05	8.20	8.35	8.50
Daily passengers (in lakhs)		2.75	3.70	5.18	7.31	8.53	9.81	10.82	12.42	12.68	13.83	14.08
Avg. fare (Rs)		13.00	13.00	14.00	14.00	15.00	15.00	17.00	17.00	19.00	19.00	21.00
EPKM (Rs)		20.43	20.91	25.89	31.01	35.53	38.71	48.42	52.80	60.24	62.57	70.41
EPKM/ CPKM		0.29	0.29	0.35	0.42	0.47	0.50	0.62	0.66	0.74	0.76	0.84
Gap/ km (CPKM – EPKM) Rs		50.59	51.31	47.55	43.67	40.41	38.51	30.11	27.06	20.96	20.00	13.56
VGF/ km (min. 60% of gap or Rs.30)		30.00	30.00	28.53	26.20	24.25	23.11	18.07	16.24	12.58	12.00	8.14
A. Amount – SMC needs to spend on actual e-Bus operations (Rs in crore)		131.51	178.88	194.37	210.41	212.41	213.67	167.05	158.03	122.40	122.64	83.14
B. Total cost for e-bus depot (Rs in crore)		60.00	21.00	44.10	46.31	48.62	51.05	53.60	28.14	29.55	31.03	32.58
Total amount to be spent on Public Transport operations and depot infrastructure (Rs in crore) (A+B)		191.51	199.88	238.47	256.71	261.03	264.72	220.65	186.17	151.95	153.67	115.72

Table 8.10: Financial impact assessment (2025-2035)2025 to 2035

8.4 Summary

To meet the target of achieving a 15% PT modal share by 2035, from the current 3% as of 2024, the city is projected to require a total of about 2100 e-buses. This growth will necessitate a significant scale-up in infrastructure, operations, and strategic planning. A financial assessment indicates that while e- bus operations currently appear to be a costlier option, achieving 100% electrification by 2035 would be economical by 20-25% reduction in the total cost investment. To accommodate the 2100 fleet size, the city will require a total of 29 e-bus depots at various locations, necessitating a capital investment of Rs 450 crore (€50 M) by 2035 as per the present value.

Considering the capital funding subsidy from GoI and the VGF from the GoG, the total expenditure for the city by 2035 is estimated to be around Rs 1,800 crore (€200 M). This projection assumes a fare revenue source based on a 60% load factor by 2035.

It is recommended that the city focus on improving public bus transport service standards to achieve a 60% load factor by 2035, which will require an increase in the fleet size. Additionally, to qualify for the capital subsidy from the GoI under the PM e-DRIVE initiative, the city should propose acquiring 1,200 e-buses by 2028. This acquisition would enhance frequency and help to meet the desired service standards.

Furthermore, the city should consider conducting a study on SBP for e-bus operations to streamline planning and operations.

09

Conclusion and Recommendations

The E-Bus Transition Plan for Surat is a comprehensive examination that reviews various plans and policies related to e-bus operations. It includes an assessment of the base situation of e-bus operations, identifies key performance challenges, and outlines action areas for improvement. The study also presents, a roadmap for achieving 100% - transition to e-buses, along with infrastructure planning and investment recommendations. The study begins with several key questions aimed at addressing the e-bus situation in Surat, and the insights gained from this study can be applied to other Indian cities.

A. Status of e-bus operations' performance and recommended action areas

The city has a unique experience of e-bus operations, collaborating with three different operators with varying specifications for e-buses and chargers. The city's operational insights provide valuable learnings that can help enhance efficiency.

Currently, the percentage of non-revenue kilometres (dead kilometres) is moderate at 6% and managed effectively by introducing shuttle trips. However, shuttle trips, now accounts for 16% of total vehicle kilometres travelled, leading to frequent transfers that can cause inconvenience for passengers. Managing dead kilometres by relying on shuttle trips may not be the most feasible solution in city bus services, due to the presence of curb side bus stops. Therefore, to address this issue, the study recommends implementing at depot-level and on-road opportunity charging infrastructure at various locations.

As key outcomes of the study, four depot locations and three on-road locations have been identified for opportunity charging under short term action areas. These changes will bring significant benefits to the existing e-bus operations, as outlined below:

- Total daily savings of 1870 dead kilometres are projected, resulting in savings of Rs 30 crore (€3.119 M) by 2035.
- Over 5,000 km of shuttle trips will be eliminated, reducing shuttle trips by 40%, leading to increased frequency of services.
- This improvement will enhance travel convenience for over 17,000 existing passengers by minimising unnecessary transfers due to shuttle trips.
- An increase in revenue kilometre by 15% in BRT bus operations is expected, equating to approximately 6,900 kms by reducing dead-kilometre and shuttle kilometre through the implementation of opportunity charging facilities.
- Increasing the bus supply will enhance service standards by improving the frequency and thereby will boost ridership. The implementation support for Sachin's on-route opportunity charging is projected to improve the headways from 6.5 min to 5 min during peak hours, which is significant from the passengers' perspective.

As discussed earlier, Surat operates with a variety of battery sizes, and performance of different buses varies in terms of efficiency. The choice of battery size has significant implications for cost economics, and the range of vehicle kilometres travelled.

The study recommends, an optimal battery size for midi buses within the range of 190 kWh to 220 kWh. This assessment is based on the existing average utilisation of 200 to 220 vehicle kilometres in urban bus services. This recommendation aims to achieve the desired average vehicle utilisation along with implementing strategically planned opportunity charging facilities at the key locations, thereby aligning with favourable cost economics regarding the per-kilometre rate.

However, for longer routes that are connecting the peripheral urban areas with the city centre, a larger battery size will be necessary, depending on route length, passenger demand and available road width. JBM 12 m buses, equipped with a 261 kWh battery, provides a higher range, averaging over 220 km in a single charge at 80% SoC. Their utilisation has been constrained due to 12 m size of bus, which limits their operations to BRT corridors. Standard buses necessitate larger battery sizes, resulting in increased per-kilometre rates. Therefore, standard (12 m) electric buses could be effectively deployed on high-demand routes, provided pre-feasibility assessments confirming their operational viability.

In contrast, Greencell buses, utilising a lower battery size of 151 kWh for midi buses, exhibit considerable dead kilometres and shuttle kilometres—approximately 28%, raising concerns regarding the operational efficiency. These buses frequently fail to complete full trips, necessitating their return to the depot for opportunity charging. This requirement complicates scheduling, extends travel time, and demand additional buses to uphold peak service frequencies. Thus, it is imperative to select the appropriate bus type, particularly the battery size and charger specifications, and optimal fleet assignment to the suitable routes.

Comprehensive operational planning is critical for the effective management of e-bus operations, ensuring synchronisation between operational planning, infrastructure facility locations, and the specifications of buses (batteries and charging systems). Considering the existing e-bus operations, it is recommended to formulate a Service and Business Plan (SBP) for efficient e-bus operations within the city.

During the initial procurement phase for e-buses in the city, there was notable variability in contractual conditions. Based on the lessons learned from these experiences, there is a robust recommendation for standardisation in the contracts related to e-bus procurement. Such contracts should serve as a definitive reference for bus operations and are essential for enhancing operational efficiency. To facilitate smoother operations and flexible scheduling, it is advisable to standardise charging infrastructure specifications, incorporate clauses for the sharing of BTM power infrastructure, enable the establishment of opportunity charging facilities, and ensure access to e-bus and battery performance data, among other considerations.

B. Future strategy for 100% E-Bus Transition

The city aims for 100% electrification of its public bus transportation by 2035, with a comprehensive transition plan that includes fleet procurement, infrastructure development, and a financial impact assessment. The goal is to increase the public bus transport share from 3% to 15%. To achieve this, the city plans to procure approximately 2,100 e-buses by 2035 in phases, addressing both fleet replacement and additional needs.

As part of the phasing plan, 29 strategic locations have been identified for the development of depot charging infrastructure to accommodate the growing e-bus fleet. The specific sites for depot locations will be determined through the SBP for bus operations, which will analyse route alignment, frequency, and bus specifications.

The financial assessment indicates that while e-bus operations may initially seem costlier, they are expected to become 20-25% cheaper than ICE bus by 2035 due to rising fuel prices. Additionally, both the Government of India and the Government of Gujarat provide substantial support through capital subsidies and VGF to facilitate this electrification initiative

- Considering the capital funding from the GoI and the VGF from the GoG, the city will need to allocate approximately Rs. 1,800 crores (€1,870 M) for e-bus operations and Rs 450 crores (€467 M) for developing depot infrastructure over the next ten years, until 2035.

- To improve the service standards, it is recommended that the city increases its fleet size, which will help boost the overall ridership. Achieving the targeted, 15% share of PT is expected to translate into about 1.5 million daily passengers, based on an estimated 60% load factor by 2035.

- It is also recommended that the city procure 1,200 e-buses by 2028. This initiative is crucial for enhancing service quality in the initial phase of the transition plan and can encourage ridership growth early in the implementation process.

- Additionally, the city may propose a study on the Service and Business Plans for e-bus operations to optimise operational planning.

Promoting e-buses as a viable alternative to diesel buses is essential, especially since some e-buses are already surpassing diesel buses in terms of range. Emphasising on the environmental benefits, such as reduced emissions and noise pollution, alongside potential long-term cost savings, will further encourage the transition to electric mobility. Integrating the supportive infrastructure, including fast chargers and better route planning, is essential to maximise the potential of electric buses in urban transit systems.

Annexures

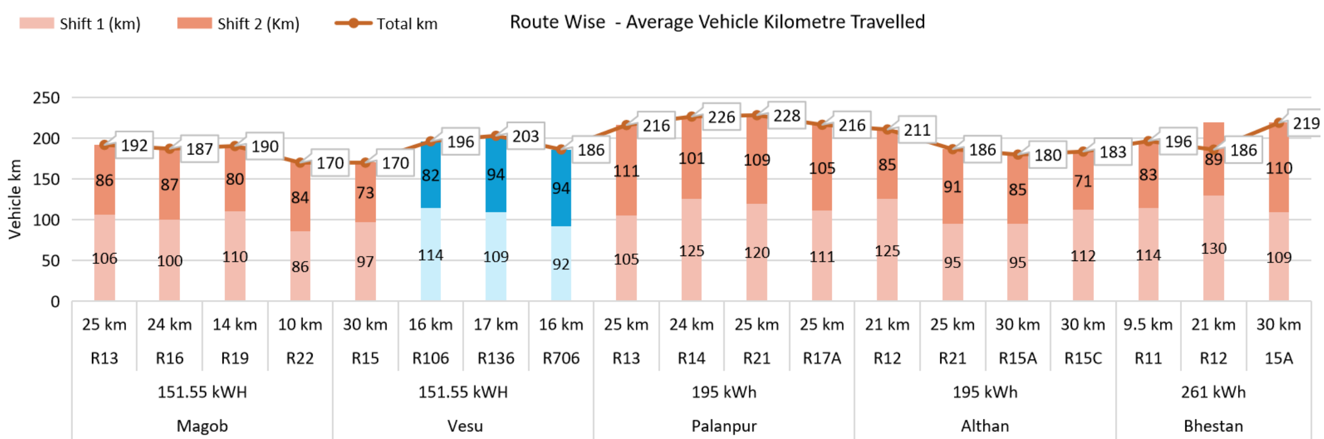
Annexure I: List of city bus

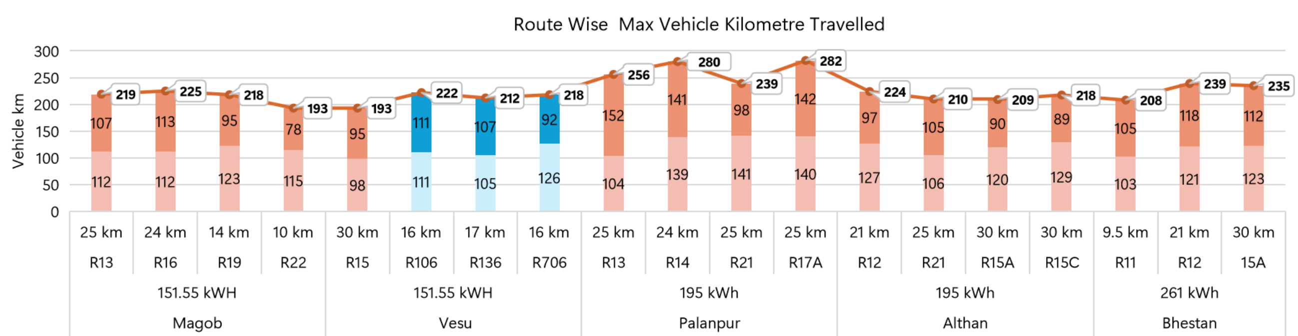
Sr no	Route No	Route Name	Length-km	Peak Head-way-min
1	01	Adajan G.S.R.T.C. Loop (Clockwise)	13	15
2	102R	Railway Station - Moti Ved	8	20
3	103K	Railway Station - Kathor Gam	17	90
4	103S	Railway Station East - Shek-hpur Gam	20	20
5	103V	Railway Station East - Ve-lanja Gam	19	26
6	104	Railway Station Terminal - Saniya Kande	10	8
7	105	Railway Station - Chikuwadi	13	8
8	106R	Railway Station - Abhva Gam	17	18
9	107J	Railway Station - Vivekanand College	15	15
10	112	Railway Station-Kosad Gam	13	12
11	116BR	Railway Station - Khajod Gam	15	36
12	116R	Railway Station - Khajod Gam(Via Ring Road)	14	26
13	117	Railway Station - Suman Jyot EWS	14	18
14	118	Railway Station - Sayan Railway Station	18	20
15	126R	Railway Station - V.N.S.G. University	11	23
16	127J	Railway Station - Rander Gam	9	90

17	136	Railway Station - Airport	16	20
18	137J	Railway Station - Variav Gam	15	16
19	147J	Railway Station - Green City Bhatha	14	45
20	153R	Umra Gaam - Kapodra(Via Ring Road)	16	23
21	202J	Chowk - Akhand Anand Society	7	23
22	204	Chowk - Raj Empire Go-dadara	13	20
23	205G	Chowk - Gabheni	21	60
24	205K	Chowk Terminal - Lajpore Jail	22	15
25	205S	Chowk Terminal - Sachin Railway Station	26	180
26	206	Chowk - C.K.Pithawala Eng. College	20	45
27	207E	Chowk Terminal - Vaish-nodevi Sky	9	45
28	209J	Dr Sp Mukher Br - Vruksh-laxmi Soc	19	18
29	212J	Chowk Terminal - Variav Gam	16	14
30	213	Dabholi Gam - Sarthana Nature Park	16	23
31	216B	Chowk - Bhimpore	17	60
32	216K	Chowk - Kaadi Faliya Du-mas	19	45
33	217	Makkai Pool - Bhesan Gam	13	90
34	217M	Makkai Pool - Bhesan Gam	14	90
35	226J	Kosad Gam - VNSG Univer-sity	21	26
36	254	Katargam - Limbayat	16	18
37	302	Kharwarnagar - Dabholi	10	90

38	302V	Kharwarnagar -Ved Gam	9	180
39	305	Kharwar Nagar - Unn Indus-trial Estate	12	20
40	315	Kharwar Nagar - Bhestan Garden	12	30
41	315B	Kharwar Nagar - Bhestan Garden (Via Bamroli)	8	90
42	402	Parvat Patiya - Mansarovar Circle	14	23
43	403	SMC Ward Office Limbayat – Sankalp Residency	15	20
44	410C	Utran Station - Utran Station (Clockwise)	19	26
45	413	Nilgiri Circle Limbayat - Sart-hana Nature Pa	14	90
46	504	Amazia Amusement - Bhes-tan Garden	16	30
47	505	Milan Point Bamroli - Budiya Gam	12	-
48	505C	Chiku Wadi - Budiya Gam	8	180
49	506	Dindoli - V.N.S.G University	14	30
50	658	Adajan GSRTC - Icchapor	10	90
51	706	Iskcon Circle - VNSGU	16	23
52	716	Gail Colony Vesu - Jahan-girpura	23	30
53	903	Pasodara Yogi Chowk	10	26

Annexure II: Route wise vehicle utilisation by shift with different battery size (existing)



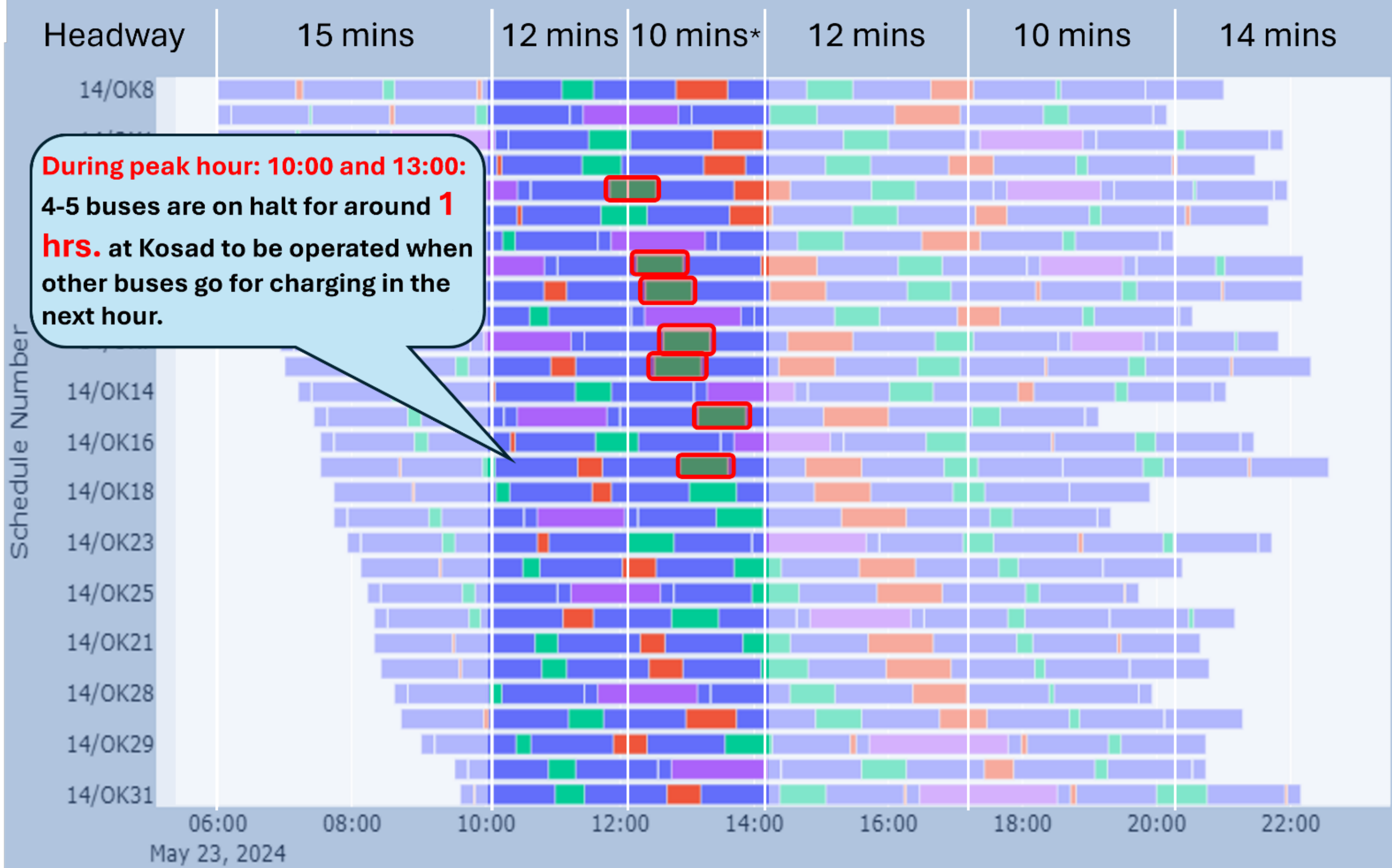


Annexure III: Replacement Ratio- Gantt chart of Palanpur (195 kWh battery size)

Illustration: Route 14: ONGC COLONY to KOSAD EWS H2 – **Battery size 195kWh**

Terminates at intermediate stop and going for opportunity charging
Halt at the start location – ONGC Colony
Halt at the end terminal - Kosad
Revenue trip on route

Existing Bus schedule

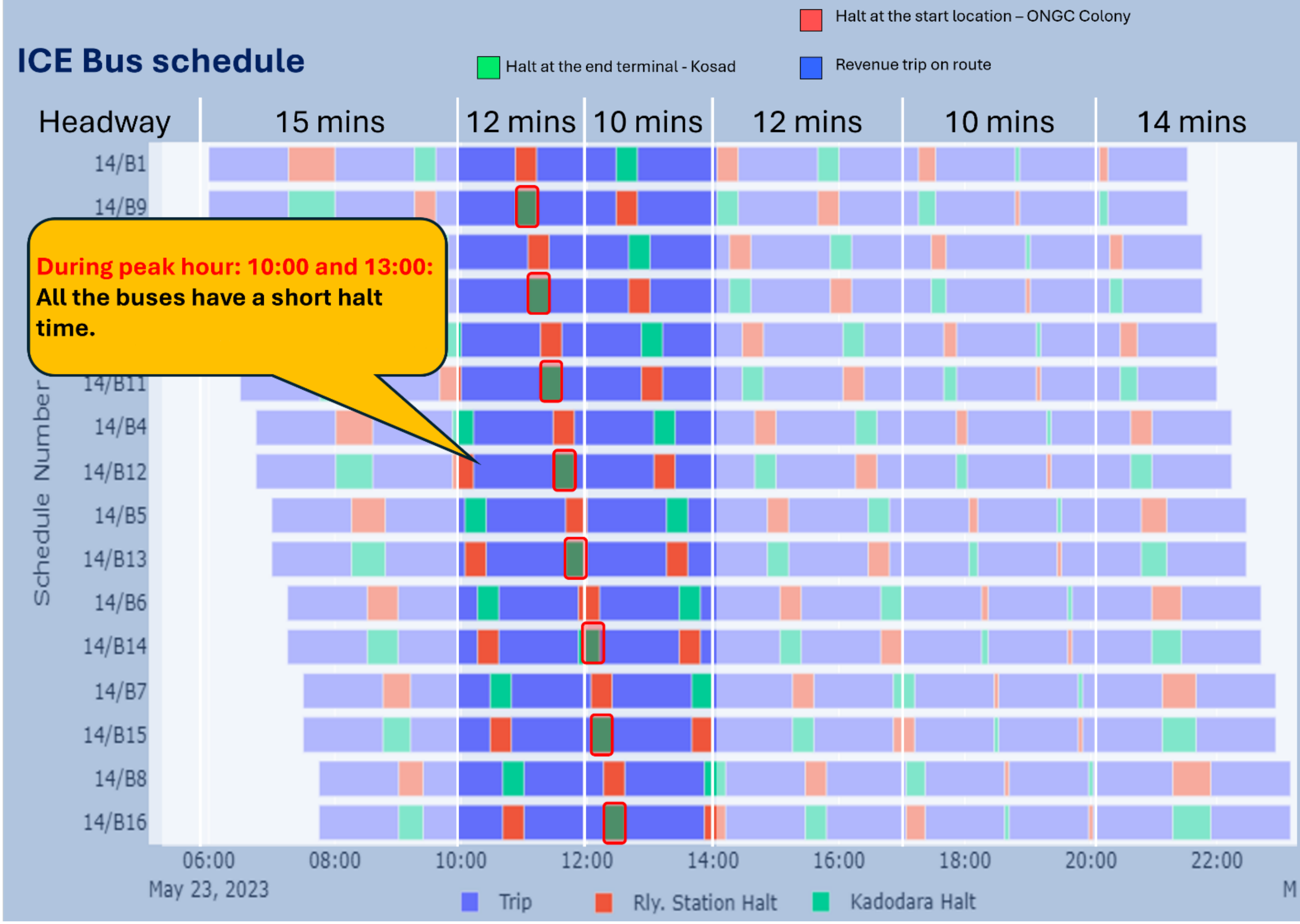


Bus	Halt time	Run time	Total time	Halt time %
OK1	05:17	10:36	15:53	13.85%
OK2	03:43	10:26	14:09	16.25%
OK3	05:08	10:37	15:45	14.39%
OK4	03:25	10:26	13:51	14.56%
OK5	05:03	10:32	15:35	15.08%
OK6	03:16	10:28	13:44	13.35%
OK7	04:50	10:03	14:53	16.57%
OK14	03:12	10:38	13:50	13.73%
OK15	03:37	08:05	11:42	19.52%
OK16	03:16	10:39	13:55	13.17%
OK22	03:29	08:06	11:35	18.85%
OK23	03:12	10:35	13:47	12.33%
OK25	03:24	08:06	11:30	17.97%
OK27	03:08	09:42	12:50	12.73%
OK28	03:12	08:06	11:18	15.19%
OK29	03:50	07:52	11:42	15.10%
OK30	03:07	08:05	11:12	15.03%
OK31	04:35	07:57	12:32	20.21%
Avg:	**03:49**	**09:29**	**13:19**	**15.44%**

** Headway is low due to more short trips for opportunity charging.*

Route 14: ONGC COLONY to KOSAD EWS H2 – **Battery size 195kWh**

ICE Bus schedule

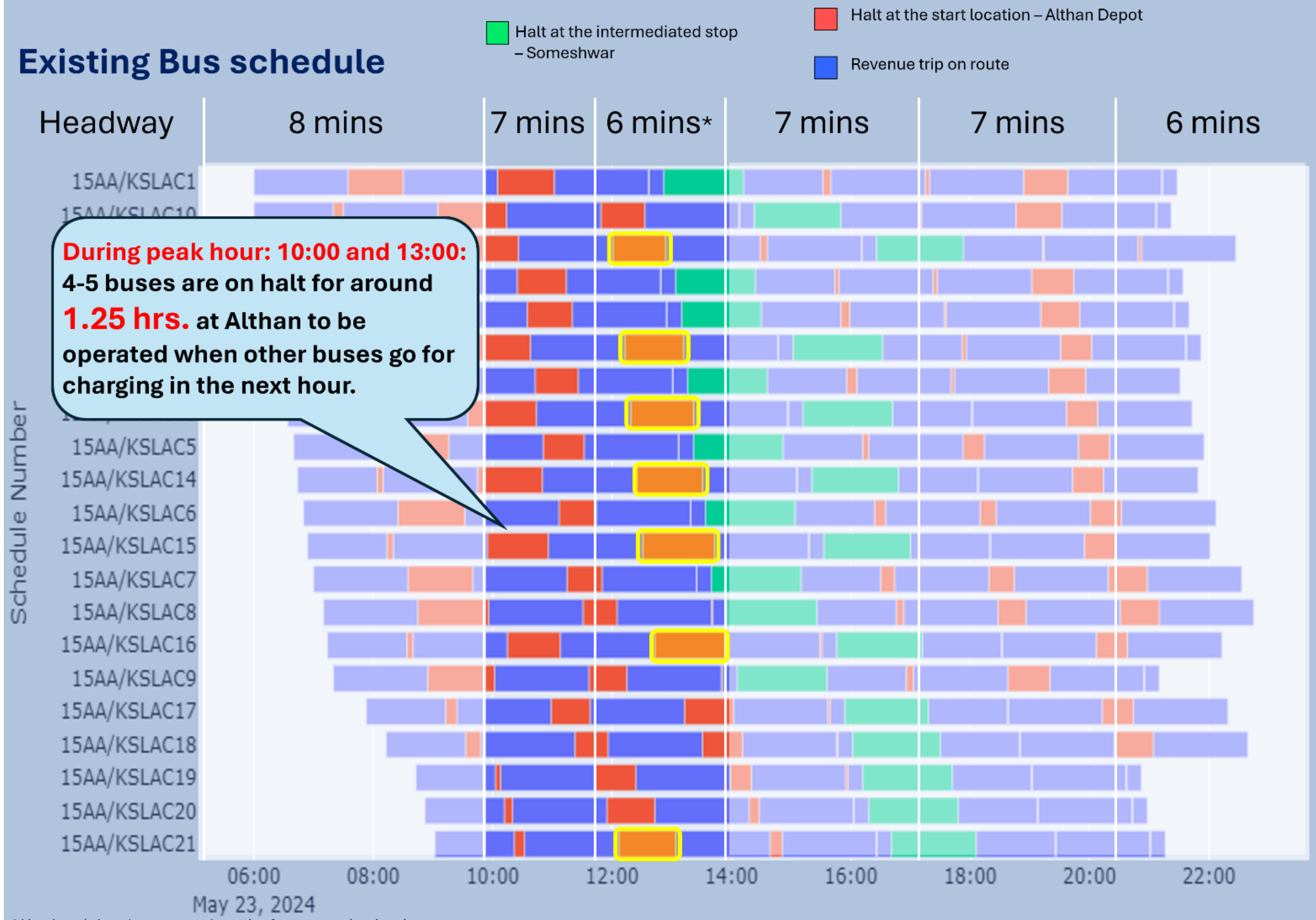


Bus	Halt time	Run time	Total time	Halt time %
B1	02:52	12:40	15:32	18.45%
B2	02:51	12:40	15:31	18.37%
B3	02:50	12:40	15:30	18.28%
B4	02:49	12:40	15:29	18.19%
B5	02:48	12:40	15:28	18.10%
B6	02:47	12:40	15:27	18.02%
B7	02:46	12:40	15:26	17.93%
B8	02:45	12:40	15:25	17.84%
B9	02:52	12:40	15:32	18.45%
B10	02:51	12:40	15:31	18.37%
B11	02:50	12:40	15:30	18.28%
B12	02:49	12:40	15:29	18.19%
B13	02:48	12:40	15:28	18.10%
B14	02:47	12:40	15:27	18.02%
B15	02:46	12:40	15:26	17.93%
B16	02:45	12:40	15:25	17.84%
Avg:	**02:48**	**12:40**	**15:28**	**18.15%**

Annexure IV: Replacement Ratio- Gantt chart of Bhestan (261 kWh battery size)

Illustration: Route 15: ALTHAN DEPOT to ALTHAN DEPOT – **Battery size 261kWh**

Existing Bus schedule



Bus	Halt time	Run time	Total time	Halt time %
KSLAC1	04:08	11:20	15:28	26.72%
KSLAC10	04:17	11:05	15:22	27.87%
KSLAC11	03:52	12:25	16:17	23.75%
KSLAC12	04:23	11:05	15:28	28.34%
KSLAC13	04:19	10:50	15:09	28.49%
KSLAC14	04:15	10:50	15:05	28.18%
KSLAC15	04:17	10:50	15:07	28.34%
KSLAC16	04:09	10:50	14:59	27.70%
KSLAC17	03:36	10:50	14:26	24.94%
KSLAC18	03:36	10:50	14:26	24.94%
KSLAC19	02:39	09:30	12:09	21.81%
KSLAC2	04:04	11:20	15:24	26.41%
KSLAC20	02:36	09:30	12:06	21.49%
KSLAC21	02:44	09:30	12:14	22.34%
KSLAC3	04:00	11:20	15:20	26.09%
KSLAC4	03:56	11:05	15:01	26.19%
KSLAC5	04:10	11:05	15:15	27.32%
KSLAC6	04:12	11:05	15:17	27.48%
KSLAC7	04:28	11:05	15:33	28.72%
KSLAC8	04:30	11:05	15:35	28.88%
KSLAC9	04:05	09:45	13:50	29.52%
Avg:	**03:55**	**10:49**	**14:44**	**26.45%**

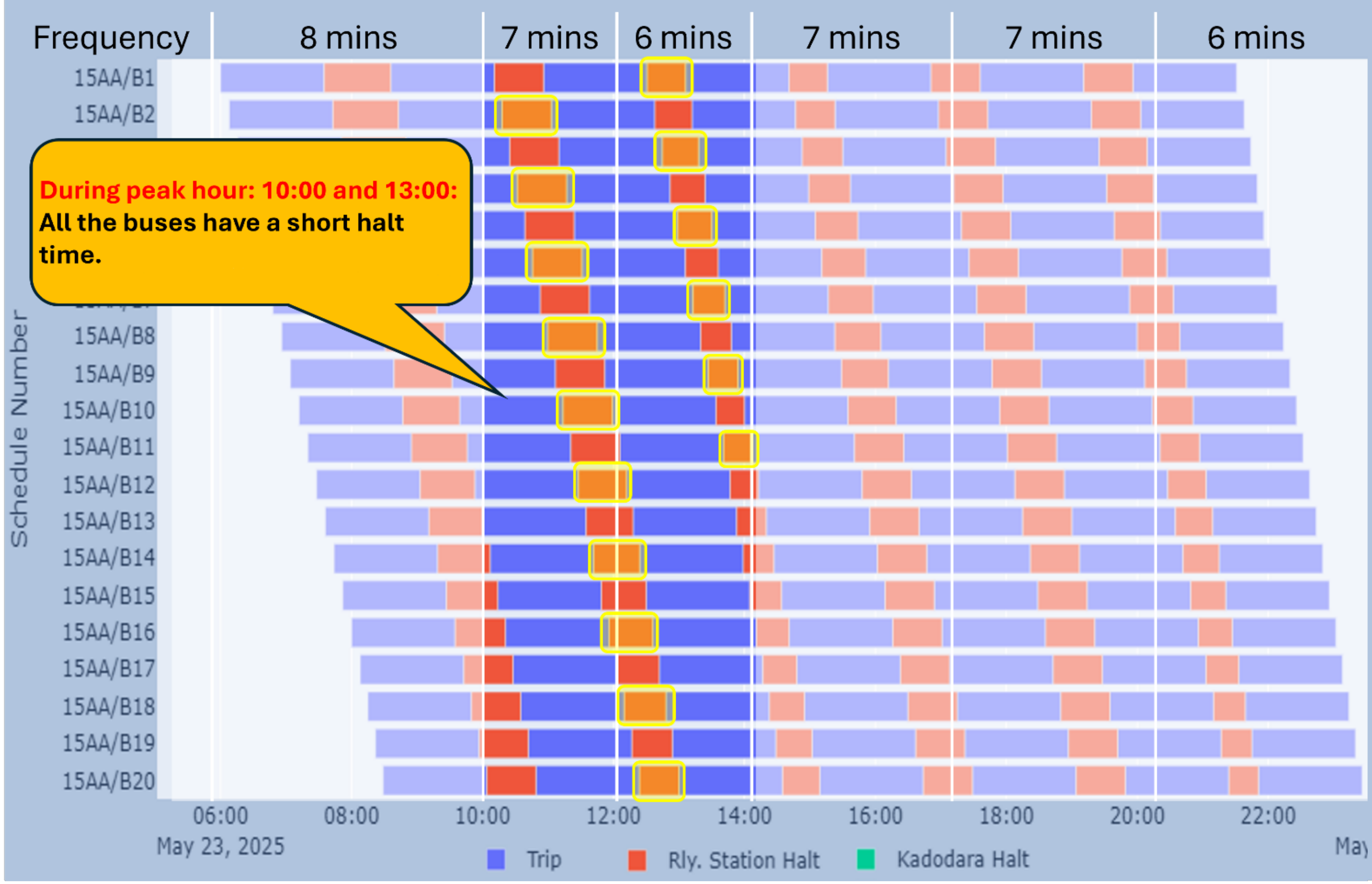
** Headway is low due to more short trips for opportunity charging.*

Route 15: ALTHAN DEPOT to ALTHAN DEPOT – **Battery size 261kWh**

ICE Bus schedule

Halt at the start location – Althan Depot

Revenue trip on route



Bus	Halt time	Run time	Total time	Halt time %
B1	04:26	11:05	15:31	28.57%
B2	04:25	11:05	15:30	28.49%
B3	04:23	11:05	15:28	28.34%
B4	04:21	11:05	15:26	28.19%
B5	04:19	11:05	15:24	28.03%
B6	04:17	11:05	15:22	27.87%
B7	04:15	11:05	15:20	27.72%
B8	04:13	11:05	15:18	27.56%
B9	04:11	11:05	15:16	27.40%
B10	04:09	11:05	15:14	27.24%
B11	04:07	11:05	15:12	27.08%
B12	04:05	11:05	15:10	26.92%
B13	04:03	11:05	15:08	26.76%
B14	04:01	11:05	15:06	26.60%
B15	03:59	11:05	15:04	26.44%
B16	03:57	11:05	15:02	26.27%
B17	03:55	11:05	15:00	26.11%
B18	03:54	11:05	14:59	26.03%
B19	03:53	11:05	14:58	25.95%
B20	03:52	11:05	14:57	25.86%
Avg:	**04:08**	**11:05**	**15:13**	**27.17%**

Annexure V: Proposed strategic public transport network map and depot location (2035)

Disclaimer: This geographical map is for informational purposes only and does not constitute recognition of international boundaries or regions; GIZ makes no claims concerning the validity, accuracy or completeness of the maps nor assumes any liability resulting from the use of the information therein

Annexure VI: Proposed tentative list of BRT and city bus routes (2035)

Sr No	Status	Route ID	Length (km)	Route Origin- Destination	Headway (min)	Fleet size	Total passenger
Bus Rapid Transit (BRT) Routes							
1	Existing	11	9.5	Udhana-Sachin G.I.D.C	3	26	22286
2	Existing	12	20.5	ONGC - Sarthana Nature Park	3	54	46286
3	Existing	13	25	Jahangirpura Community Hall-Kadodara	3	53	45429
4	Existing	14	24	ONGC Colony To Kosad Ews H2	3	66	56571
5	Existing	16	28	Kosad Depot-Sachin G.I.D.C.	3	66	56571
6	Existing	18	6.1	Railway Station-Utran RoB	10	8	6857
7	Existing	19	16	Railway Station-Kadodara	7	18	15429
8	Existing	20	13	Kharwarnagar - Kosad	7	14	12000
9	Existing	21	25.3	Jahangirpura Community Hall - Althan Terminal	3	112	96000
10	Existing	22	12	Kosad EWS H2 - Sarthana Nature Park BRTS	8	16	13714
11	Existing	23	32.5	Kamrej Terminal - Sachin Railway Station	3	74	63429
12	Existing	15AA	30	Althan Depot - Althan Depot (Alticlockwise)	5	44	37714
13	Existing	15C	31	Someshwar-Someshwar Clockwise	3	76	65143
14	Existing	17A	23.5	Kamrej Terminal - Pal Rto	3	54	46286
City Bus Routes							
15	Existing	1	13	Adajan GSRTC to Adajan GSRTC	10	13	7163
16	Existing	104	10	Railway Station - Vrukshlaxmi Society	5	22	12122
17	Existing	105	13	Railway Station - Chiku Wadi	5	26	14327
18	Existing	112	13	Railway Station - Kosad Gam	5	33	18184
19	Existing	136	16	Railway Station - Surat Airport	7	23	12673
20	Existing	204	13	Chowk - Raj Empire Godadara	10	13	7163
21	Existing	206	29	Chowk - C.K.Pithawala Eng.College	10	27	14878
22	Existing	213	16	Dr S.P Mukher Brid -Purushottam Nagar	10	16	8816

23	Existing	254	16	Suman Darshan - Mangal Pandey Hall Godadara	10	16	8816
24	Existing	302	10	Kharwarnagar Brt - Dabholi Gaam Approach	10	11	6061
25	Existing	305	12	Kharwar Nagar - Unn Indus-trial Estate	10	12	6612
26	Existing	315	12	Kharwar Nagar - Bhestan Garden	10	12	6612
27	Existing	402	14	Magob Gam - Utran Rail-way Station	8	16	8816
28	Existing	403	34	Smc Ward Office Limbayat -Sankalp Residency	7	43	23694
29	Existing	413	14	Smc Ward Office Limbayat -Sarthana Nature Park	10	14	7714
30	Existing	504	16	Amezia Amuzement Park -Bhestan Garden	10	15	8265
31	Existing	506	14	Sunrise Vidyalay Dindoli - Vesu Gam	10	13	7163
32	Existing	658	11	Adajan G.S.R.T.C. - Mora Char Rasta	10	11	6061
33	Existing	706	16	Iskcon Circle - V.N.S.G. University	8	19	10469
34	Existing	716	46	Sai Pujan Residency -Gail India Ltd Vip Road	10	40	22041
35	Existing	102R	8	Railway Station - Moti Ved	10	10	5510
36	Existing	103K	19	Lambe Hanuman Temple - Kathor Gaam /Aaboli Char	10	17	9367
37	Existing	103S	20	Lambe Hanuman Temple to Haridarshan Residency	10	19	10469
38	Existing	106R	17	Railway Station - Abhva Gaam	10	16	8816
39	Existing	107J	15	Railway Station - Vivekanand College	5	36	19837
40	Existing	116BR	25	Railway Station - Khajod Gam	10	24	13224
41	Existing	126R	11	Railway Station - Somesh-war Junction	10	11	6061
42	Existing	127J	9	Railway Station - Rander Gaam	10	10	5510
43	Existing	137J	15	Railway Station Ter - Kavi Shree Amrut Ghayal	10	14	7714
44	Existing	147J	14	Lambe Hanuman Tem-ple-Green City Bhatha	10	21	11571
45	Existing	153R	16	Umra Health Centre -Kapo-dara	10	16	8816
46	Existing	202J	12	Makkaipool Terminal -Akhand Anand Park Soci-ety	10	13	7163
47	Existing	207E	9	Chowk to Vaishnodevi Sky U	10	10	5510

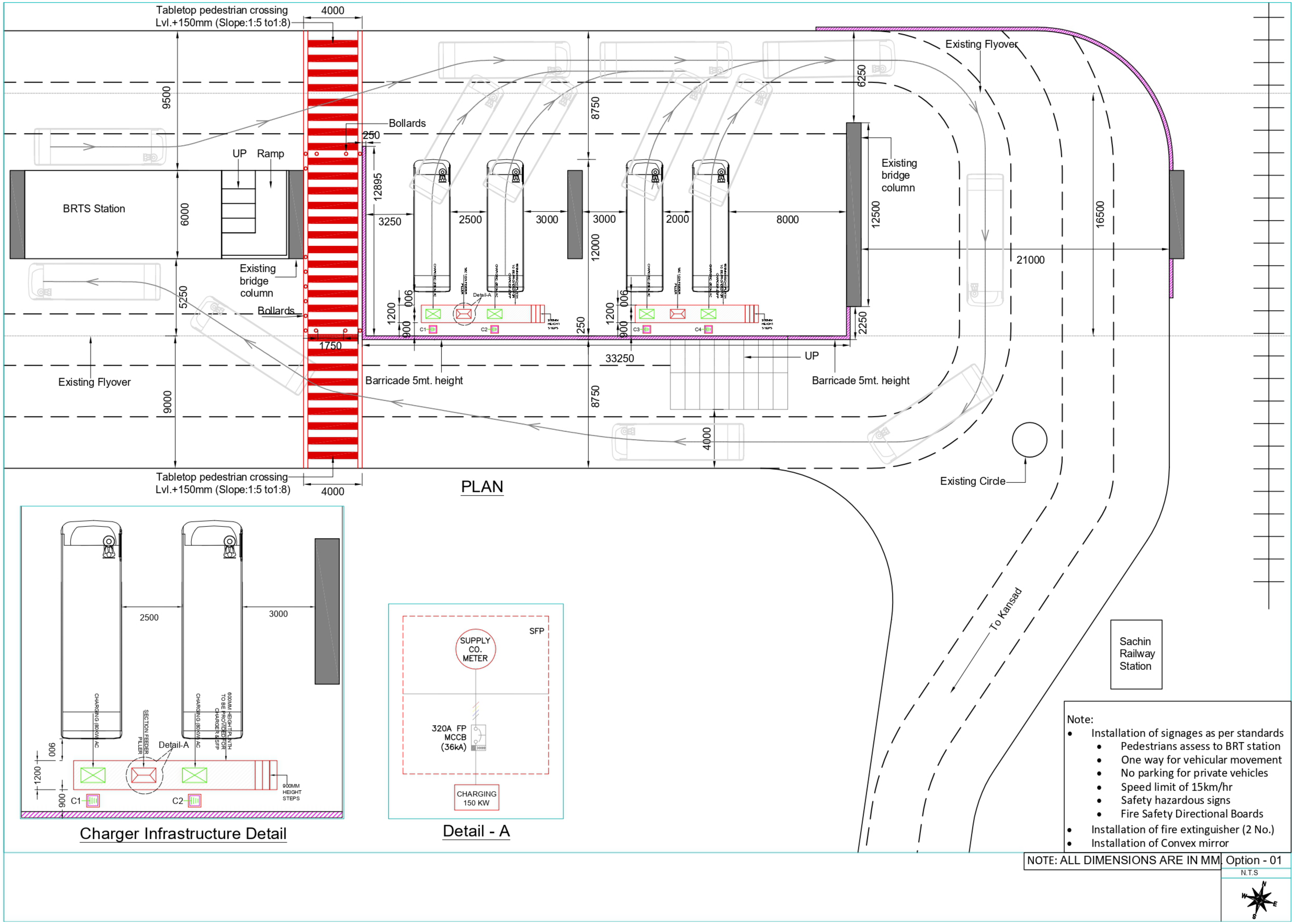
48	Existing	209J	19	Dr S.P Mukher Brid -Vrukshlaxmi Society	10	18	9918
49	Existing	212J	16	Makkaipool Terminal- Variav Gam	5	37	20388
50	Existing	216B	17	Chowk - Bhimpore	10	24	13224
51	Existing	216K	19	Chowk - Dumas Langar	10	18	9918
52	Existing	226J	29	Kosad Gam - V.N.S.G. University / Kinex Waterpark	10	26	14327
53	Existing	302V	9	Kharwarnagar Brt - Moti Ved	10	11	6061
54	Existing	410A	20	Utran Lake Garden - Utran Lake Garden	10	19	10469
55	Existing	504S	16.9	Vesu Gam - Delvada	10	17	9367
56	Existing	506D	17	Amezia Amusement Park - Bhestan Garden	10	17	9367
57	Existing + extension	117	26	Railway Station - Hazira	10	23	12673
58	Existing + extension	118	22	Railway Station - Kareli	10	22	12122
59	Existing + extension	903	21	Satyam Residency Puna Ga-m - Natrang	10	19	10469
60	Existing + extension	103V	23	Lambe Hanuman Temple -Pardi	10	23	12673
61	Existing + extension	205G	25	Chowk Terminal -Kalpheta	10	24	13224
62	Existing + extension	205K	39	Chowk Terminal -Navsari	10	36	19837
63	Existing + extension	205S	28	Chowk Terminal - Maroli	10	27	14878
64	Proposed	P1	18.8	Kharvasa - Kamrej	10	19	10469
65	Existing	P2	14.9	Piplod - Dindoli	10	15	8265
66	Existing	P3	12.0	Khatodara GIDC BRT -Sachin GIDC BRT	10	13	7163
67	Existing	P4	21.2	Parvat Patiya- Kadodara	10	21	11571
68	Proposed	P5	16.9	Shree Darshan Society -Khadi Road	10	17	9367
69	Proposed	P6	27.6	Palsana- Choryasi	10	26	14327
70	Proposed	P7	31.9	Jahangirpura, Amrol -Karamla Branch Post Office	10	30	16531
71	Proposed	P8	18.3	Adajan Bus Port -Near Tena Lake	10	18	9918

72	Pro-posed	P9	13.0	Jahangipura- Karamla	10	13	7163
73	Pro-posed	P10	19.9	ONGC Circle -Sachin G.I.D.C. Junction BRT	10	20	11020
74	Pro-posed	P11	24.4	Gopin Circle, Mota Varach-ha - Naka, Sachin GIDC	10	24	13224
75	Pro-posed	P12	19.2	Kharwarnagar BRTS -Kath-odare	10	19	10469
76	Pro-posed	P13	20.6	Adajan GSRTC BRT - Di-hen	10	20	11020
77	Pro-posed	P14	27.6	Adajan GSRTC BRT- Near Prathmik Sada Hazira Road	10	26	14327
78	Pro-posed	P15	17.5	Dindoli Char Rashta -Bar-doli	10	17	9367
79	Pro-posed	P16	14.3	Sachin G.I.D.C. Junction BRT - Diamond Industries	10	15	8265
80	Pro-posed	P17	26.0	Kamrej - Natrang	10	25	13776
81	Pro-posed	P18	20.2	Parvat Patiya - Bardoli	10	20	11020
82	Pro-posed	P19	17.2	Simada Naher Junction BRTS -Valan	10	17	9367
83	Pro-posed	P20	26.0	Adajan Bus Port - Olpad	10	25	13776
84	Pro-posed	P21	45.0	Railway station - Valenja	10	42	23143
85	Pro-posed	P22	16.3	Kumbhariya Gaam BRTS -Kamrej Terminal BRTS	10	16	8816
86	Pro-posed	P23	19.0	Railway station - Sandhier	10	19	10469
87	Pro-posed	P24	13.4	Unn Industrial Estate BRT- Datar Chowk	10	14	7714
88	Pro-posed	P25	19.5	Parvat Patiya - Bangumara	10	19	10469
89	Pro-posed	P26	19.6	Dindoli - Bardoli	10	19	10469
90	Pro-posed	P27	15.1	Dindoli Kharwasa Road BRTS - Palasana	10	15	8265

Annexure VII: Proposed list of strategic depot locations (2035)

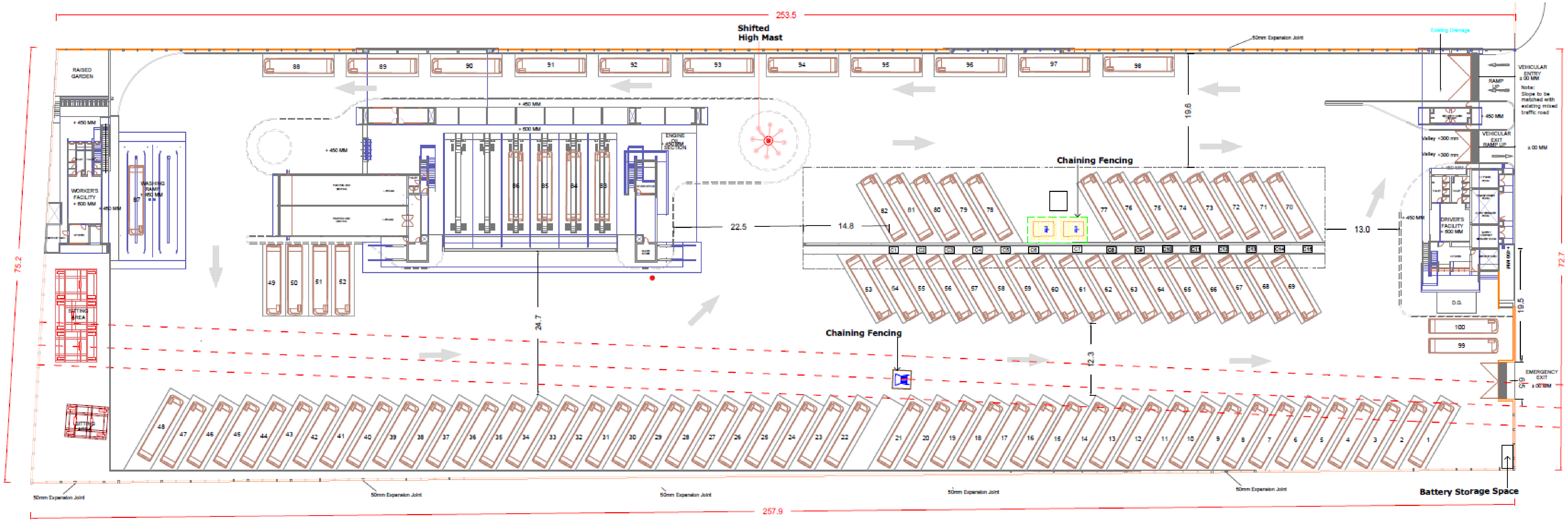
Sr No	Depot Name	Status	Depot Type	Type of Depot
1	Magob	Existing	Depot	Electric
2	Bhestan	Existing	Depot	Electric
3	Vesu Depot	Existing	Depot	Electric
4	Adajan Pal (nr. Star Bazar)	Existing	Depot	Electric
5	Altan	Existing	Depot /Terminal	Electric
6	Palanpur	Existing	Depot /Terminal	Electric
7	VIP Road	Existing	Depot	Diesel
8	Kosad Depot (BRT/CB)	Existing	Depot	Diesel
9	Puna	Existing	Depot	Diesel
10	Bhestan Garden	Existing	Depot	Diesel
11	Kosad City Bus (nr Fire Station)	Existing (Non-operational)	Depot	Diesel
12	Pal (nr LP Savani)	Existing (Non-operational)	Depot	Diesel
13	Pasodara	Existing (UC)	Depot	Electric
14	New Kosad	Existing (UC)	Depot	Electric
15	Olpad	Proposed	Depot	Electric
16	Sayan	Proposed	Depot	Electric
17	Kansad	Proposed	Depot	Electric
18	Ichchhapor	Proposed	Depot	Electric
19	Kanade	Proposed	Depot	Electric
20	Kharwarnagar	Proposed	Depot	Electric
21	Palasana	Proposed	Depot	Electric
22	Kamrej	Proposed	Depot cum terminal	Electric
23	Kadodara	Proposed	Depot cum terminal	Electric
24	Sachin	Proposed	Depot cum terminal	Electric
25	Dindoli	Proposed	Depot cum terminal	Electric
26	Nr Vivekanand college	Proposed	Depot cum terminal	Electric
27	Adajan Patiya	Proposed	Depot cum terminal	Electric
28	Dream city	Proposed	Depot cum terminal	Electric

Annexure VIII: Proposed Layout for Bus Circulation and Chargers location at Sachin (Alternative 1- 4 AC Chargers)



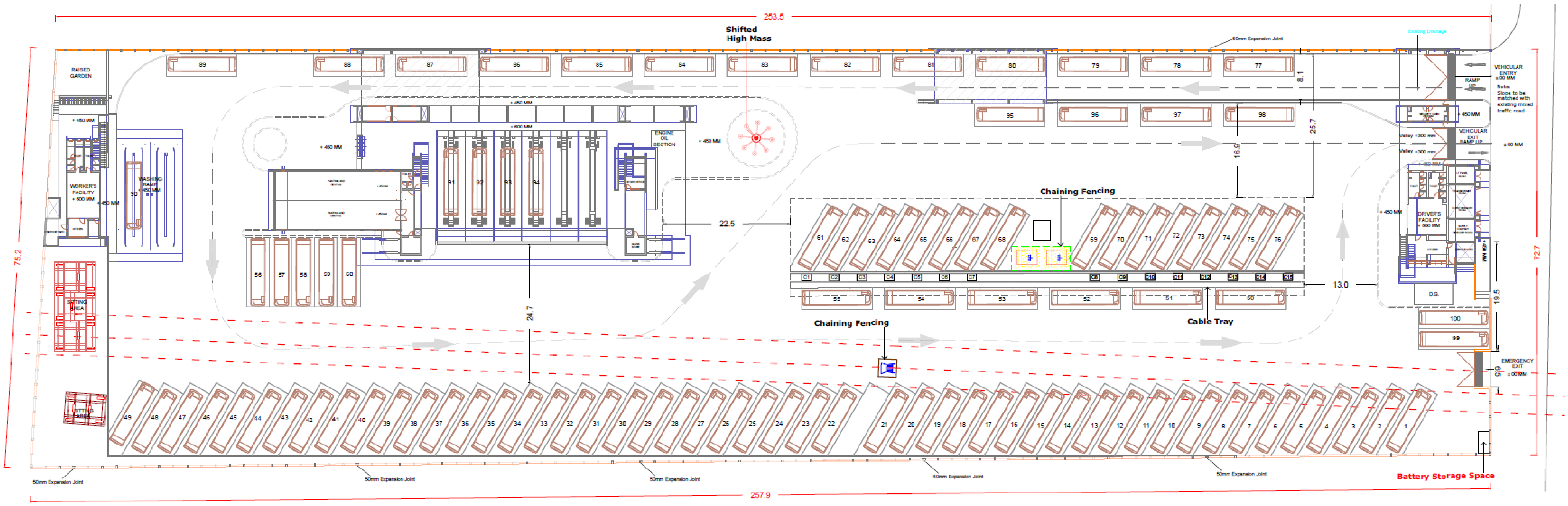
Annexure IX: Proposed Alternative Layout Plan for Bhestan Depot

1. Proposed Layout Option 1 – (Recommended option)



- Major modification is shifting charging sheds (along with chargers) 6 m towards west which enables 30 buses charging at a time with 15 chargers.
- Also, there are minor modifications including the removal of few obstacles at the depot which are not needed or else can be relocated.

2. Proposed Layout Option 2 – (Recommended option)



Major modification is shifting charging sheds (along with chargers) 6 m towards west which enables 30 buses Charging sheds and chargers are as existing; this can charge 22 buses at the same time. Of 22 buses, 14 buses will charge from single gun and 8 buses will charge from dual guns.

Only with minor modification includes removal of a few obstacles at the depot which are not needed or else can be relocated.

The Ministry of Heavy Industries (MHI), Government of India and the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH are jointly implementing the Indo-German Development Cooperation project "Promotion of transformation to sustainable and climate-friendly E-mobility", commissioned by the German Federal Ministry for Economic Cooperation and Development (BMZ). As part of the Green Urban Mobility Partnership (GUMP) between India and Germany, the project aims to improve the conditions for coupling the transport and energy sectors for climate-friendly electric mobility and achieve sustainable, socially balanced, and inclusive urbanisation (SDG 11). The project works with Surat (Gujarat) to promote systematic, safe, and sustainable adoption of electric mobility solutions to reduce the emission intensity of the transport sector.