WRI INDIA
ROSS CENTER

BMTC at 2035

Long term vision plan for bus operations in Bengaluru

MAY 2021

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1. OVERVIEW

With over 70 million passenger trips serviced daily, bus-based public transport systems form the backbone of the mobility systems in India[1]. The National Sample Survey conducted in 2016 reported that buses are the most frequently used mode of transport across both rural and urban areas, with close to two-thirds of respondents reporting travel by bus. Even in cities with extensive metro systems such as Delhi, the mode share of public buses is higher than that of the metro. In Delhi 64% of all public transit trips completed in the city are by bus and 34% are by metro[2]. Buses form a cornerstone of the Indian mobility system and are unlikely to lose relevance.

Passenger transport, in India, is the responsibility of the State Government. Accordingly, bus systems are operated by government-owned State Transport Undertakings (STUs) to provide safe, affordable, and accessible services for all. Public bus systems in the country are operated through 1.4 lakh buses, owned and hired by STUs. While the services account for almost 75% of all the public transport trips[3], cities across the country are burdened with extreme traffic woes. STUs do not operate on purely commercial terms. They provide services on non-performing routes and offer concessional passes, while ensuring continued operations. At the same time, with rising fuel prices and staff costs, STUs have high operational costs and no capacity to alter fares to meet their financial needs. In short, STUs do not earn enough revenue to cover the costs of operations leading to financial stress and heavy dependence on State and Central Government support. As of 2016-17, STUs incurred combined losses of up to INR 16,404 crore[4].

Losses over an extended period have resulted in a disproportionate growth in the number of buses procured for public bus operations in cities. While road passenger traffic has grown at a rate of 15.4%[5], bus fleet has grown at 7%[6]. Despite guidelines prescribed by the MoHUA on the number of buses required for cities of different sizes, public buses account for only 0.74% of the total registered vehicle population across the country[6]. Over the years, this trend has initiated a transition to the use of private vehicles rather than public transit modes. Based on the data collected by the Census of India, only 16% of all the work-related trips made in the country are on public transport[7].

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[1] Ministry of Road Transport and Highways, GOI, REVIEW OF THE PERFORMANCE OF STATE ROAD TRANSPORT UNDERTAKINGS (PASSENGER SERVICES) FOR APRIL, 2014 – MARCH, 2015, 2016
http://www.indiaenvironmentportal.org.in/files/file/Review%20of%20the%20Performance%20of%20State%20Road%20Transport%20Undertakings%20(SRTUs)%20for%202014-2015.pdf
[2] Rahul Goel, and Geetam, Promoting Low Carbon Transport in India, 2014
http://docplayer.net/13448279-Case-study-of-metro-rails-in-indian-cities.html
[3] WRI India, Fiscal Policies and Taxation Incentives for Improved Public Bus Systems in India, 2019
https://shaktifoundation.in/wp-content/uploads/2019/07/Bus-Taxation-Reforms-Deep-Dive.pdf
[4] Central Institute of Road Transport (2018). State Transport Undertaking Profile and Performance (2016-17)
[5] National Transport Development Policy Committee (2014). India Transport Report, Moving India to 2031 Volume 1 Executive Summary. Page 4
[6] Ministry of Road Transport and Highways, Government of India (2019). Annual Report 2018-19
https://morth.nic.in/sites/default/files/Annual_Report_English_2018-19.pdf
[7] Census of India 2011,
http://www.indiaenvironmentportal.org.in/media/iep/infographics/transport/index.html

While there are plans to construct over 1000 km of metro rail systems across the country over the next five years[8], public bus agencies will need to acquire between 5.84 lakh buses per lakh population to meet the needs of the growing population which will reach 1.48 billion by 2031.

If this growth is not planned for, this increase in demand will not only burden transit agencies financially due to a transition away from public transit, but also increase congestion and air pollution in cities, severely impacting the quality of life. Considering the existing and future challenges, it becomes imperative for every State and transit agency to prepare a holistic long-term vision plan to ensure better preparedness and efficient operations of public bus systems.

With this aim, this report presents a long-term vision for the scaling of the bus systems for one public bus agencies and an action-plan for implementation of this vision. The report will follow the following structure:

1. As-is assessment
    - Asset and inventory assessment: Movable and Immovable
    - Financial assessment: Costs, Revenue, Asset valuation and Profit/loss
      Operational assessment (system level performance): Cost Per Kilometre (CPKM), earnings per kilometre (EPKM), effective kilometres, ridership
    - Institutional assessment: Staff and Capacities
2. Setting goals through focussed group discussions
    - City level goals: Mode share, Public transport usage, Ridership, Bus occupancy
    - Service level goals: Fleet strength, Effective km operated, Reliability, Cancellation rate, Network coverage and Technology adoption
    - Financial goals: Revenue and loss reduction
3. Gap analysis
    - Public transport service provision
        - Number of buses required
        - Minimum effective km of operation
        - Maximum cancellation rate
        - Minimum network coverage
        - Bus infrastructure requirement
    - Financial requirement
        - Funding for buses procurement
        - Funding for bus operation
        - Funding for set-up of infrastructure
        - Funding for technology upgradation (E-bus, ITS, online payment, etc.)
4. Roadmap for goal achievement
    - Identification of strategies to meet goals
        - Operational plan
        - Financial plan
    - Assessment of potential impact of strategies

[8] Ministry of Housing & Urban Affairs, Metro projects in India- Rapid Strides in Urban transport & Mobility, 2019
https://pib.gov.in/Pressreleaseshare.aspx?PRID=1564876#:~:text=of%20India.,metro%20line%20proposals%20under%20planning.

2. INTRODUCTION: BANGALORE

With a population of 8.6 million[9], Bengaluru, the capital city of Karnataka, is the third most populous city in the country. Previously referred to as the garden city, Bengaluru has, over the years, established itself as a corporate hub. Several multi-national companies from around the world are strategically based along the city's 11 major traffic corridors. This has provided employment for the residents of the city and opportunities for people from across the country, resulting in the city getting the title of 'Silicon Valley of India'. This has not only resulted in an exponential increase in the population, growing at 84% annually[9], but also a tremendous increase in the vehicle growth rate at 129% annually[10]. Considering the current trends in population and vehicle growth rate, the number of vehicles in the city will surpass the population by 2024 with 14.8 registered vehicles and 14 million population.

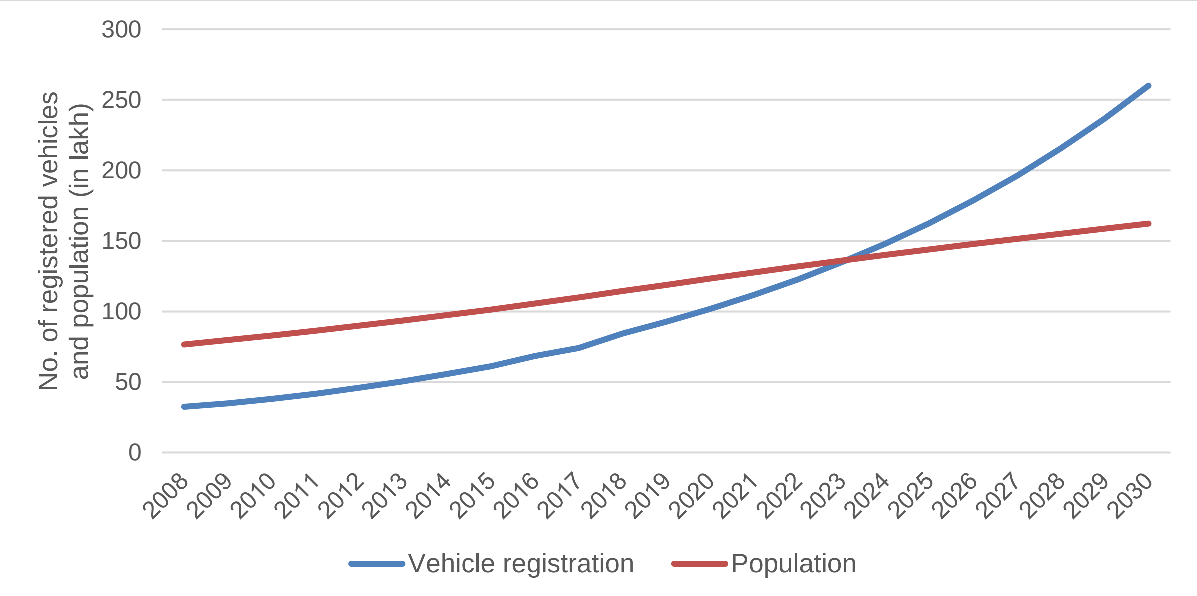

Figure 1: Comparison of growth in number of vehicles registered and population in Bangalore City[11]

The growing use of personal vehicles has caused Bengaluru to lose some of its shine, and the city has become infamous for its tedious traffic snarls. A recent report by TomTom mentions that the city is home to the worst traffic congestion in the world[12]. A report by BCG states that the annual cost of congestion in the city equates to approximately INR 38,000 crore[13]. Despite the increased use of private vehicles in the city, the public transport system continues to service majority share of all the trips completed (32.4%)[14]. Public transport has been identified as a viable solution to the issue of congestion being faced in the city.

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[9] Census 2011, Government of India
[10] Transport Department, GoK, Annual Report (2017 18)
[11] Karnataka Road Transport Authority, http://transport.karnataka.gov.in/uploads/files/Tran_Annual_Report_Eng_2017-18.pdf
[12] TomTom, TomTom Traffic Index, 2019 Accessed on 19th July 2020: https://www.tomtom.com/en_gb/traffic-index/ranking/
[13] BCG, Unlocking Cities, 2017 https://image-src.bcg.com/Images/BCG-unlocking-cities-2017_tcm93-178660.PDF
[14] DULT, GOK, Comprehensive Mobility Plan, 2019

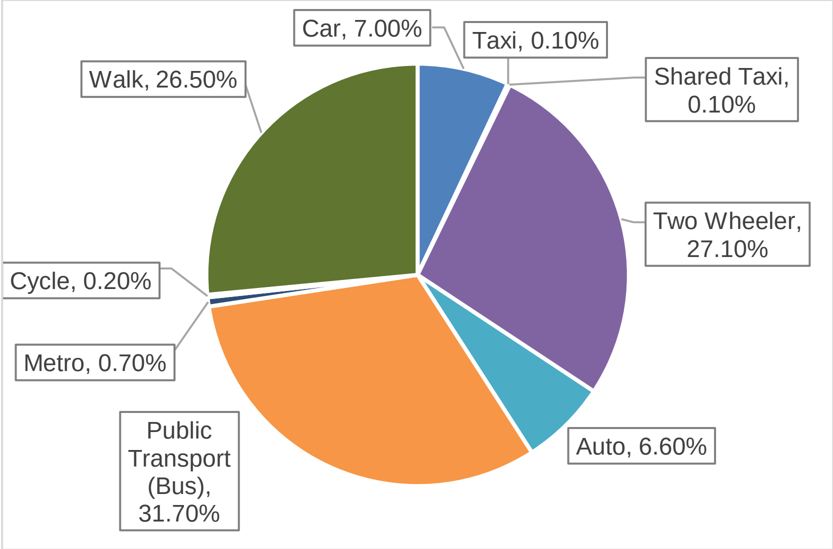

Figure 2: Mode Share in Bangalore

Public transport, served by a sizeable city bus network and a growing metro rail system, continues to carry a sizeable number of vehicular trips in the city. The following table summarizes the public transit services operational in the city.

Table 1 Summary of public transport services in Bangalore

BMTC	
Number of buses	6,526 buses
Ridership	35 Lakh/day[15]
BMRCL	
Total operational kms	42 km
Total length under construction	72 km
Ridership	4.05 Lakh/day[16]
Suburban Rail	
Number of stations within the city	29[17]
Ridership	150,000-200,000 passengers

A network analysis of the existing public transit services shows that 85% of the city's population lives within a 500m walking distance from a public transit station.

[15] BMTC
[16] BMRCL & DULT, Comprehensive Mobility Plan For Bangalore, 2019
[17] Sharma, M. (2018, December 24). Bengaluru to get 52 new suburban stations. *The New Indian Express*. https://www.newindianexpress.com/cities/bengaluru/2018/dec/24/city-to-get-52-new-stations-1915795.html

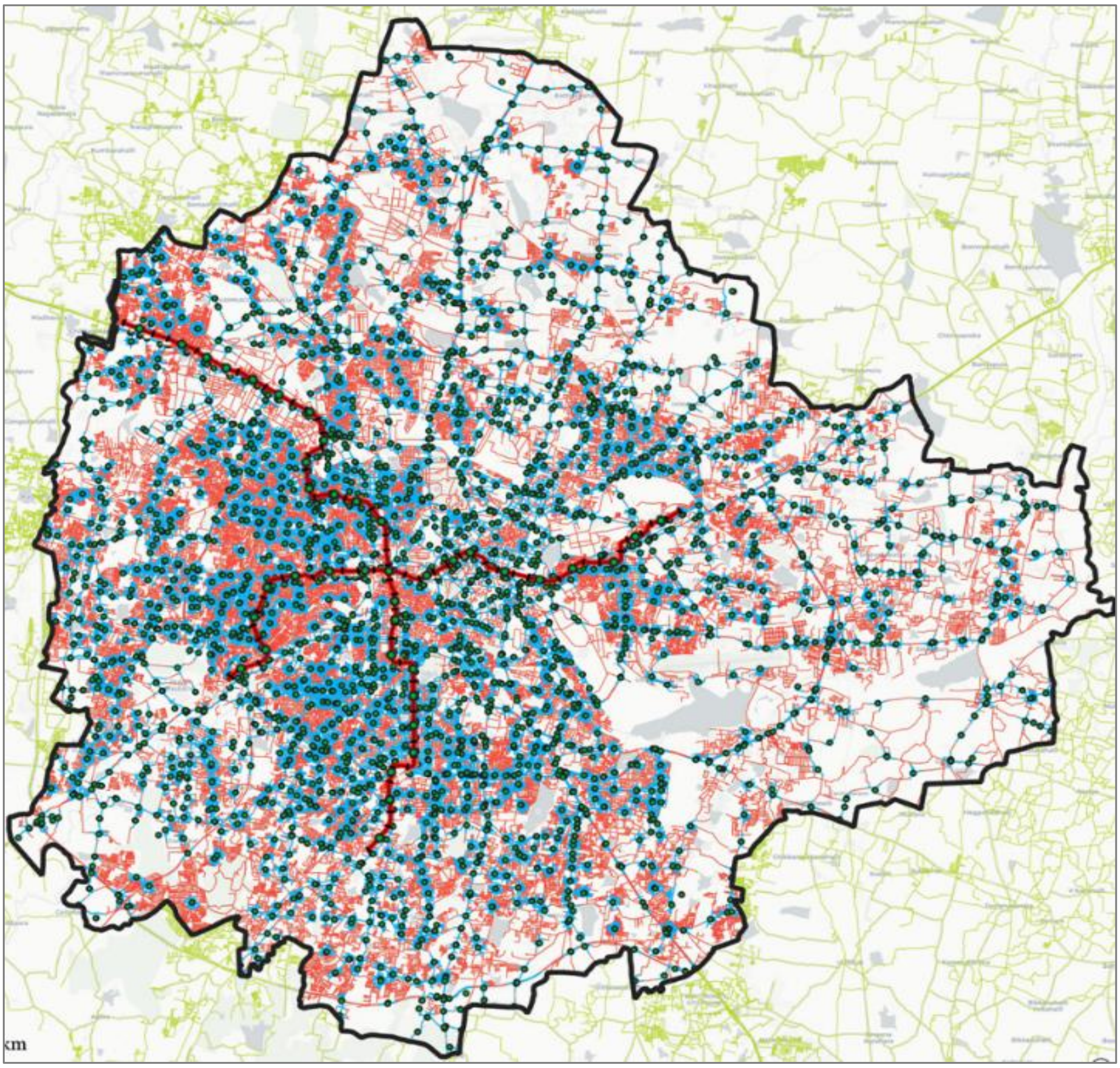

Figure 3: Map of all BMTC bus stops (Blue) and BMRCL network (Red with green)

Other components of Bengaluru's transport ecosystem include formal and informal paratransit services, corporate employee transport services and numerous app-based new mobility services (see Section 7 for a definition of new mobility services). In addition to a fleet of 150,000 autorickshaws, a significant number of informal bus and shuttle services ply along major bus corridors across the city. Fleets of private service vehicles, both cars and buses, provide corporate employee transport services to the many IT and tech parks in Bengaluru. In recent years, the city has been home to a growing number of new mobility services, which are characterised by on-demand transport that can be accessed via mobile application. These are primarily ride hailing services provided by cab aggregators, with over 170,000 taxis attached to these app-based services[18]. The average trip length for different modes in the city are presented in Table 1. The per capita trip rate including walking trips is 1.24 and the motorized trip rate is 0.91[14].

[18] Government of Karnataka, Annual Report 2018-19 Pg. 37, 2020
https://transport.karnataka.gov.in/storage/pdf-files/Annual%20Report%20Eng%202018-19.pdf

Table 2: Mode wise trip length in Bangalore[14]

Mode	Trip Length
Shared Taxi	15.4
Chartered bus	15.1
Taxi	13.1
Car	12.8
Bus	10.7
Minibus	10.7
Two-Wheeler	8.0
School bus	5.1
Auto	3.7
Cycle	2.6
Walk	1.0

While long-term planning for sustainable mobility in the city needs to consider all these modes, this draft of the report will detail measures only pertaining to the long-term planning for the public bus system in the city operated by the BMTC.

3. BMTC BACKGROUND

BMTC came into existence in 1997 after bifurcation from the Karnataka State Road Transport Corporation (KSRTC). As seen in Figure 2, servicing over 3.5 million passenger trips daily, the public buses are the most prominent mode of transport in the city. Today, BMTC owns 6526 buses and operates an average of 6194 schedules daily. The buses are operated and maintained at 45 bus depots, serving around 2212 bus stops spread across the city. BMTC's services cumulatively cover over 1.38 million kilometres in the city. The bus stops are placed at a 500m distance making these accessible to 86% of the population. BMTC also operates 14 major Traffic Transit Management Centres (TTMCs) that act as hubs offering a varied range of integrated passenger services amenities to commuters to improve access, comfort and quality of commute.

Historical assessment of BMTC's services

While most of the passenger trips in the city are serviced by BMTC, a historical analysis of BMTC's services reveal that the mode share of public buses has reduced drastically over the last decade.

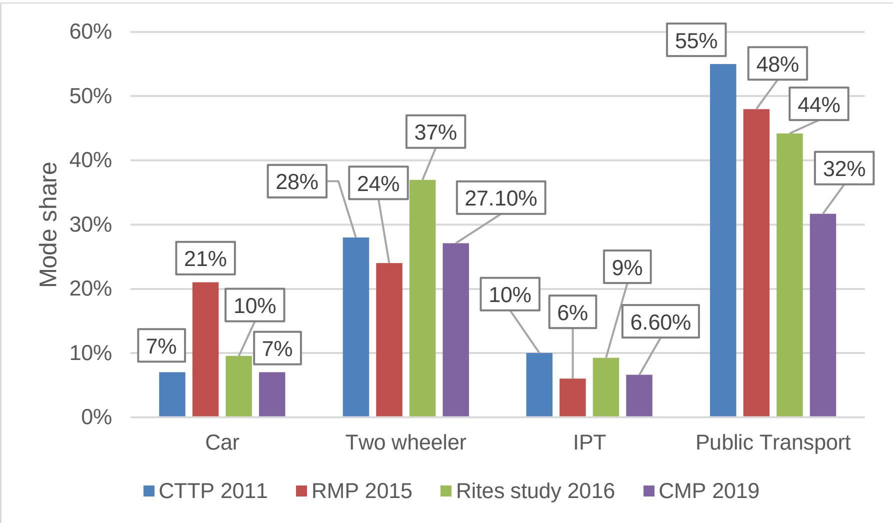

Figure 4: Comparison of mode share of motorized modes in Bangalore city from 2011 to 2019

The increase in private vehicle usage is commensurate with that of the vehicle population growth as seen in Figure 1. This has not only resulted in increased congestion in the city but has also severely affected the public bus services offered by BMTC. The rate of cancellation of trips by BMTC has increased on average 17% annually, from 2.8% in 2008 to 11.2% in 2019.

Fleet size

Despite the increase in population in the city, the fleet size held by BMTC has only seen a marginal increase. While the MoHUA prescribes a minimum of 60 buses per Lakh population for a city with a population equivalent to Bangalore, BMTC currently operates only 53. The stagnating fleet size has also resulted in the increase of the average age of the bus fleet held. As seen in Figure 7, 38% of the fleet held by BMTC is over the age of 8 years. This has resulted in the reduction in the average fuel efficiency if the fleet to 3.8 kmpl, 15% lower than that recorded in 2008. This has further led to the increase in the total fuel expenses.

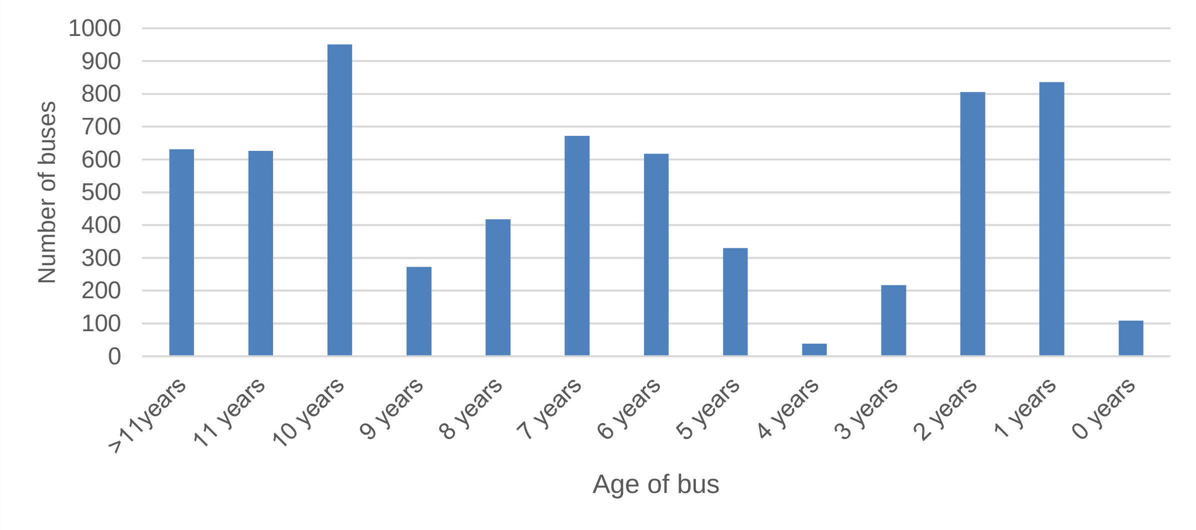

Figure 5: Age-wise distribution of BMTC's fleet in 2019

Performance

Bangalore's population has increased by 49% since 2008. However, as the graph shows, BMTC's service provision has reduced. The fleet has grown by only 17% and mode share has reduced by more than 30%. On top of this, the daily distance covered by the average BMTC bus has fallen by 12.2% from 228 km/bus/day in 2008 to 199 km/bus/day in 2019.

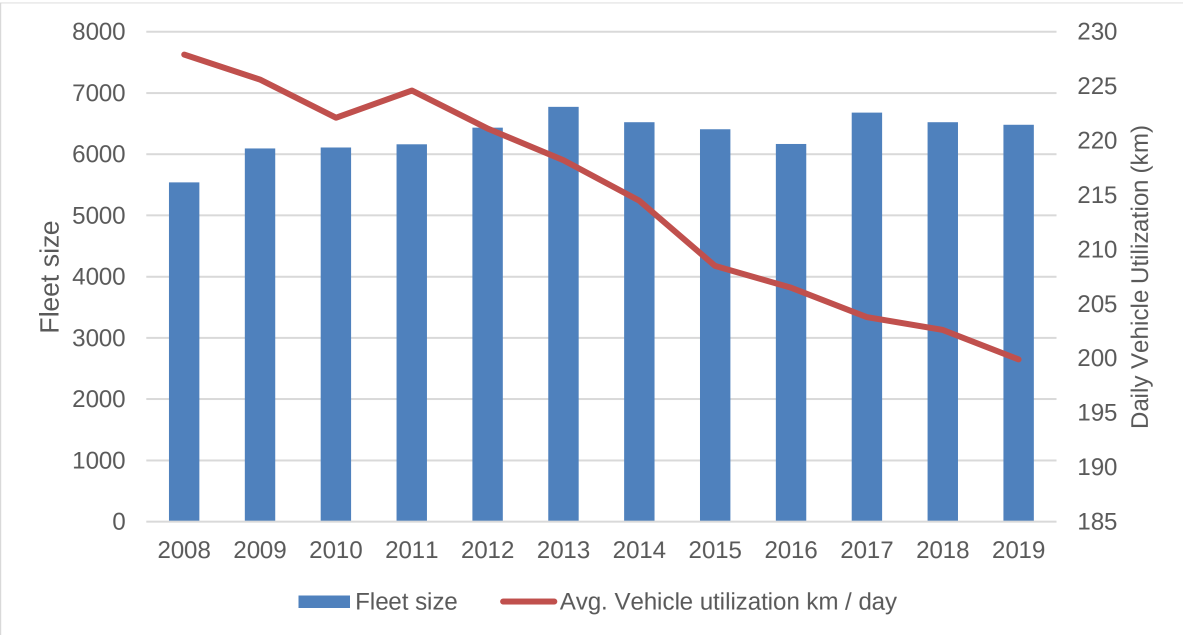

Figure 6: Trend in BMTC's vehicle utilization and fleet size

Additionally, considering marginal increase in bus fleet observed, the total effective kilometres operated per day has seen a meagre 100 km increase compared to 2008. This has also resulted in a 13% fall in BMTC's ridership, from 4.02 million in 2008 to 3.5 million in 2019, which hit a maximum of 5.1 million in 2014.

Cost and revenue

The increasing average age of the fleet, coupled with the reducing vehicle utilization, resulting from increased congestion in the city, has further impacted the CPKM of operation. A comparison of the CPKM and EPKM shows that both these values have seen an increasing trend and the costs have continued to be higher than the earnings. This is despite the 14% increase in bus fares in 2012 that was implemented to meet rising costs. Since 2008, the CPKM has seen an average annual increase of 12%, resulting in the CPKM recorded in 2019 being 2.15 times that of 2008. Considering that neither staff cost, nor fuel cost are expected to reduce soon, a reversal in this trend is unlikely.

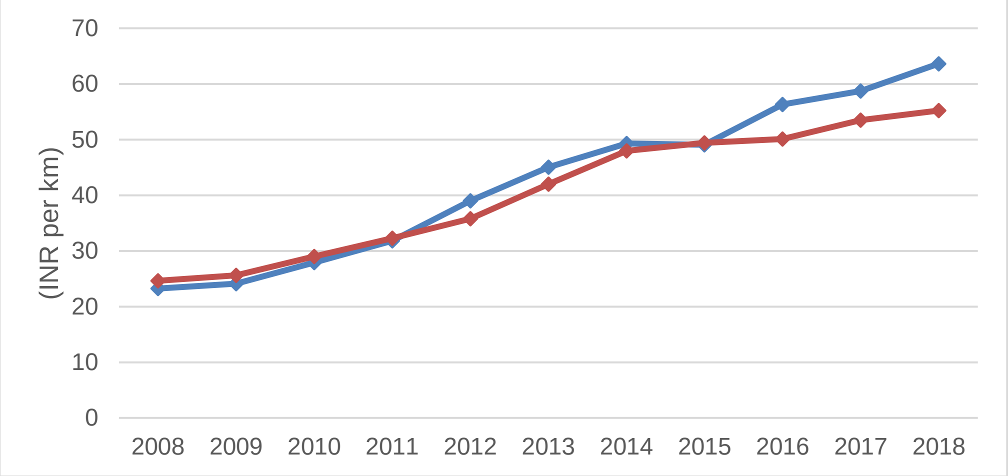

Figure 7: CPKM vs EPKM from 2008 to 2019

Considering the decreasing trend in ridership, no further increase in fare has been possible as this would further threaten a reduction in ridership. Currently BMTC's ticket fares and cost of passes is higher than that of other comparable STUs. To overcome the severe financial burden, BMTC received their an operational subsidy in 2019, when the Karnataka State Government sanctioned the agency INR 240 crore as viability gap funding.[19]

While the agency has undertaken several measures to reduce costs, by increasing revenue from other avenues such as renting out space in the TTMCs owned by the agency, allowing advertising on the back of the bus, the operating margins continue to remain low.

[19] Based on discussions with BMTC

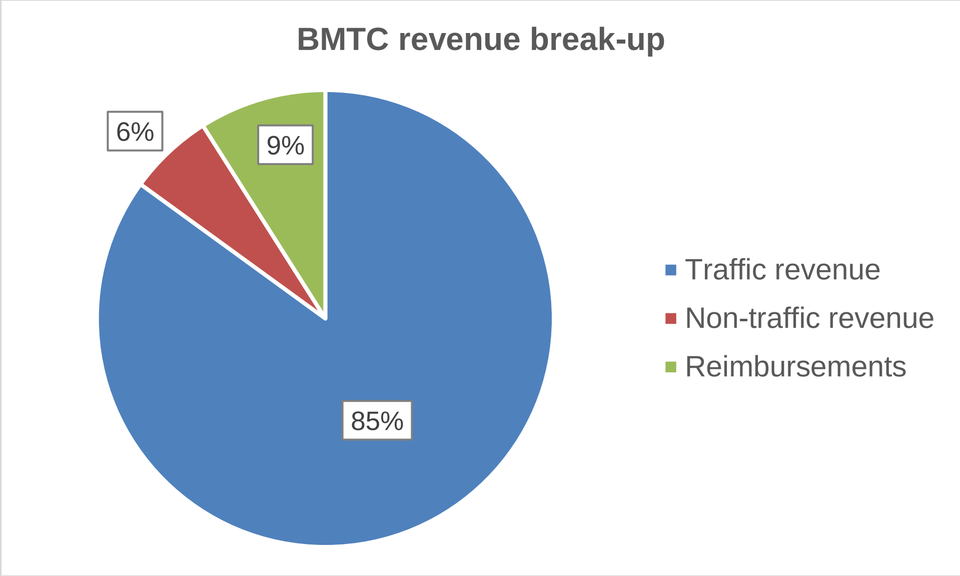

Figure 8 BMTC revenue breakup 2019

BMTC's revenue breakup for 2019 shows that the share of non-farebox revenue recorded by BMTC is significantly low and accounts for only 9% of the total revenue. The following figure presents the breakup of the major sources of non-farebox revenue.

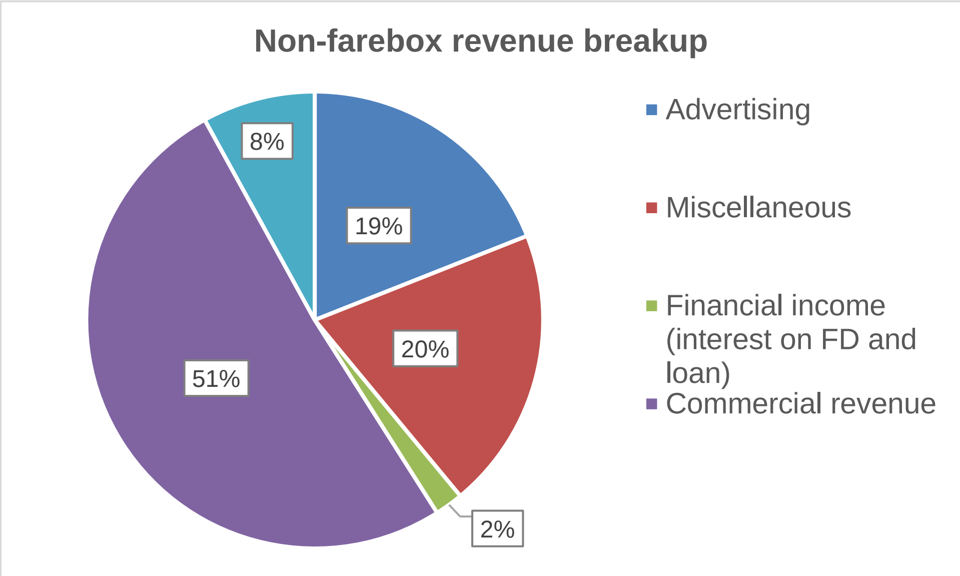

Figure 9 BMTC non-farebox revenue breakup

As seen, commercial revenue accounts for the largest portion of the non-farebox revenue, followed by advertising revenue and revenue from the sale of scrap buses and parts.

Profit and loss

The fall in the ridership has resulted in reduced revenue for BMTC. This, coupled with increasing cost of operations, has riddled the agency with extreme financial woes. The analysis of the agency's gross revenue shows a steep decline, which corresponds to the increasing operating cost of the system.

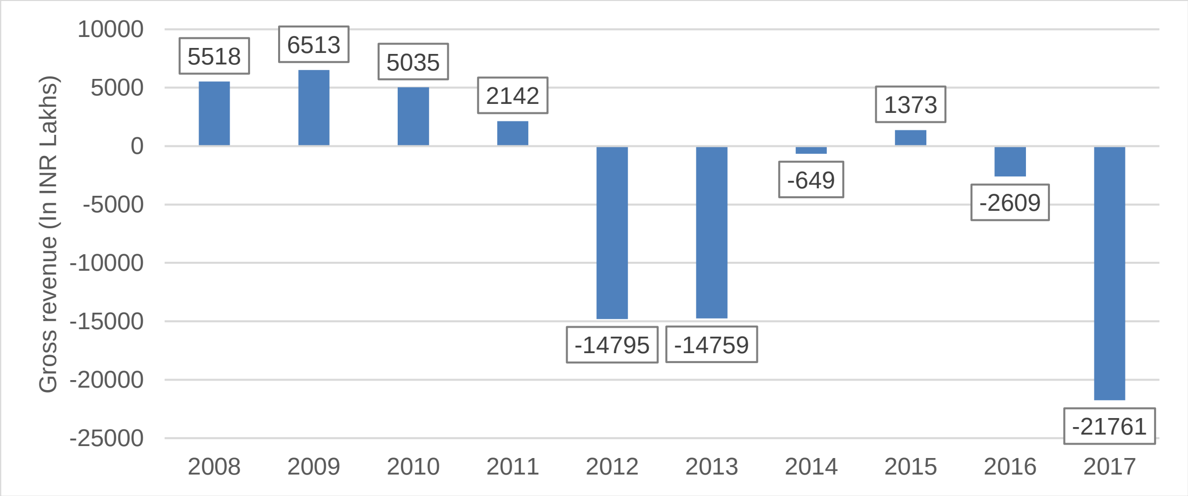

Figure 10: BMTC gross revenue (profit/loss), 2008 to 2017

Some of the major reasons for these losses include the steep increase in staff cost and fuel cost. A comparison of the staff and fuel cost between the October to December quarter in 2015 and 2016 revealed a 16% increase in staff cost and a 20% increase in fuel cost.

Taxation

Analysis of the direct tax paid by the agency to State Government has revealed that BMTC's Motor Vehicle (MV) Tax liabilities are significantly higher than those for other agencies.

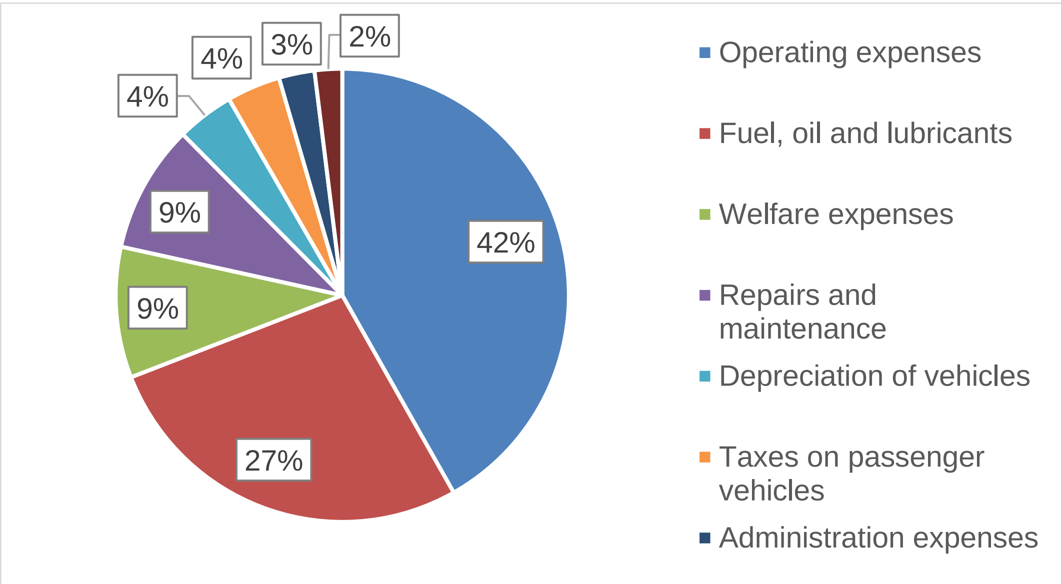

Figure 11: BMTC's operational costs components[20]

Figure 11 shows a split up of all the expenditure incurred by BMTC in 2019. While the chart shows only one head titled "taxes," BMTC incurs four major types of taxes that account for a large part of the agencies annual loses. They are:

[20] BMTC FY 2019-20 profit-loss statement

1. The Motor Vehicle tax
   The MV Tax applied by Karnataka State Government is a standard 5.5% on the total traffic revenue generated by BMTC. It accounts for 4% of the total expenditure incurred by the agency while that of other agencies do not exceed 2%. While the agency was exempted from the payment of INR 120 crore for the MV tax for the FY 2017-18, this was a one-time waiver and more sustainable means of reducing losses needs to be implemented[21].
2. Commercial tax –
   The commercial tax 18% of licensing fee collected from commercial establishments. Since 2016, BMTC has paid an average of INR 16 Crores in commercial tax annually.
3. GST –
   The GST applied on BMTC's revenue is four-fold. It includes 5% on AC bus revenue, 18% on advertising revenue, 5% on sale of scrapped and unserviceable stores, and 18% on sale of fully depreciated vehicles + penalty and ground rent. On average BMTC incurs GST equivalent to INR 17 Crores annually.
4. Fuel tax –
   The taxes imposed on fuel sale in Karnataka are 2-fold: a central excise duty of INR 31.7/litre of HSD sold levied by the central government, and a VAT levied by the State Government. In Karnataka the VAT on HSD has ranged between 19% and 24% since 2016.

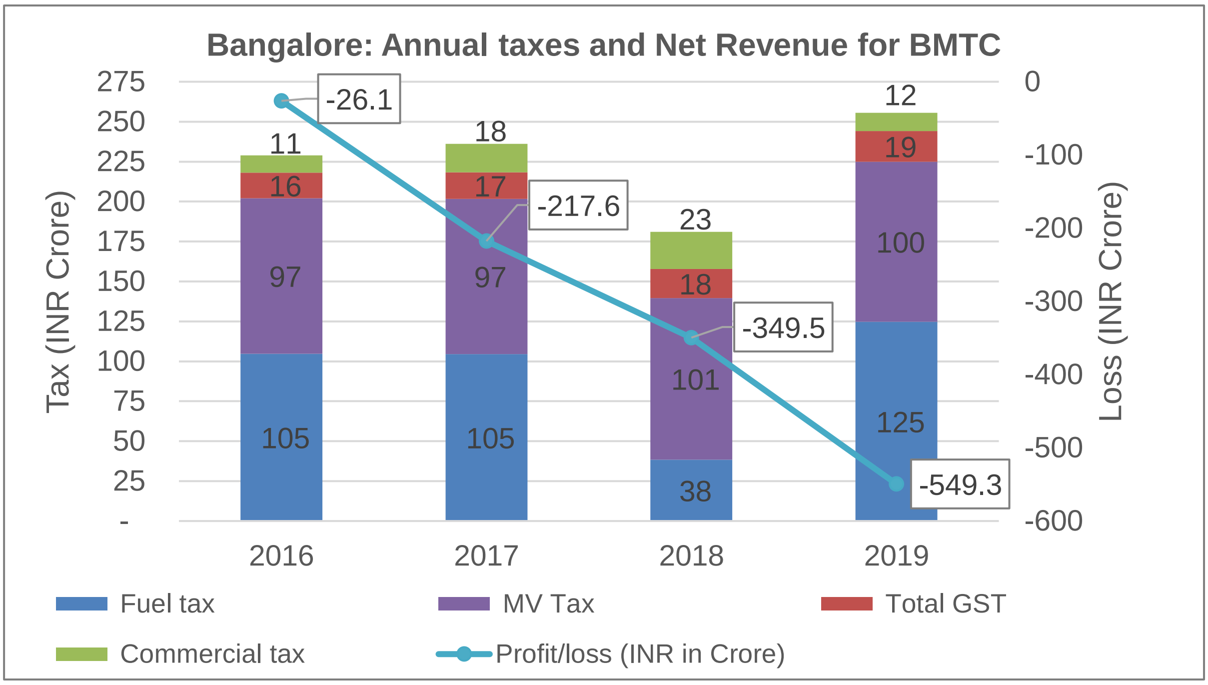

Figure 12 Comparison of taxes and annual losses incurred by BMTC from 2016 to 2019

A comparison of the total taxes and losses incurred by BMTC over the last four years shows that the four taxes together were 171% more than the total losses incurred between 2016 and 2019, indicating that just reducing the tax burden from MV and Fuel taxes would bring BMTC out of the red.

[21] WRI India, Bus Taxation Reforms – Deep Dive Analysis, 2019

Considering this context, it is evident that there is a need for the agency to establish a long-term plan to improve the quality of services and implementing strategies to improve efficiency of services and reduce loses. The following section will highlight how the current trend in the growth in fleet size and implementation of strategies to improve public bus services significantly fall short of meeting the demand. A long-term plan is thus, critical for the improvement of the quality of life for citizens and the reduction of the negative environmental externalities associated with transport in the city. Increased supply to meet the raising demand, strategies to reduce travel time and wait time and in-turn cost of congestion, and enhancement of fleet to use cleaner fuel have the potential to aid the transition away from the increasing trend of using private vehicles to the use of cleaner, more sustainable modes of public transport.

4. GAP ANALYSIS

Methodology

Studies have suggested that the number of public buses required by a city is a function of the population, trip rate, public transport mode share, network length, average trip length, frequency of services, peak hour speed, vehicle utilization of public buses, and the average occupancy on-board buses[22]. A report published by GIZ in 2019, presents two distinct approaches to calculate the minimum bus fleet required for the city.

1. **Method 1: The supply side**

This method relies on supply-side parameters and states that,

$$Minimum\ bus\ fleet = \frac{Network\ Length\ (km) \times Service\ frequency\ (buses\ per\ hour)}{Average\ peak\ hour\ speed\ (km\ per\ hour)}$$

2. **Method 2: The demand side**

   This method assumes the general travel patterns of the city. This method is a little more complex and uses the following equation

$$Minimum\ bus\ fleet = \frac{Minimum\ passenger\ capacity}{Passenger\ capacity\ of\ bus\ \times Occupancy\ ratio}$$

where,

$$Minimum\ passenger\ capacity = \frac{Motorized\ trips \times PT\ mode\ share \times Avg\ trip\ length\ (km)}{Avg.daily\ revenue\ distance\ of\ a\ bus}$$

An additional 10% of buses are added to this calculation to account for spare bus fleet.

Method 1 is most suitable to consider specific operational details for the city, setting these as targets to be achieved. This is more applicable for cities that have a uniform demand across all major corridors of the city. However, as the vision planning exercise, at this stage, is being conducted at the network level, method 2 has been selected for the analysis.

Method 2 considers three main parameters that can be altered based on BMTC's needs and goals for the long term. These include, the average daily revenue distance per bus, bus size (capacity of the bus), and the occupancy ratio.

Data sources and assumptions

Data has been collected from BMTC and DULT on specific operational and financial parameters of BMTC and city level travel patterns to analyse the projected needs of the city. The population projection data provided by the United Nations has been considered for the analysis.

Based on the data collected on the mode share, motorized trip rate and trip length using public transport in the city in the past, these parameters have been projected considering a business as usual trend over the course of the next 15 years. Here, due to the lack of past data on the trip rate, it has been assumed to increase to 1.3 by 2035. The projections are based on the best fit trend line. The passenger capacity of the bus has been considered as 60, considering a standard sized 12 m bus.

The following graph present the assumed change in the above mentioned parameters over the next 15 years.

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[22] Prashant Bachu, published by GIZ, Bhubaneshwar on the move – Tools and guidelines for city bus operations, 2019

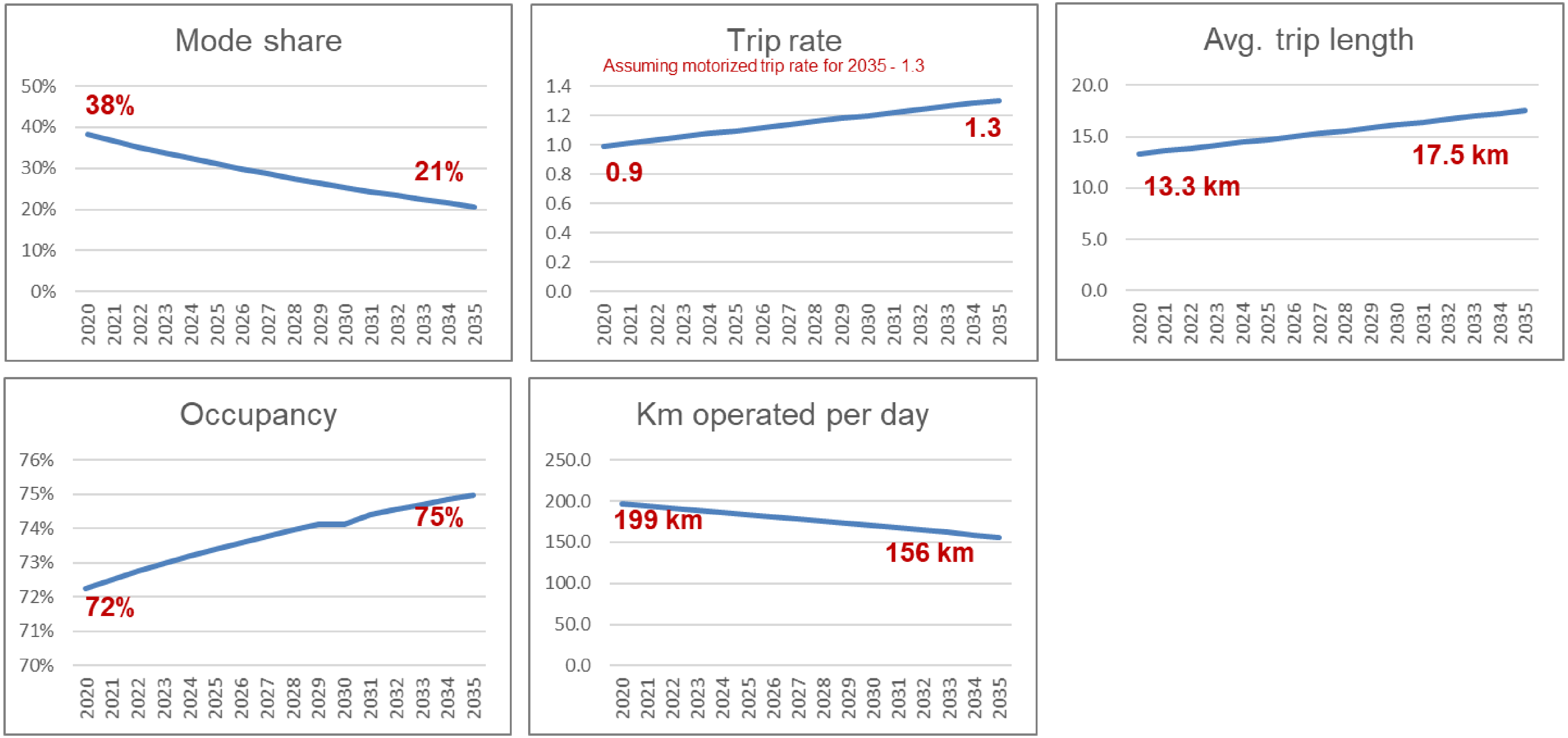

Figure 13 Projected change in base parameters

The decrease in mode share of BMTC indicates a potential surge in congestion in the city. This could result from the increase the population of registered vehicles in the city, and the declining trend exhibited by BMTC's service over the last decade. This in turn could result in the reduction in the daily fleet utilization from 199 km in 2020 to 156 km per bus per day in 2035. The trip rate and average travel distance have been assumed to increase over time to accommodate for the growth of the city. Finally, the occupancy has also been assumed to increase following the trend observed over the last decade, and considering the absolute increase in ridership compared to 2019 values and only a marginal increase in the number of buses.

Considering the disparity in the cost of AC and standard diesel and electric buses in the market, this report considers certain assumptions for the procurement of AC and standard buses and fast and slow chargers required for the operation of electric buses. These are as presented in the following table.

Table 3 Electric and diesel bus assumptions

	Standard Diesel	AC Diesel	Standard Electric	AC Electric
Cost of bus INR Lakh*	35	80	150	180
Lease cost INR/km*			100	150
Frequency of procurement	Yearly	Once in 3 years	Yearly	Alternate years
% of added fleet	70% of diesel fleet	30% of diesel fleet	50% of electric fleet	50% electric fleet
Inflation in vehicle cost	5%	5%		
Annual change in cost of electric bus purchase			-5%	-5%
Mode of procurement	Purchase	Purchase	Purchase + lease (short term)	Purchase + lease (short term)
Lease period			8 years	8 years
Lease model adopted till			2025	2025

Table 4 Electric bus charger assumptions

	Fast charger	Slow charger
Cost of charger in Lakh	15	36
Number of buses serviced by each charger	3	1
Percentage buses serviced by each charger	30%	70%
Annual change in charger cost	-5%	-5%

These assumptions have been made considering the procurement pattern of AC and standard buses procured by BMTC in the past and based on inputs from and interests highlighted by representatives from BMTC.

The assumptions made to estimate the total investment required for the installation of supporting infrastructure as presented in the following table.

Table 5 Assumptions made to estimate the cost of supporting infrastructure

	Depot	Terminal	ITS
Total area required			-
Cost of construction	INR 20 Crore	INR 20 Crore	5% of bus proc. cost
Number of buses accommodated	100-145	450-700	-

Findings

For gap analysis, method 2 has been used to calculate the number of buses required to meet the needs of the growing population over the next ten years, considering these parameters as a constant at their of 2019 level over the next ten years. This has been compared with the projection of the fleet size using a best fit curve, based on the data from 2008.

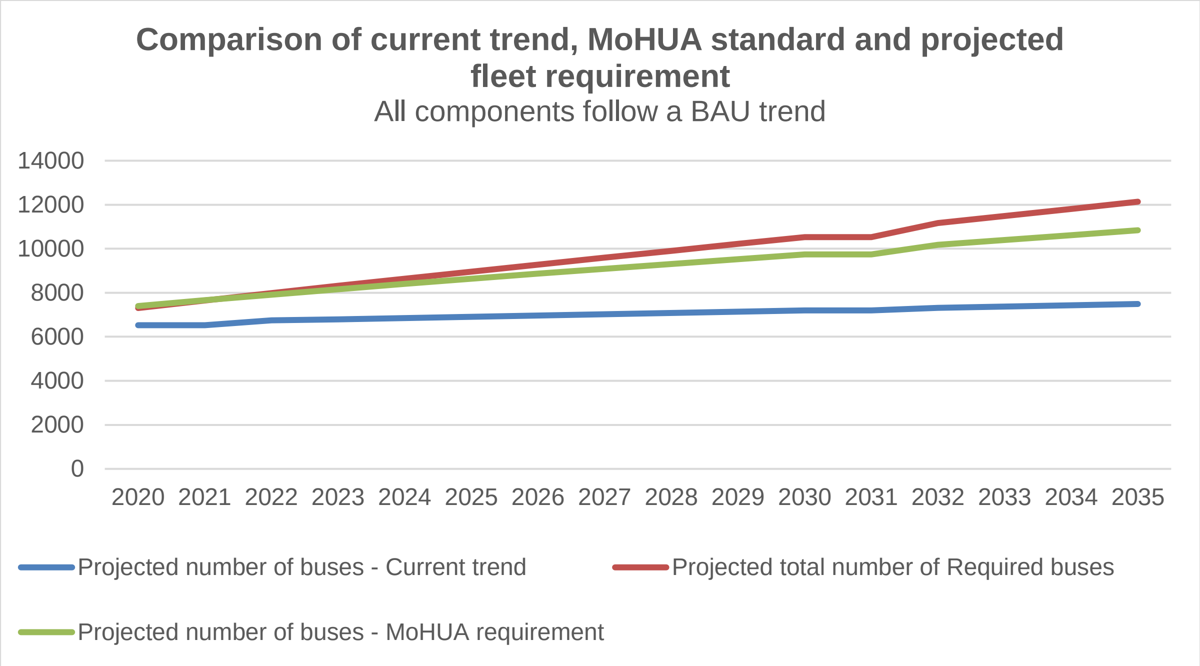

Figure 14: Current trend of fleet growth and the required fleet for BMTC - 2020 to 2030

Based on this method, and considering the assumptions made, the number of buses required by 2030 is 62% more than the number of buses the city would own and operate, considering the current trend of bus procurement. While this method considers past trends and projects future requirement, it is important to consider the impact of the current COVID-19 pandemic on the future needs of the city.

Covid Impact

Public transport has been one of the major sectors that have been impacted due to the COVID – 19 pandemic and the sub-sequent restriction of movement within cities established by the Government across India. While cities have embarked on the "unlock" journey, movement in public transport in major cities continues to be restricted resulting from the increased adoption of work-from-home practices and the perceived safety concerns of public transport commuters. This has resulted in the reduction in trip rates, trip lengths and changed the mode share in major cities. Additionally, public transit services have also reduced.

As there is a lack of conclusive data on the impact of the pandemic on mobility patterns in Bangalore, this study assumes a 40% reduction in the above mentioned parameters for 2020, increasing gradually increasing to 100% of the projected trend by 2023 (as seen below).

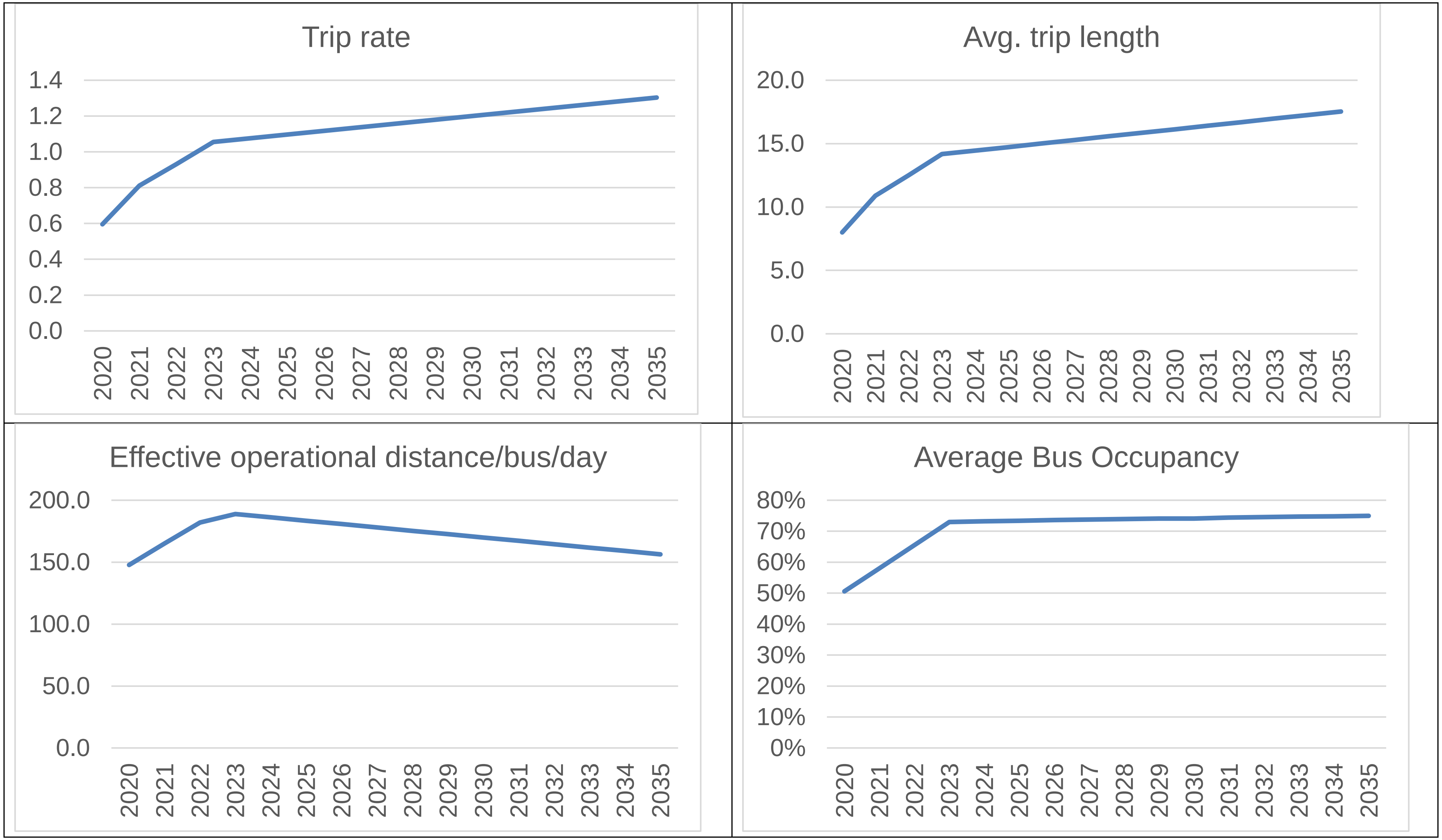

Figure 15 Assumed impact of COVID - 19 on the projected travel behavior in Bangalore

Thus, the required fleet also changes correspondingly as seen in the following graph.

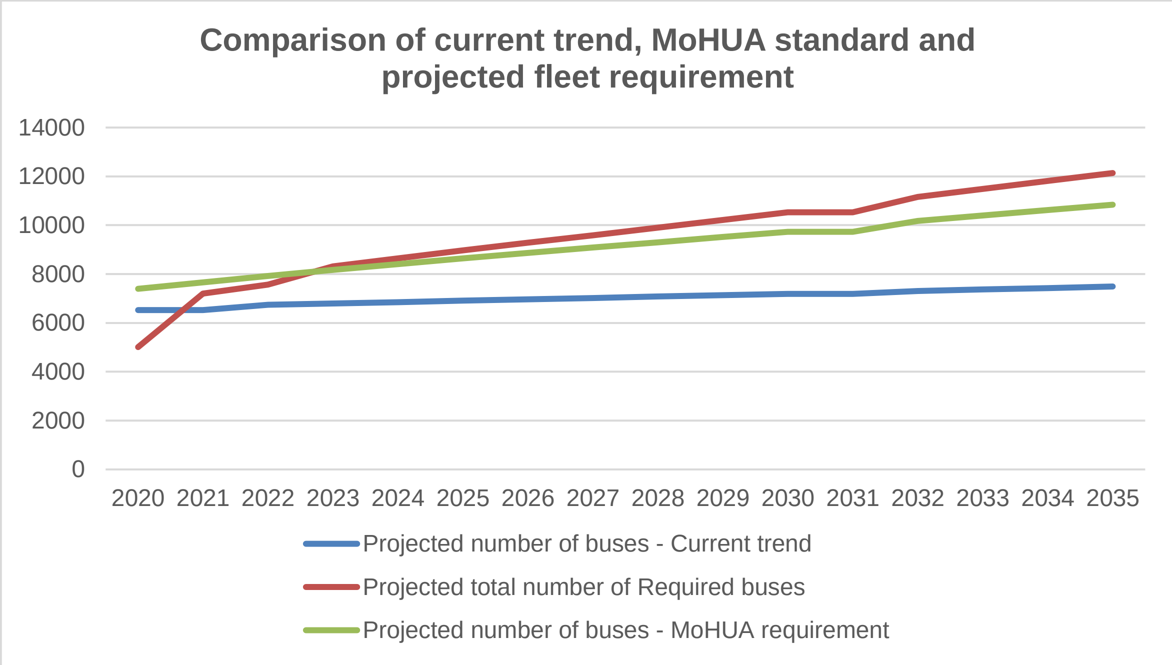

Figure 16: Comparison of trends in fleet addition

In addition to the severe impact on travel and public transit usage behaviour in the city, the COVID – 19 pandemic has exacerbated the financial issues faced by public transit agencies across the country. BMTC, with one of the largest bus fleets and the staff for a for city bus services in the country, faced crippling financial issues during the first quarter of FY 2020-21. The agency, unable to make any revenues, requested financial support from the State Government to pay staff salaries. Considering these financial challenges, this report assumes that no new buses will be procured till 2022.

Additionally, while the number of required buses for the city highlights the need for annual addition of buses of up to over 2000 buses in some years, the transit agency and/or OEMs may not be able to meet this sudden change in demand. In order to account for this, this report assumes that the annual fleet addition will not exceed 1406 buses, which was the maximum number of buses added in any year over the last decade.

Considering these conditions, the number of buses to be procured annually to meet the needs of the city, considering the age of the current bus fleet, is as shown in the following figure. The current trend shows that over the next 15 years the net addition to BMTC's fleet will be only 925 buses, while the required addition calculated shows a net addition of over 7100 buses. As mentioned earlier, based on the guidelines prescribed by the MoHUA, a city the size of Bangalore requires a minimum of 60 buses per lakh population. With the current trend in bus procurement, by 2035, BMTC will only have 42 buses per lakh population. BMTC will need to consider a net addition of a minimum of 4600 buses to meet this standard.

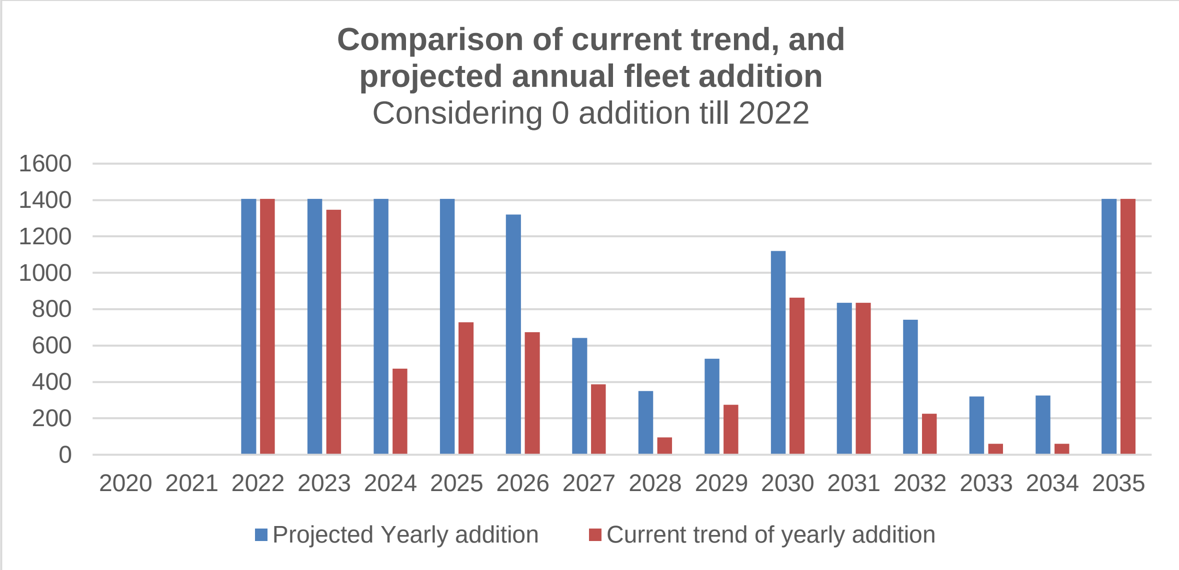

Figure 17: Number of buses to be procured each year from 2020 to 2035

Electrification

Analysis of the total cost of procurement and operation of a 100% diesel fleet shows that BMTC will need to invest close to INR 5.2 Crore annually over the next 15 years. Additionally, considering the increasing cost of fossil fuels, diesel bus maintenance and staff cost, the difference between CPKM and EPKM (farebox) highlights a growing deficit.

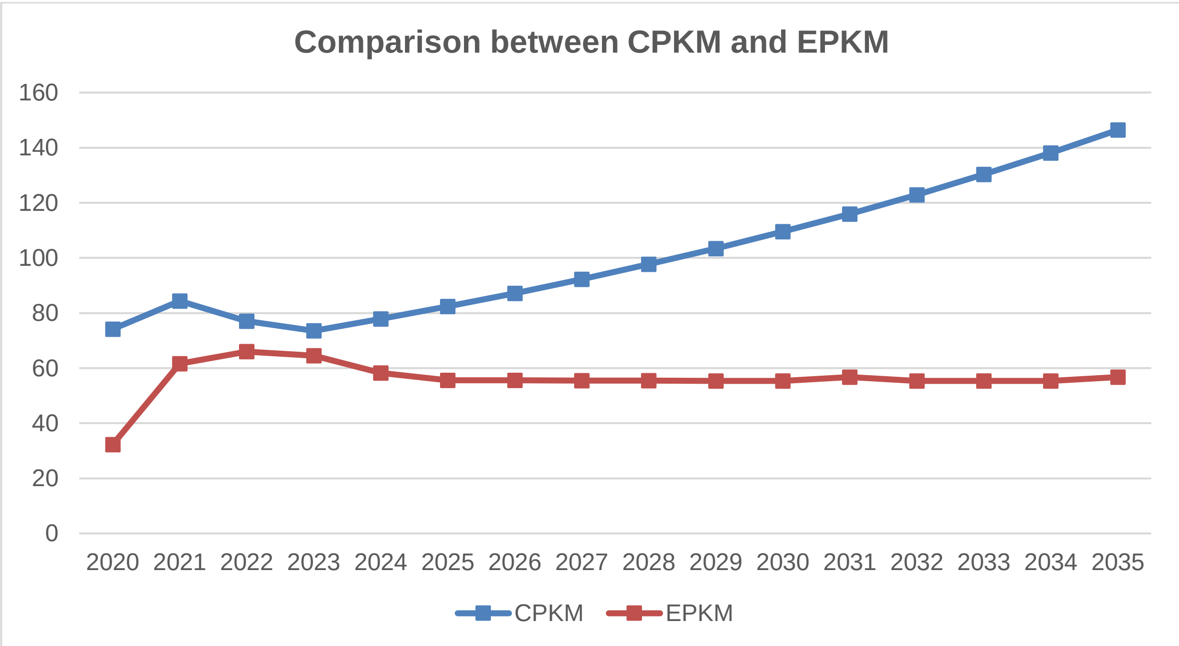

Figure 18: Comparison between CPKM and EPKM in 100% diesel scenario

For an all diesel scenario, BMTC will face an average deficit of INR 44.9/km of operations over the next 15 years.

With the aim of reducing air pollution and reduce the cost of bus operations, Government of India has been making efforts to promote the electrification of public transport across the country. In this regard, transit agencies around the country have been developing electrification roadmaps. The latest Government subsidy under the FAME 2 scheme has supported bus procurement only under the lease or the gross cost contract (GCC) model, where public transit agencies lease the electric buses from OEMs for a set duration of time and pay based on the operational distance. While, the GCC model has been considered most suitable for electric bus adoption, BMTC has historically preferred to own and operate their buses.

Considering this trend, this report assumes that the agency will procure electric buses under the GCC model for the short term, till 2025, when the electric vehicle market in the country is expected to stabilize. While the cumulative total cost for a fully electric scenario (all the buses added from 2022 onward are electric buses) where 100% of the buses are owned and operated by BMTC (INR 81,000 Crore) is less than that of the scenario considering 100% of the buses are procured on the GCC model (INR 1.6 Lakh Crore), the bus leasing scenario allows to avoid the risks associated with vehicle ownership, specifically considering their lack of experience working with E-buses. This drastic disparity in the cost between these scenarios necessitates the need for a mixed procurement model. In the scenario where the e-buses added in the short term are leased and the remaining e-buses added in the medium and long term are owned and operated by BMTC, the cumulative cost reduces by 22% compared to the 100% lease scenario (INR 1.2 Lakh Crore). However, this scenario is also 46% more expensive than the 100% diesel scenario. There is, thus, a need to strike a balance between the addition of diesel and electric buses and the procurement and lease of electric buses.

Thus, this report assumes 6 scenarios for the electrification of the bus fleet. The following figure highlights the assumptions made on the percentage of electric buses in the annual fleet procured.

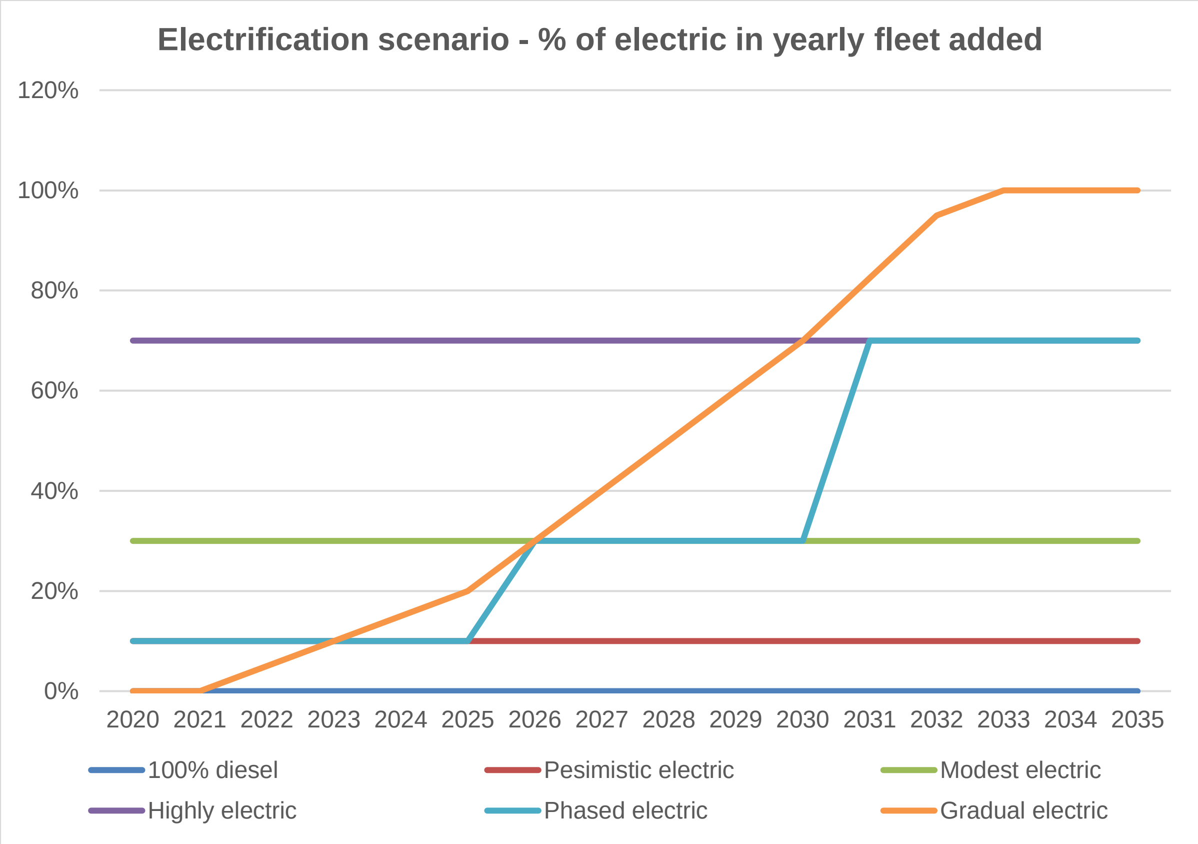

Figure 19 Electrification scenarios

Electrification scenarios:

1. 100% diesel scenario – where no electric buses are procured till 2035
2. Pessimistic electrification scenario – where only 10% of the annual bus fleet added is electric
3. Modest electrification scenario – where 30% of the annual bus fleet added is electric
4. Highly electrification scenario – where 70% of the annual bus fleet added is electric
5. Phased electrification scenario – where in the short term, till 2025, only 10% of the annual bus fleet added is electric, in the medium term, from 2026 to 2030, 30% of the annual bus fleet added is electric, and in the long term, from 2031 to 2035, 70% of the annual bus fleet added is electric
6. Gradual electrification scenario – where the addition of electric buses increase by 10% annually.

The projected electric fleet held by BMTC in each of these scenarios is as shown in the following figure.

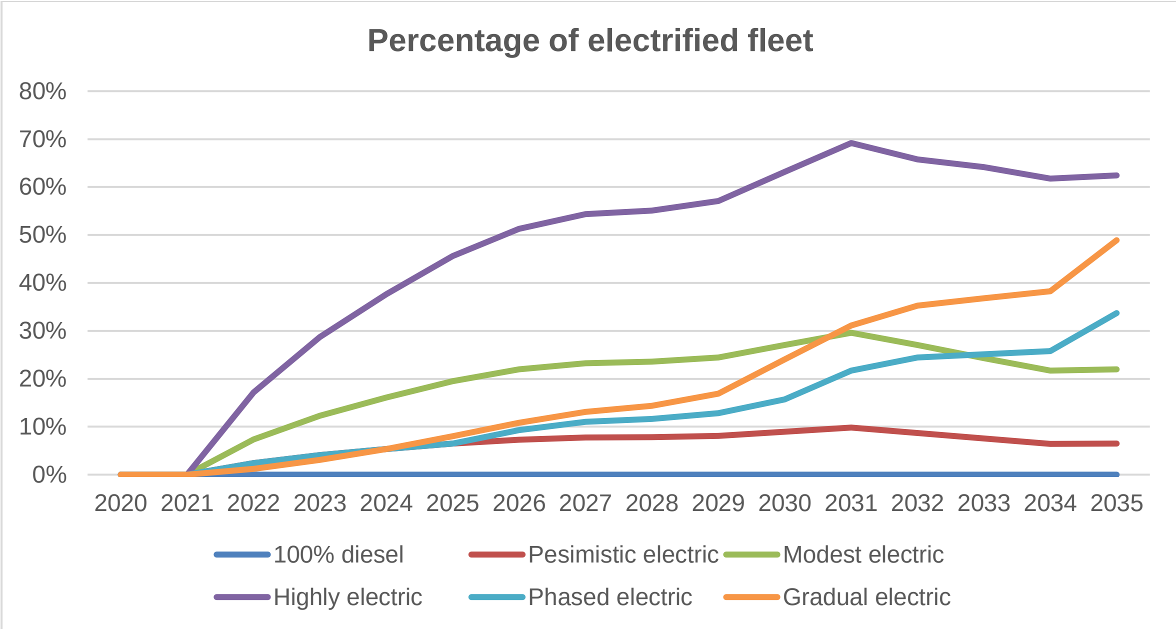

Figure 20 Projected electrified fleet under each scenario

The data shows that the number of e-buses owned by BMTC will surpass the proportion of diesel buses by 2026 in the highly electric scenario. While the modest and pessimistic scenarios enable the electrification of only 22% and 7% of BMTC's fleet, respectively, the phased and gradual electrification scenarios enable the electrification of 34% and 49% of the fleet, respectively.

Costs

The comparison between the total annual cost of procurement and operation of the buses in each of these electrification scenarios is presented in the following figure.

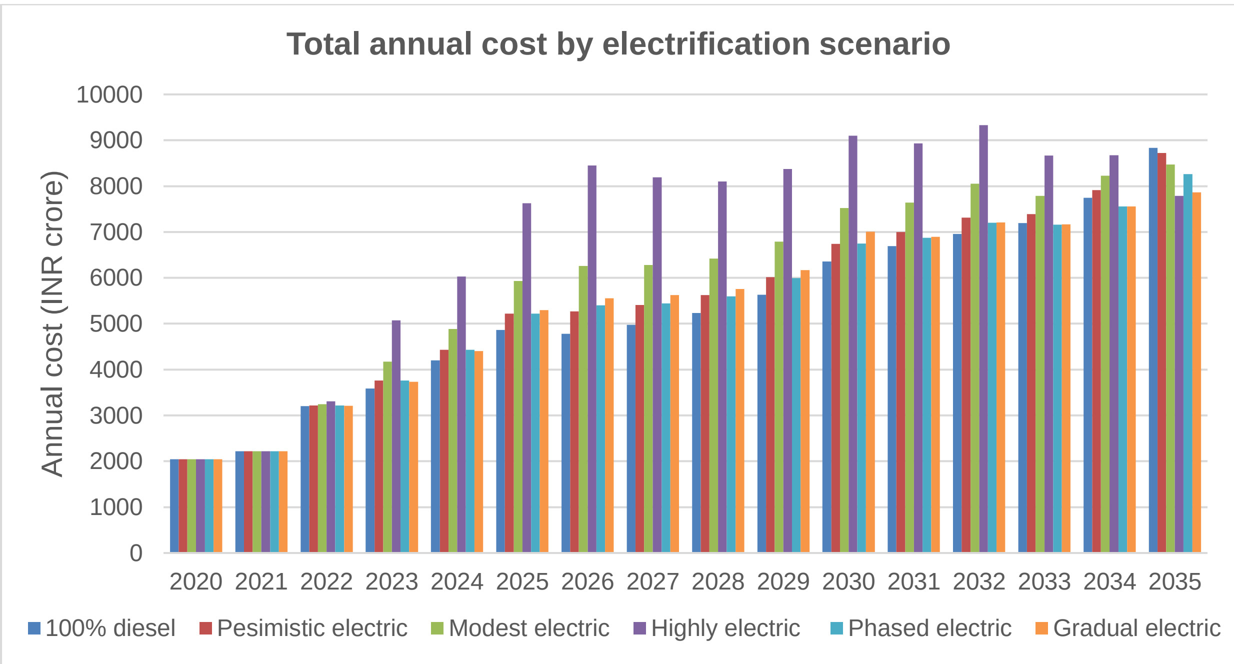

Figure 21 Total annual cost by electrification scenario

The data shows that BMTC will require between INR 88,000 to INR 1.1 Lakh Crore cumulatively over the course of 15 years based on the electrification scenario selected. This amounts to an average of INR 5445 Crore to INR 6995 Crore. The highly electric scenario is associated with the highest cost consider the faster adoption of electric buses and chargers.

A comparison of the cost of procurement across all the scenarios shows that the cost of procurement of the electric buses are a minimum of 92% more expensive in the pessimistic electric scenario than the 100% diesel scenario, up to a maximum of 639% in the highly electric scenario.

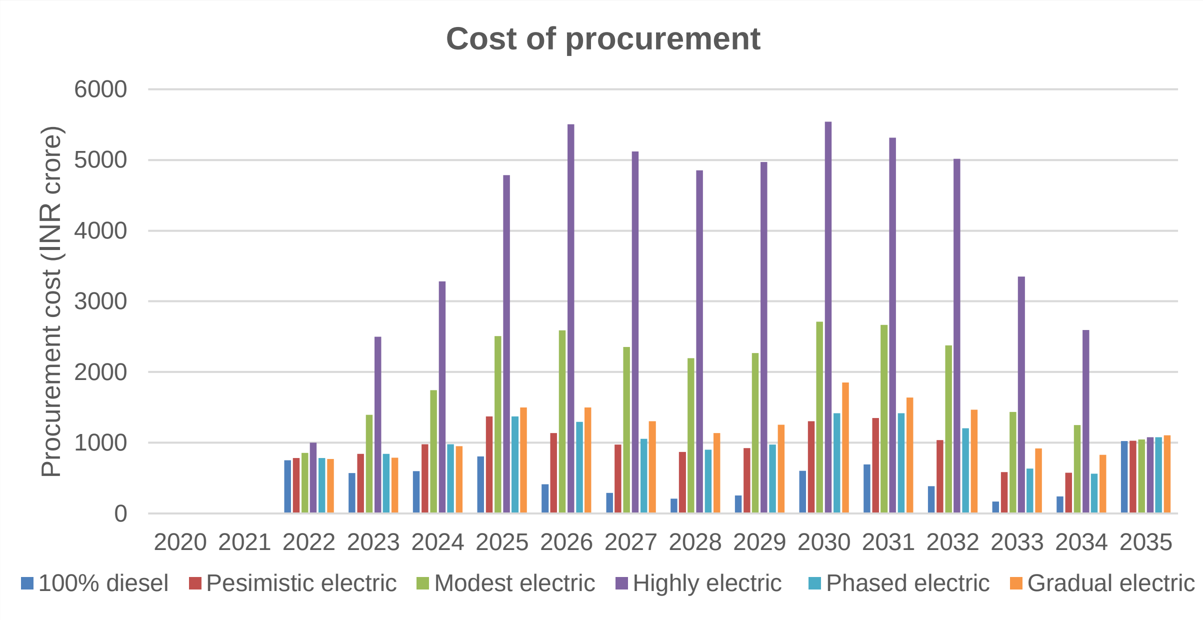

Figure 22 Comparison of procurement cost across electrification scenario in BAU

Considering the costs proposed, and the rate of electric bus adoption, the phased electrification scenario seems to be the most economical. However, this data needs to be further analysed and compared with scenarios with increasing mode share, and public transport service provision.

Supporting Infrastructure

Considering the increasing fleet size, BMTC will also need to construct depots and terminals to support bus operations. Currently BMTC owns 45 bus depots, 10 TTMCs, 27 bus smaller stations and 2 major bus stations in the city. To support the operation of the 10,733 buses required for the city by 2035 considering the BAU scenario of decreasing mode share, BMTC will need to operate a total of 87 bus depots. Discussion with BMTC also revealed that going forward, the agency is planning on not constructing standalone bus terminals, and will instead partner with other agencies in the city to develop multimodal hubs. Thus, in addition to the existing 10 TTMCs, BMTC will operate 3 TTMC that are currently under construction and will need two additional multi-modal hubs to mee the demand in 2035. In addition to these, BMTC will also need to invest in upgrading and adding equipment to support continued operation of their ITS infrastructure.

Considering the assumptions to estimate the total investment required for the installation of supporting infrastructure, BMTC will need to invest a total of INR 1060 Crores to develop this infrastructure over the course of 15 years. This, however, does not take the cost of development of charging infrastructure into consideration.

Based on discussions with BMTC, a scenario with a combination of fast and slow chargers has been selected. Fast chargers enable opportunity charging for buses during operational hours. However, these are almost twice as expensive as slow chargers, which enable overnight charging of buses. Based on this hybrid model, BMTC will require between 53 and 500 fast chargers, and 372 and 3500 slow chargers, with the pessimistic scenario needing the least number of chargers and the highly electric scenario needing the most. The cumulative investment for the charging infrastructure ranges from INR 78 Crores to INR 570 Crores based on the electrification scenario selected.

Ridership and revenue

Considering the BAU trend for mode share, trip rate and population considered in this scenario, the projected ridership for the projected is forecasted to increase from 2.8 million in 2020 to 4.4 million by 2035.

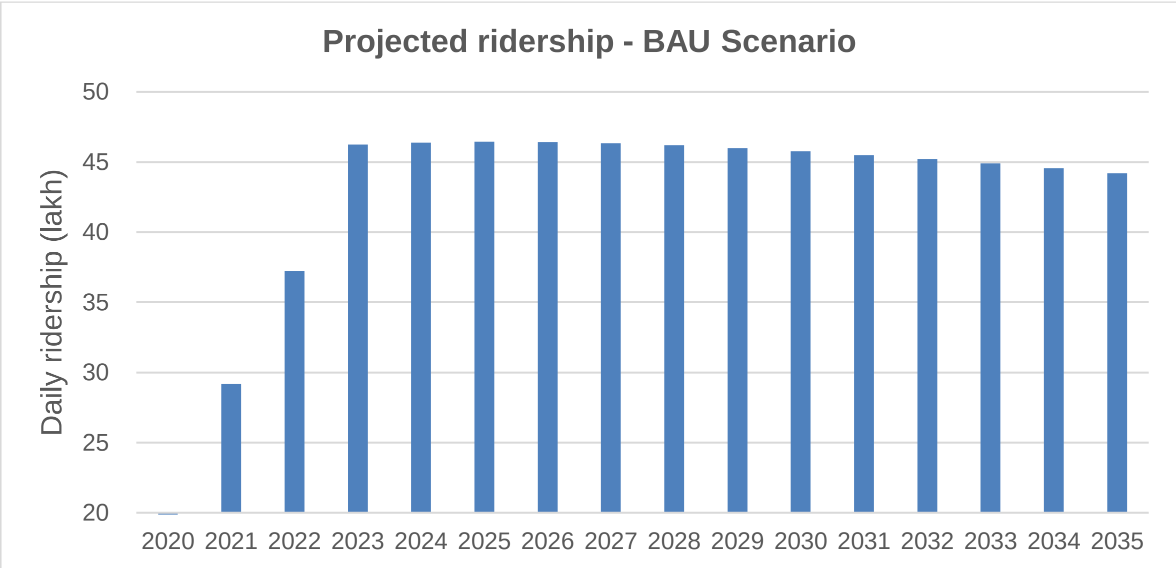

Figure 23 Projected Ridership

The total farebox revenue has been calculated using the average cost of each ticket, calculated to be INR 15.6 based on trip length, and assuming that 30% of BMTC's passengers are pass users. As this calculation does not consider any changes with regard to assumptions made for the electrification scenarios, the total revenue, and in turn the earnings per kilometre (EPKM), does not change based for the different electrification scenarios. The total farebox revenue is projected to increase to INR 3026 Crore by 2035, considering a 1.5% annual inflation in the cost of the ticket.

A projection of the non-farebox revenue sources of commercial revenue, revenue from the sale of scraps and advertising revenue show an annual average non-farebox revenue of INR 168.7 Crore, and a cumulative earning of INR 2350 Crore over the next 15 years.

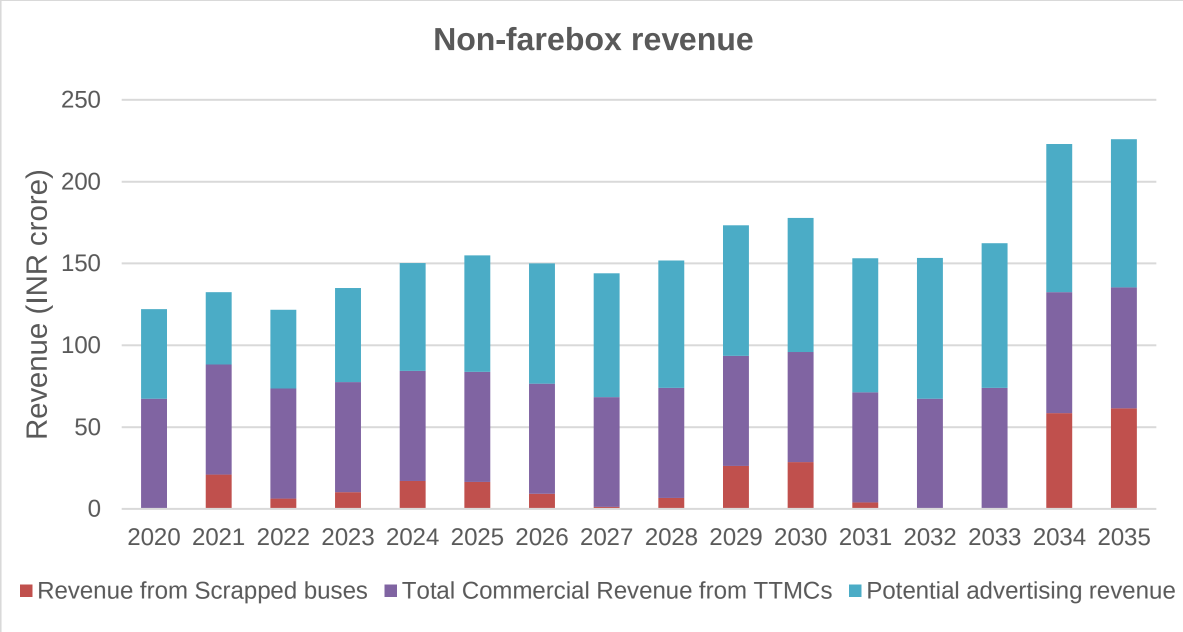

Figure 24 Projected non-farebox revenue

Profit and loss

A comparison of the total cost of bus operations per kilometre (CPKM) considering current trend of operations of only diesel vehicles and the EPKM (farebox) is as shown in the following figure.

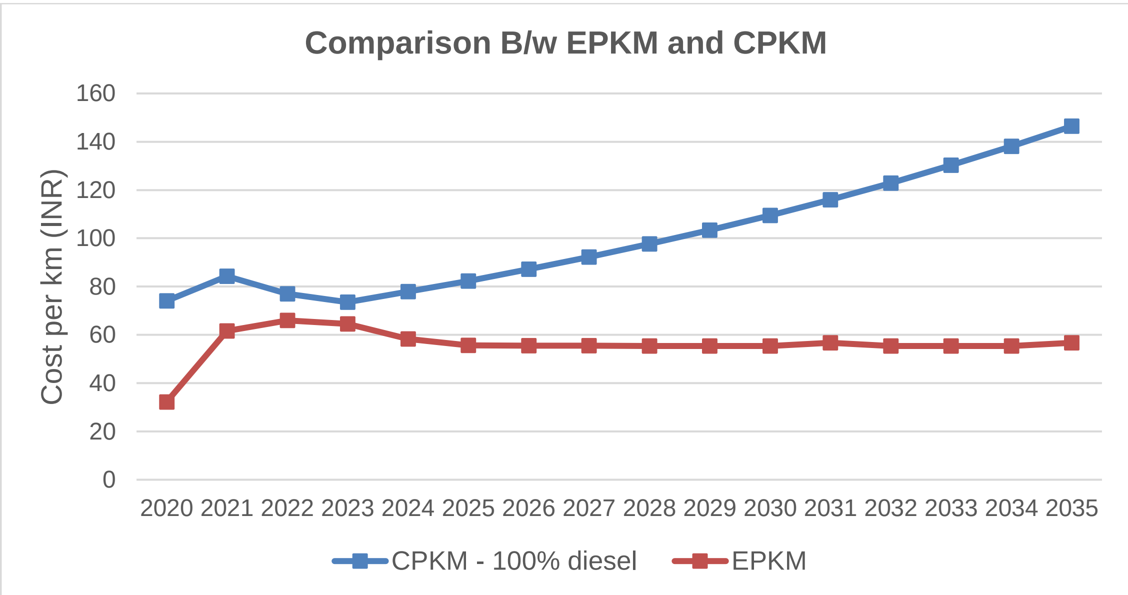

Figure 25 Comparison between CPKM (100% diesel scenario) and EPKM for each electrification scenarios

The difference between the CPKM and EPKM gives the annual deficit the agency needs to bear. The above graph shows that in the 100% diesel scenario, BMTC must bear an annual deficit of INR 44.87/km. This number, however, reduces in the electrification scenarios.

The following figure compares the CPKM of each electrification scenario considered in the BAU. The data shows that the deficit reduces considerably with every electrification scenario, reducing to a minimum annual average of INR 19.1/km in the highly electric scenario.

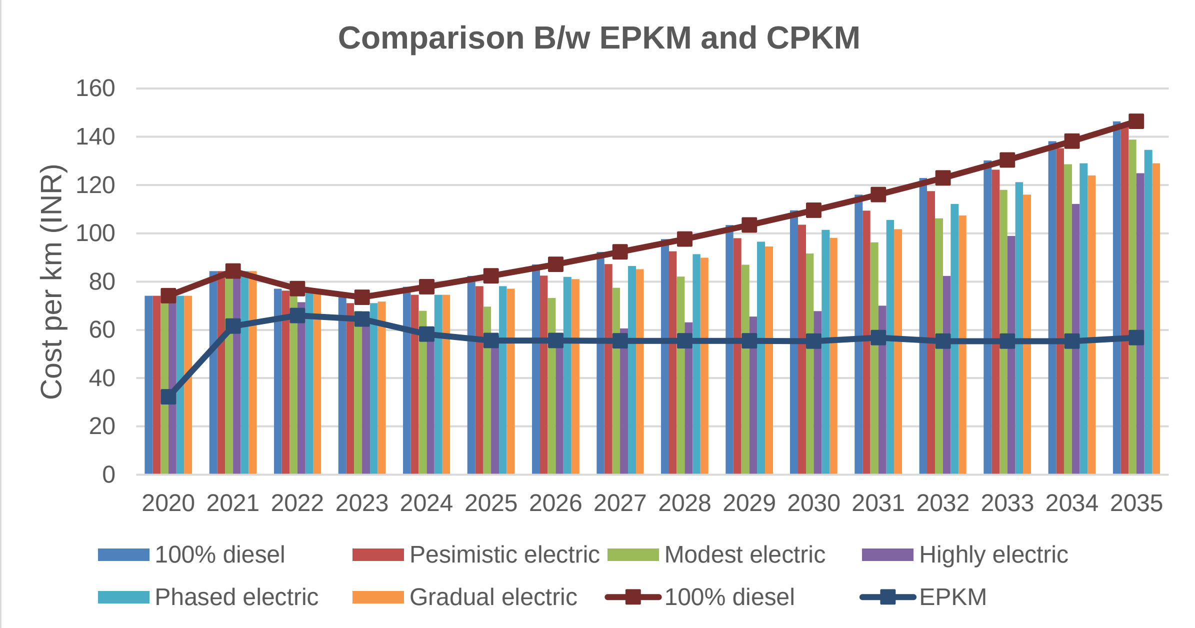

Figure 26 Comparison of EPKM and CPKM by electrification scenario

5. SCENARIO BUILDING

It is clear from the data presented in the BAU scenario that the declining trend in mode share will have severe repercussions on BMTC's finances. In addition to this, a decreasing mode share in public transport indicates an increasing mode share of low occupancy vehicles such as private two wheelers and cars and autos, which will further exacerbate the current levels of traffic congestion in the city. There is, thus, a need to plan strategies that will make public transport in the city more appealing and affordable.

As seen earlier, BMTC has observed a drastic increase in the rate of cancellation of their services, resulting from increased congestion. This has in turn affected the schedule adherence of the service which greatly impacts the occupancy of the bus. The city's congestion has also resulted in a decrease in bus speed which has severely impacted the daily the operated km for BMTC's services. Interventions to improve these parameters have the potential to greatly bring down the requirement of new buses and, thus, the total cost incurred.

The potential increase in ridership and the required fleet size has been calculated considering various scenarios of strategies to improve ridership and bus operations have been calculated based on their potential impact on ridership, daily effective km operated per bus and the occupancy of the bus. These strategies have been presented in the following scenarios.

Scenario 1: BAU scenario

This scenario is the business-as-usual scenario described in the previous section, where all the components that impact the total required bus fleet are assumed to change as per the past trends observed. In this scenario, the effective bus utilization sees a decreasing trend along with the public bus mode share, while the population, trip rate, trip length, and bus occupancy observe an increasing trend over the vision period analysed. Thus, while the mode share decreases, the absolute ridership continues to increase as the rate of change of the trip rate and the population combined overshadow the decrease in mode share. This decline in mode share indicates to an increase in private vehicle use and in turn, congestion in the city. This increased congestion in the city further exacerbated the quality of public transport service that leads to the reduction in the bus speed and hence, the effective kilometres operated by BMTC, increasing travel time, fuel consumed and air pollution.

Scenario 2: Bare Minimum

Scenario 2 presents the bare minimum strategies that BMTC and other city level agencies have already planned for over the last few years. These include the implementation of the bus priority lane, the development of a new and improved mobile application, and the adoption of automatic fare collection systems. It is estimated that the combined impact of these strategies may not be able to sustain an increasing trend in the mode share for public transport over the long term but enables a mode share better than that observed in the BAU scenario. It is estimated that the combined impact of these strategies will result in a ridership increase of 45% and a cumulative revenue increase of 29% by 2035, when compared to the BAU scenario.

BMTC Mobile application

Since the installation of the ITS system at BMTC in 2016, BMTC has been putting in efforts to develop a world class mobile application to allow passengers to access bus information in real time. However, despite several efforts, the app developed has fallen short on meeting the expectations of the userbase. A survey conducted by WRI India in 2018, highlighted that the provision of accurate bus information to existing and potential bus users has the potential to increase ridership by 3% along the major corridors of the city. Based on discussions with transport experts, this impact, extrapolated across the entire network, could potentially improve ridership by 10% over a span of 3 years. Thus, this scenario proposes that a mobile application be developed and rolled out by 2023, enabling its full potential of increase in ridership by 2025.

Bus Priority Lane

Based on the information presented in the CMP, BMTC along with other agencies in the city plans to roll out the BPL along all the major corridors in the city, accounting for a total of 220 kms. The city plans to accomplish this over the span of 15 years. While the first 18 kms have been installed in 2019, this study assumes that the construction of the remaining 202 kms will begin only from 2023 onwards, allowing time for the agencies to recover from the impact of the COVID 19 pandemic. The timeline of construction is as presented in the following graph.

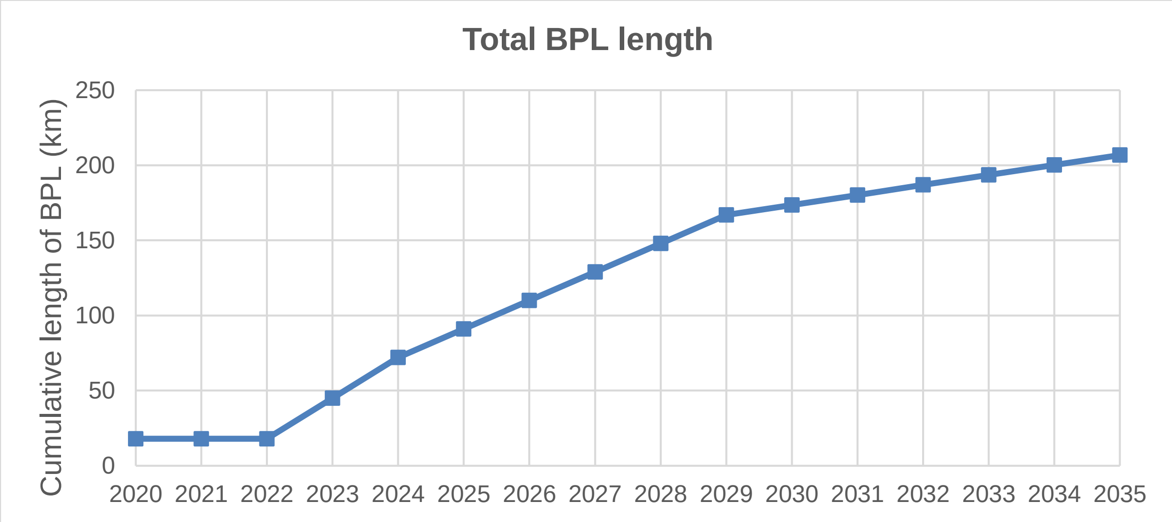

Figure 27: BPL construction timeline considering delay due to COVID 19 Impact

Based on the experience of the 18 km BPL in Bangalore along the ORR, it is evident that the BPS has the potential to increase ridership and improve bus operations. According to a study conducted on the impact of bus priority and NMT on mode choice, the development of priority bus lanes has the potential to improve ridership along the developed corridor by up to 50%. The ETM data collected from BMTC in 2019 highlighted that the ridership along the major corridors in the city accounts for ~30% of the total ridership in the city. Thus, the ridership increase has been calculated based on the year-on-year completion of the BPL along the major corridors in the city.

Additionally, the VKT increase resulting from the improved efficiency of operation has been calculated based on the required number of bus trips needed to meet the rising demand for bus services. Here, the occupancy has been assumed to increase by 1% year on year compared to the BAU scenario.

Automatic Fare Collection System

Finally, the last strategy proposed under scenario 2 is the adoption of automatic fare collection systems on all newly added buses starting from 2023. This strategy, while not enabling a major increase in ridership, has the potential to reduce operation cost significantly. As seen earlier, the staff cost forms close to 55% of the total bus operation cost. The use of an AFC gate in all newly added buses will reduce the number of staff required for bus operations in the city while not going below the existing staff strength.

The following table shows that the adoption of of AFC gates has the potential to reduce staff cost by up to 20% compared to that seen in the BAU scenario.

Table 6 Comparison of the total staff cost between Scenarios 1 & 2 (INR crore)

	100% diesel	Pessimistic electric	Modest electric	Highly electric	Phased electric	Gradual electric
Scenario 1	41,720	40,435	38,001	34,072	40,439	40,003
Scenario 2	33,532	33,204	32,588	31,584	33,207	32,977
% Difference	20%	18%	14%	7%	18%	18%

Scenario 3

Scenario 3 includes the strategies in scenario 2 and further suggest easier measures BMTC can take to improve its ridership and revenue collection. It is estimated that their implementation will result in a ridership increase of 75% and a revenue change of 25% by 2035, when compared to the BAU scenario. This scenario needs a total of 12,834 buses by 2035. Due to the modal shift towards buses in this scenario, we estimate an increase in daily revenue kilometer/bus of 3% compared to Scenario 2. To estimate this properly, in-depth travel demand models need to be created to study the true impact on VKTs. The strategies are listed below:

Table 7: Scenario 3 Strategies

Strategy	Starting year	Equilibrium year	Impact
Fare rationalisation	2022	2023	+12.70% ridership
One free intra/inter-modal transfer within 2 hours	2023	2024	+25% ridership
Parking Policy	2022	2025	+150.2 cr/year revenue
Reduction of MV tax by 50%	2020	N/A	46% reduction in deficit/km

One free transfer in a 2-hour period

Typically, if a rider takes multiple trips on bus and/or metro in a single journey, then they must pay the full fare of each trip. This makes travel more expensive based on route connectivity. It also disproportionately affects female riders, who are more likely to make multiple stops in a journey, known as trip chaining.

This penalty can be reduced by making specified number of transfers free for some time. E.g.: Make 1 transfer free within a 2-hour period. This policy is dependent on complete implementation of an AFC system. The journey details of the rider are tracked through the card.

Methodology:

1. For this report, we rely on 3 sources to estimate the potential effect of <u>one free transfer in a 2-hour period</u> on BMTC's ridership and traffic revenue:
    a. Census 2011 gives the distribution of bus riders in Bangalore based on distance to workplace. Work trips make up 65% of bus trips as per the 2019 CMP.
    b. BMTC's 2019 annual report gives the average ticket costs at ₹15.7. Based on the fare structure, the average trip length is 6.7 km.
    c. Gadepalli (2017)[23] estimates the fare elasticity of BMTC riders at -3.3. Other studies (Nagesha et al. 2016)[24] calculate a more conservative elasticity of nearly -1 for smaller fare decrease. For this report, we have taken a maximum elasticity of

[23] Dhok, D., & Gadepalli, R. (2018). *Demand elasticities of Bus ridership in India Case study of Bangalore*. Urban Mobility Conference & Expo 2018. http://www.urbanmobilityindia.in/Upload/Conference/2953e025-357f-4cdc-bc6a-805c0c80e524.pdf

[24] Nagesha and Verma A., (2016) "Price Elasticity of Demand for Urban Bus Transit: A Case of Bengaluru City Bus Service", Indian Journal of Transport Management, Central Institute of Road Transport, India, Vol.40, No.2, pp.76- 87.

-2, keeping in mind that BMTC has among the highest fares in the country. We then consider a range of elasticities based on distance and reduction in cost/trip.

2. If x is the distance to the workplace, the number of trips taken in a single journey = $x/6.7\ km$. This gives us the number of trips based on the distance travelled. We round trip values < 1 up to 1 and cap the max number of trips in a direction at 4. Since these are work journeys, we assume they all make return journeys. Doubling the trips gives total number of daily work trips on BMTC.
3. The cost/trip reduces if a rider makes more than 1 trip in the time period. We derive the percentage reduction in fare from this. Using appropriate elasticity, we derive the potential increase in riders for each distance.

Comments:

1. The elasticity is higher for short and long trip-makers.
2. Free transfers might incentivise longer OD journeys, the implications of which need to be explored.
3. We consider that 77% journeys (work + education) return.

Fare Rationalisation

Currently, BMTC employs a telescopic fare structure which costs more per km for short-medium trips than for longer ones. However, most (85%) riders are travel up to 12 km. Verma et al (2019)[25] propose revising the fare structure such that cost/km for short-medium trips (<12 km) reduces, which will increase ridership for this group by 15%, or 12.7% of the entire ridership. The study also proposes increased fare for later stages which will need to be considered before implementation, and which is not considered in this report.

Parking Policy

In 2020, DULT released a parking policy for Bangalore which would introduce a permit system to annually charge private vehicles for using designated parking spots in the city. The permits are priced proportional to the vehicle size.

Table 8 - Annual permit cost for different vehicles under the Parking Policy (2020)

Vehicle	Annual permit cost	% of total 4 wheelers
2-wheeler	500	-
4-wheeler – small	1000	50
4-wheeler – medium	3000	35
4-wheeler – SUV	5000	15
Avg. 4-wheeler permit cost	2300	← Based on above percentages

Based on registration data from the state transport department, we estimate the number of vehicles in Bangalore annually till 2035. Multiplying the numbers with respective annual permit cost gives the parking revenue collected by BBMP. To be realistic, we assume that, on

[25] Vajjarapu Harsha, Omkar Karmarkar, Ashish Verma, Sustainable Urban Transport Policies to Improve Public Transportation System: A Case Study of Bengaluru, India, Transportation Research Procedia, Volume 48, 2020, Pages 3545-3561

average, only 33% of the vehicles buy a permit. The policy also proposes funding public transport through this revenue; since details are pending, we assume that BMTC will receive 40% of the parking revenue.

Based on these assumptions, this provides BMTC with additional non-farebox revenue of ₹150 cr annually.

Table 9 - Two scenarios for Parking Policy implementation

Parameters	Conservative	Ambitious
Permit inflation	0.00%	1.50%
% vehicles with pass	33%	67%
BMTC revenue share	40%	60%
Avg. Annual Revenue for BMTC (₹ crore)	**150**	**502**

Reduction in Motor Vehicle (MV) tax by 50%

BMTC pays an MV tax equal to 5.5% of its ticketing revenue annually. In Karnataka, this tax contributes towards the development of road infrastructure. However, in 2019, BMTC made a loss of ₹550 crore, while paying ₹256 crore in various taxes – fuel (49%), MV (40%), GST (7%), and commercial (4%). Thus, for scenario 3, the MV tax is reduced by half to 2.75%. **This simple measure would eliminate BMTC's average deficit per km of ₹19 in Scenario 3.**

Scenario 4 – Ambitious

This scenario builds on top of the previous two and proposes 2 ambitious strategies to drive ridership and revenue up. Compared to the BAU scenario, ridership goes up by 178% and revenue by 22% by 2035. The required number of buses in 2035 is 14,506. Due to the modal shift towards buses in this scenario, we estimate an increase in daily revenue kilometer/bus of 5% compared to Scenario 2. To estimate this properly, in-depth travel demand models need to be created to study the true impact on Vehicle Kilometers Traveled (VKTs).

Fare capping

Fare capping can be considered as an automated pass system which kicks into effect after the rider has completed a specified number of trips. For e.g., BMTC caps the chargeable number of trips in a day at 2. Then, for the rest of the day, a user will not have to pay any fare after completing 2 trips. The agency can change the cap or its duration (1 day, 1 week etc.) to suit its scenario. Fare capping also requires the complete presence of an AFC system to track riders.

Benefits:

1. It reduces the average cost per trip for frequent travelers.
2. It simplifies the fare structure since it removes the need for purchasing different passes.
3. It corrects the travel penalty that women pay, as they are more likely to do trip-chaining.
4. Though fare capping reduces farebox revenue, it is balanced by the increase in ridership and loyalty. The increase can be estimated from the fare elasticity for that service.

The methodology used to calculate the revised ridership for this strategy is similar to that presented in Free Transfer (Scenario 3) based on assumptions about fare elasticity.

Daily trip cap ->	2	3	4
Ridership change	+96%	+66%	+44%

Complete waiver of MV tax

Building on top of the 50% waiver in Scenario 3, this scenario proposes completely waiving off the tax. Scenario 4 is costlier, owing to its ambitious fare reduction goals. Completely removing the MV tax would reduce the average deficit per km for this scenario by 84%.

A note on the implementation of ITS

BMTC has previously attempted to harness ITS to better track fleet performance and increase cashless transactions on-board. However, this implementation was plagued by faulty ticketing machines and the system was abandoned in 2019. Going forward, BMTC will need to consider the role of ITS as indispensable. The strategies suggested above, like free transfers and fare capping, rely completely on the transport agency's ability to maximize the penetration of smart cards among riders. New York implemented its free transfer policy in 1997 and witnessed a quick uptick in ridership. However, the city preceded this introducing and marketing the smart card for 3 years. Within a few months of starting free transfers, smart card usage in NYC had crossed 60%.

ITS and smart cards will also help BMTC in carrying out a travel demand analysis to rationalize its route network and improve vehicle utilization. Since, as of 2021, BMTC is in the process of contracting ITS, its presence has been taken as a given for the scenarios.

6. SCENARIO COMPARISON

This section presents a comparison of the impact of each of these scenarios on the base parameters that affect used in this study, and the ridership, fleet size and the associated infrastructure and cost parameters. It also presents a comparison of the electrification scenarios of Scenario 4.

Base parameters

The overall impact of the scenarios presented above shows that the strategies considered in this assessment have a significant impact on the public transport mode share, and operations. The cumulative impact of the scenarios on the mode share, vehicle utilization or productivity and bus occupancy have been presented on the following graphs.

Mode Share

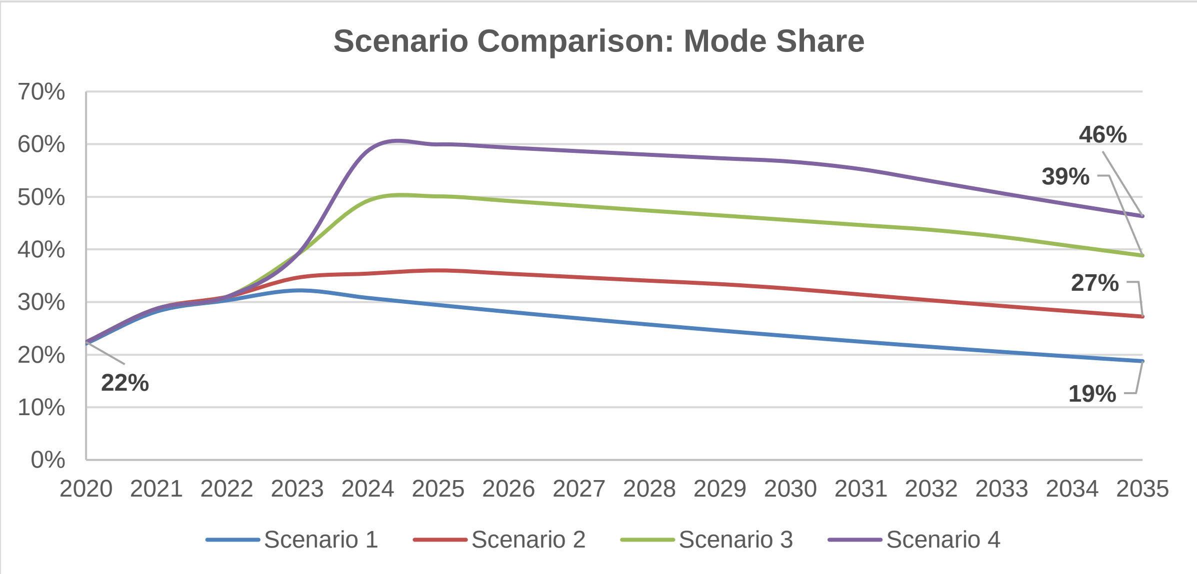

Figure 28: Mode share comparison

The mode share increases from 22% in 2020 to 27% in scenario 2, 39% in scenario 3, and 46% in scenario 4, while reducing to 19% in the BAU scenario. This shows that as the scenarios to improve public transport access and service level become more ambitious, the mode share of public transport increases, indicating that the mode share of other modes, primarily two wheelers, auto rickshaws, and four wheelers reduces. This further highlights the impact of these scenarios on the traffic congestion in the city.

Vehicle Kilometers Traveled (VKT) and Occupancy

Among other factors, the distance traveled daily by a bus (VKT) is dependent on the congestion levels, cancellation rates, and rationalization of routes. As such, correlating increase in mode share of bus to increase in VKT would require an in-depth demand analysis, which is outside the scope of this report. Nevertheless, it is estimated conservatively that compared to BAU, scenarios 2,3, and 4 will see an increase in VKT of 38%, 51%, and 59% by 2035, respectively. A more proper estimate is likely to arrive at higher km, which would reduce the required fleet strength further.

Similarly, increased ridership and fare capping strategy are likely to increase occupancy on low ridership routes, though this requires a more careful look. Here, the conservative estimates for occupancy in 2035 are shown in table below.

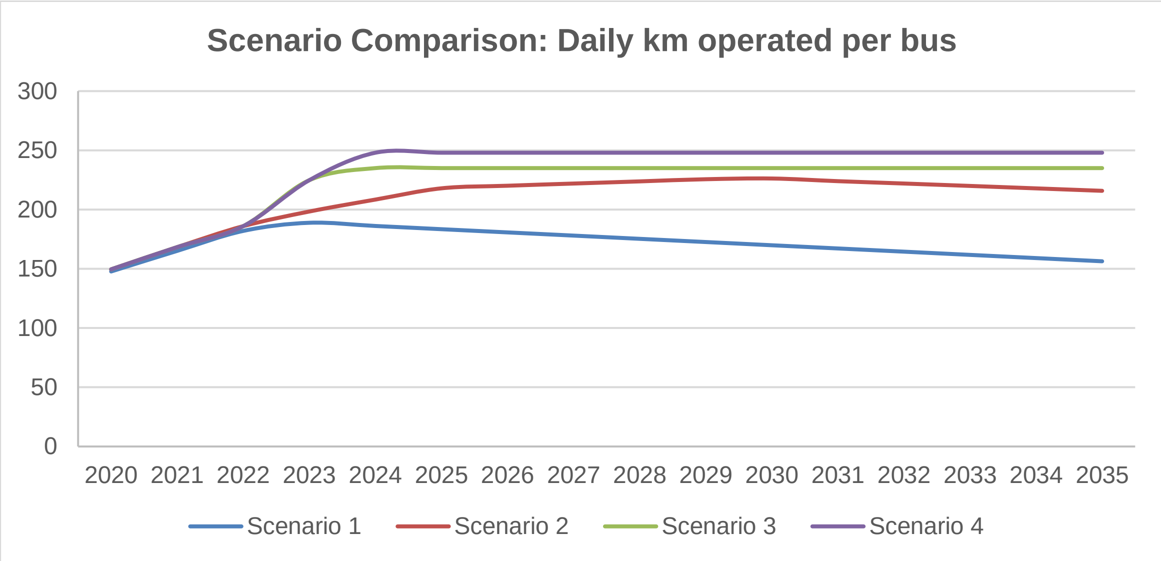

Figure 29: Daily km operated comparison

Table 10: Average occupancy (2035) comparison

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Average occupancy in 2035	75%	76%	77%	80%

Performance

This section presents a comparison of the 4 scenarios in terms of ridership, revenue, and efficiency indicators. All comparisons are considered for a 100% Diesel fleet. They highlight that the most ambitious scenario, Scenario 4, would drastically improve BMTC's ridership and mode share in the city. It would also improve utilization of the buses, though this needs to be explored in-depth. However, this scenario leads to lesser revenue collection than in scenarios 2 and 3 due to reduced cost of travel.

Ridership

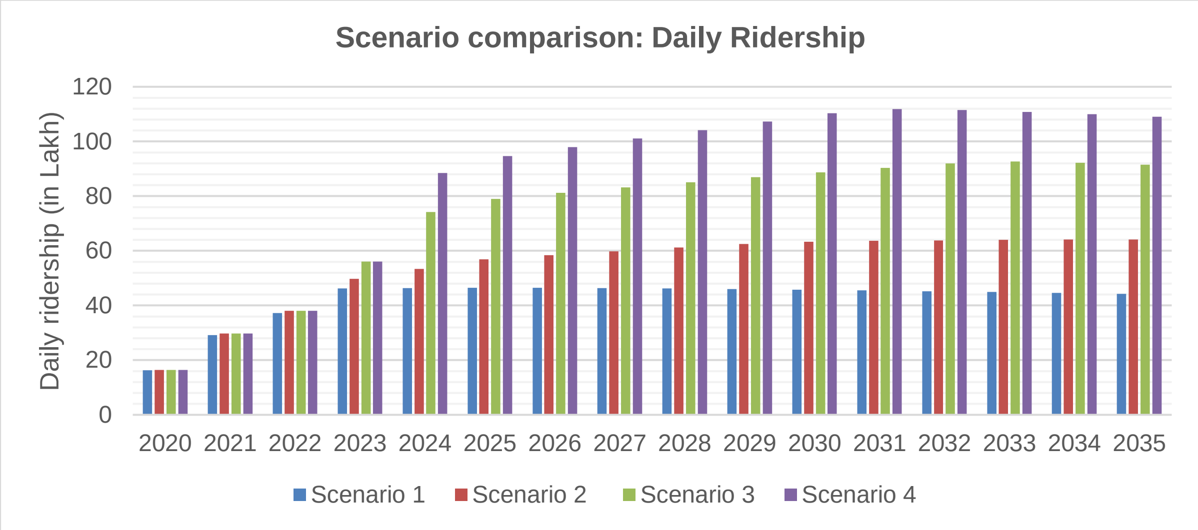

Figure 30 Daily ridership comparison across scenarios

The daily ridership shows a similar trend, being 147% higher in scenario 4 compared to BAU by 2035. The strong increase in ridership in scenarios 3 and 4 is based on the strategies to bring down the cost of travel, as explored previously.

However, all these strategies are estimated to achieve equilibrium by 2028, which results in a declining trend in both parameters thereafter, indicating a need for continuous interventions to increase mode share the long term.

Farebox Revenue

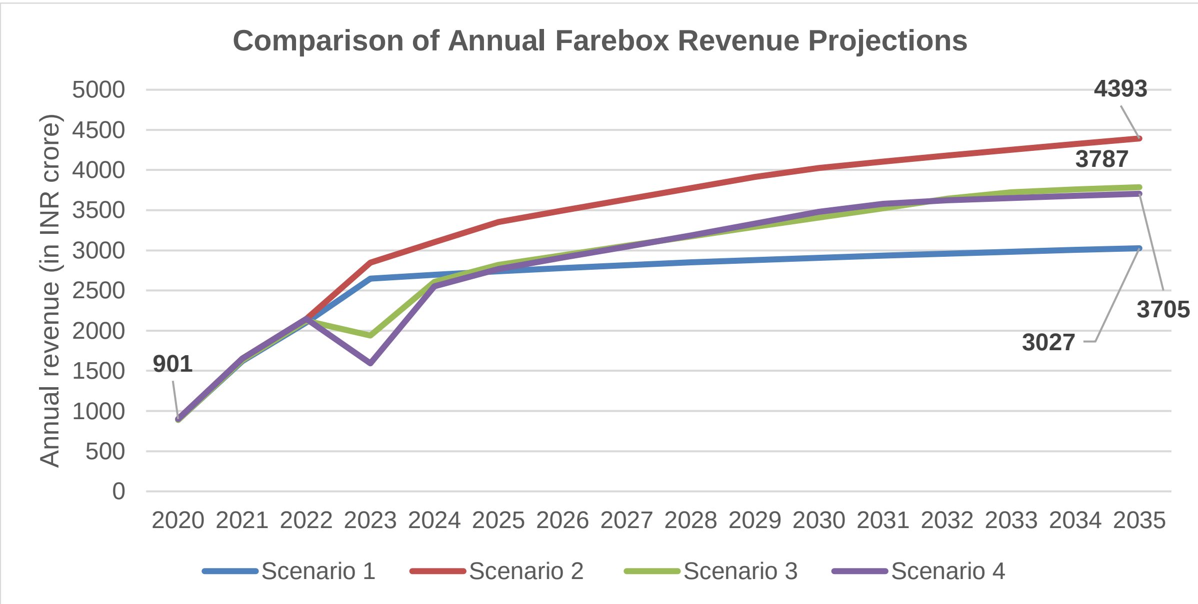

Figure 31: Annual revenue comparison

The annual farebox revenue is dependent on ridership and the average ticket cost. The declining ridership in BAU is predicted to lead to low revenue growth. In Scenario 2, the gradual implementation of the BPL helps increase revenue to 45% more than BAU in 2035. However, both these scenarios do not take measures to reduce BMTC's nationally high ticket costs. In the next scenario, a faster BPL implementation coupled with fare rationalization and free transfer strategies lead to high revenue growth, reaching more than twice that of BAU by 2035. Finally, as seen above, the most ambitious Scenario 4 drastically increases ridership due to the reduced average ticket cost. Annual revenue, by 2035 however, is only 22% greater than in BAU. In Figure 31, a sharp dip in revenue is seen for Scenario 4 in 2023; this is due to introduction of the fare capping strategy which reduces average fare. However, **Error! Reference source not found.** shows that ridership picks up strongly in the next year.

Table 11: Average fare (2035) comparison

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Average fare for a ticket in 2035 (₹)	19.5	19.5	11.8	9.7

Fleet size

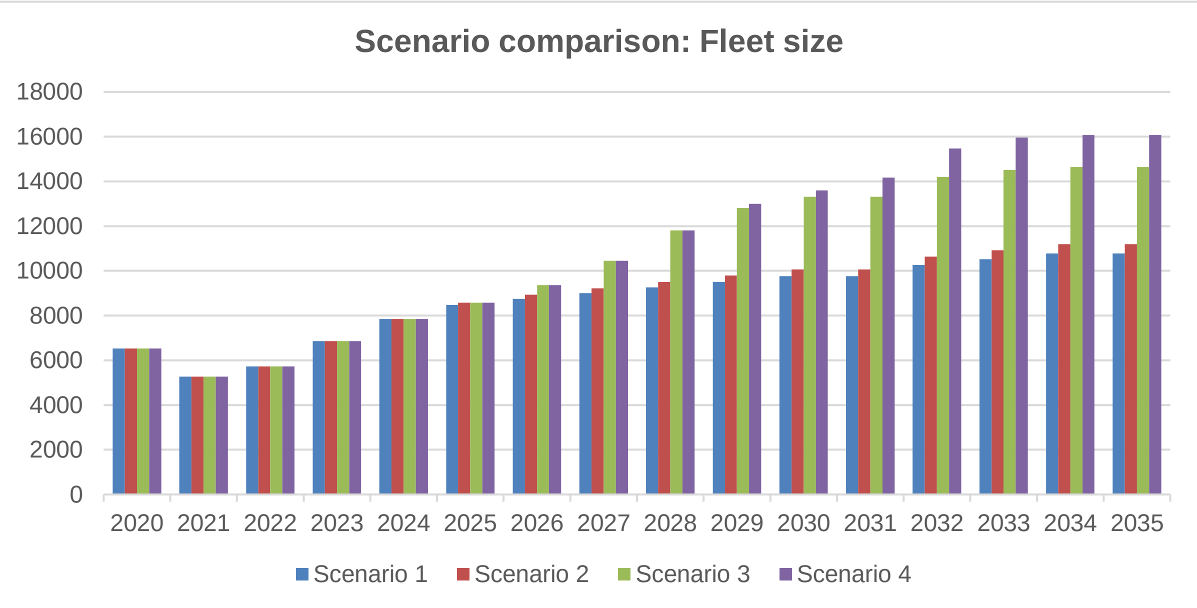

Table 12: Fleet size comparison

The increase in ridership in scenarios calls for larger fleets, while maintaining occupancy upto 80%. By 2035, scenarios 2,3, and 4, warranting 45%, 107%, and 147% higher ridership in 2035 compared to the BAU scenario, will require 11,197, 14,639, and 16,069 buses, respectively. It must be noted that the requirements will be affected by a more accurate estimate of VKT growth.

CPKM Vs EPKM

In every subsequent scenario, the VKT and occupancy show an increasing trend. As each bus becomes more effective and is able cover longer distances, do more trips and carry more passengers, the total fleet size required reduces. This will also reduce the cost per km (CPKM). On the other hand, as indicated above, despite increasing ridership in every scenario, reducing cost of the ticket reduces earnings per km (EPKM).

Table 13: Average annual CPKM, EPKM and deficit for scenarios in 2020-2035

	CPKM	EPKM	Deficit
Scenario 1	101	56	45
Scenario 2	82	57	25
Scenario 3	79	40	38
Scenario 4	78	38	40

Taxation

In Scenarios 3 and 4, BMTC is liable to close to INR 2550 Crore and INR 2519 Crore cumulative MV tax (5.5% of total revenue) across the visioning period. Reducing the MV tax in Scenario 3 and eliminating it in 4 would massively reduce the deficit per km of operations by INR 17/km and INR 33.7, by 46% and 84%, respectively. Doing so would drastically reduce the state's role in supporting BMTC with funding support to maintain viability.

Cumulative costs

In total, scenarios 2,3, and 4 will cost 3%, 29%, and 40% more than BAU. However, this absolute increase is better understood in the context of reduced deficit in each of these scenarios compared to BAU.

Table 14: Cumulative cost comparison (INR crore)

Scenario 1	84,521
Scenario 2	87,155
Scenario 3	1,08,909
Scenario 4	1,18,074

Non-fare box revenue

Over the years, BMTC has relied on various non-farebox sources like commercial revenue from TTMCs, sale of scrapped buses, and provision of advertising spaces. Going forward, scenarios 1 and 2 continue with this trend. For the other two, revenue from implementing the parking policy is considered. This annual revenue becomes significant when one considers its contribution to reducing the deficit per km (see table).

Table 15: Non-farebox revenue comparison

Revenue ->	Annual (₹ crore)	Cumulative (₹ crore)	Contribution to reduction in average deficit/km (₹)
Scenario 1	158.2	2,531	2
Scenario 2	160.3	2,565	2-3
Scenario 3	318.4	5,094	4-5
Scenario 4	324.1	5,186	4-5

Based on the data presented above, it is evident that Scenario 4 offers the most accessible and financially viable solution for BMTC users, by reducing the average ticket cost by ~50% enabling a 147% increase in ridership compared to the BAU scenario. This will further enable the improvement of quality of life in the city by reducing traffic congestion, which will have knock-on effects on the operational performance of BMTC's buses. As mentioned earlier, based on the assumptions, BMTC can achieve an improved vehicle utilization of up to 250 kms/bus/day which indicates to a reduction in cancellation rate and significantly improve service level and schedule adherence for customers. The improvement in performance also results in the reduction of the CPKM by 23% compared to the BAU scenario.
Despite a ridership increase, the total farebox revenue increase compared to BAU is only 22% (compared to 45% and 25% offered by scenarios 2 & 3). This results from the reduction in the per ticket cost for a BMTC user based on the combined effect of fare rationalization and fare capping scenarios. However, the non-farebox revenue sources presented in this scenario ensure a collection 105% more than that in the BAU scenario. Further analysis on fare rationalization is required to ensure optimal return on investment.

Electrification

This section presents the comparison of the electrification scenarios within Scenario 4 considering the advantages presented above.

The following graph presents the progression of electrification of BMTC's fleet in Scenario 4.

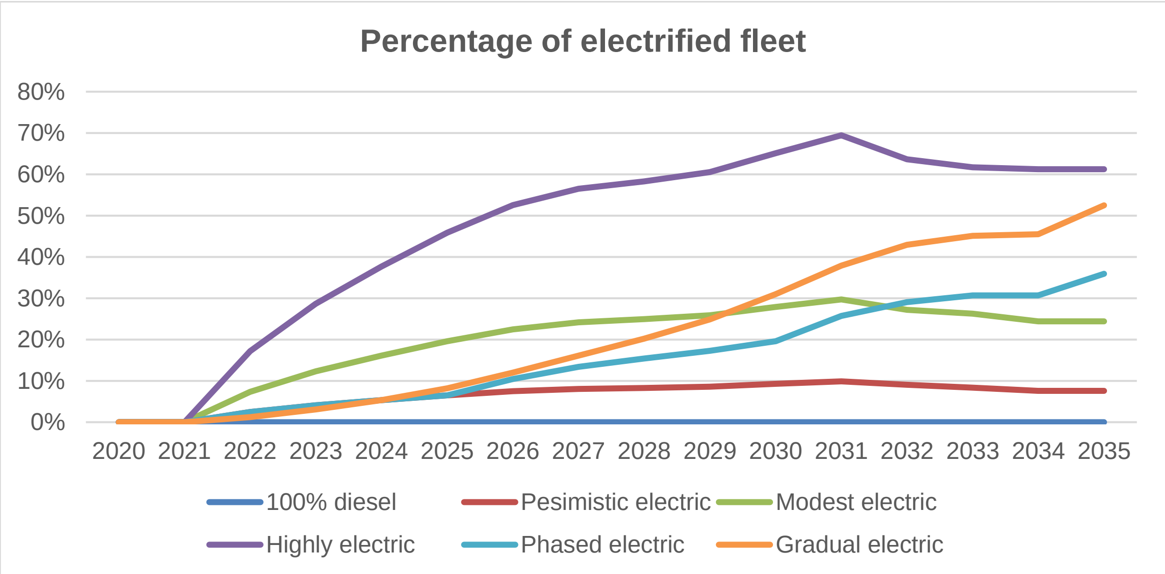

Figure 32 Progression of fleet electrification considering various electrification scenarios in Scenario 4

It is evident from the graph that the highly electric scenario offers the quickest means to electrify the entire fleet, resulting in 61% electric fleet in 2035. Closely following the highly electric scenario is the gradual electric scenario enabling 52% fleet electrification by 2035 and the phased electrification scenario enabling 36% electrification.

A comparison of the total cost of procurement and operations of the fleet shows that the gradual and phased electrification scenarios are 3% and 1% cheaper than the 100% diesel scenario, while the pessimistic, modest an highly electric scenarios are 3%, 8%, and 16% more expensive.

Table 16 Comparison of total cost of procurement and operations of electrification scenarios in Scenario 4

Cost (INR crore)	100% diesel	Pessimistic electric	Modest electric	Highly electric	Phased electric	Gradual electric
Cumulative cost of procurement and operations	1,18,074	1,21,046	1,27,023	1,36,387	1,16,325	1,14,852
Average annual cost	7,380	7,565	7,939	8,524	7,270	7,178

This reduction in cost of electrification results from the design of the phased and gradual electrification scenarios where in majority of the buses are procured and owned by BMTC only in the long term when the price of E-buses has been projected to stabilize. These scenarios highlight the need for agencies to adopt pure lease or variants of the lease mode to ensure that the risks associated with the adoption of E-buses is passed on to the OEM in the short term when the technology is still new and under development. This will allow agencies to gain experience in operating and maintain E-buses when they are procured by the agency.

A comparison of the total tax to be borne by BMTC over the vision period shows that the total tax also reduces with the electrification scenario.

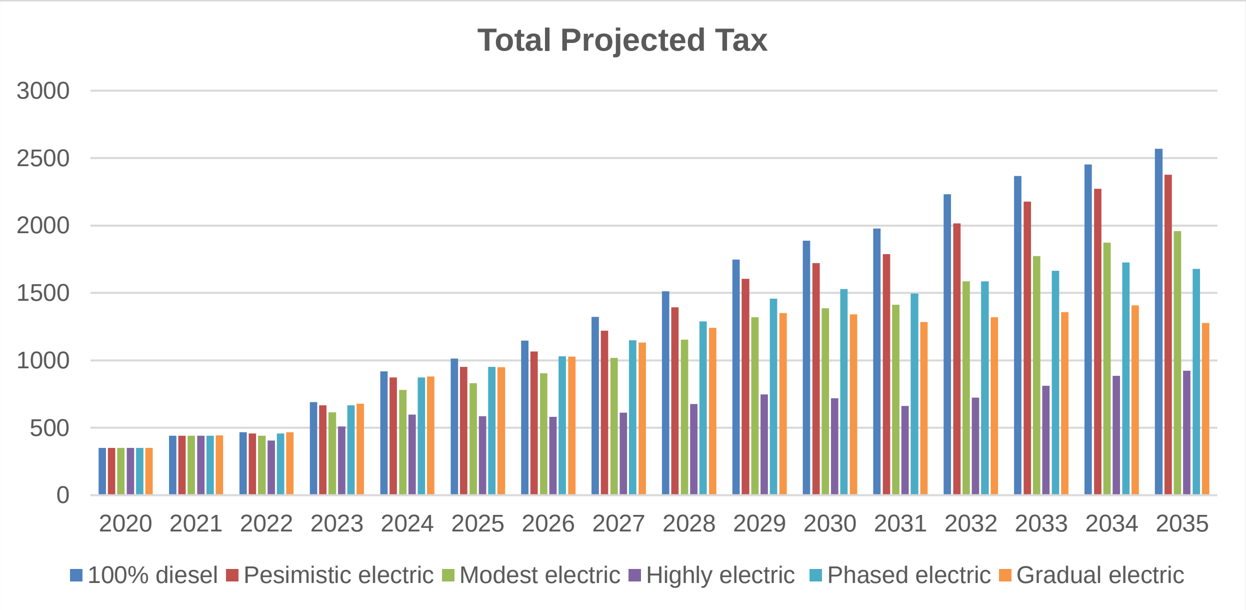

Figure 33 Comparison of taxes by electrification scenario in Scenario 4

It is evident that the tax under the highly electric scenario is the lowest, at 56% lower than that in the 100% diesel scenario, followed by the gradual and modest electrification scenarios, at 29% and 23% lower than the 100% diesel scenario. This reduction in the total tax is derived from the reduction in diesel consumption. BMTC currently pays a VAT of 24% on diesel in addition to the central excise. As the percentage of fleet electrified increases, the fuel tax decreases significantly.

Table 17 Comparison of fuel tax by electrification scenario in Scenario 4

Cost (INR crore)	**100% diesel**	**Pessimistic electric**	**Modest electric**	**Highly electric**	**Phased electric**	**Gradual electric**
Total fuel tax and central excise	22,001	20,281	16,756	9,160	17,252	15,122

This reduction in fuel cost significantly reduced the CPKM of each electrification scenario.

A comparison of the CPKM and EPKM (farebox) is presented below. The CPKM is lowest for the Highly electric scenario at INR 59/km followed by the gradual electric scenarios at INR 69/km.

Table 18 Comparison of CPKM and deficit by electrification scenario in Scenario 4

	100% diesel	**Pessimistic electric**	**Modest electric**	**Highly electric**	**Phased electric**	**Gradual electric**
Avg. annual CPKM	78	75	70	59	72	69
Avg. annual deficit	40	38	32	21	34	32

The deficit is also seen to decrease as the electrification scenario becomes more ambitious with an average annual deficit of INR 21/km in the highly electric scenario, followed by the gradual and modest electric scenarios at INR 32/km.

Based on the data presented above, it is evident that the gradual electrification scenario gives the most return on investment. This scenario enables the electrification of 52% of BMTC's fleet by 2035, while being 3% cheaper in terms of the total cost of procurement and operation compared to the BAU scenario. As this scenario proposes a gradual increase in the number of E-buses inducted into the fleet, it ensures that the agency can lease a small number of buses in the short term and gradually move into owning a larger portion of the fleet in the medium and long term.

7. CONCLUSION

This report aims to provide a snapshot of the current scenario of the public bus transport in Bengaluru and project the potential impact of several strategies that can be adopted to improve the existing level of service in the city.

BMTC has been the backbone of the transportation system in Bangalore for several decades. It provides services to meet the demands of commuters from various walks of life, and with a pre-pandemic mode share of 43%, it is the most affordable and commonly used mode of transport in the city. However, growing transport demand, overburdened infrastructure, increasing use of unsustainable transport modes, severe financial constraints and a fragmented governance structure have led to an inefficient public transportation system with significant negative externalities for the city and its residents. Data has shown that, due to the increasing congestion in the city, BMTC's service provision has dropped resulting in an 8.4% increase in the trip cancellation since 2008 and a reduction in vehicle utilization from 227 km per bus per day in 2008 to 199 km/ bus per day in 2019. This has in turn affected BMTC's mode share, reducing it from a peak mode share of 55% in 2011 to 43% in 2019[UK1] .

Today, Bangalore is infamous for its traffic congestion and is on the top of the list for cities with the worst traffic congestion globally. Studies have estimated that the city incurs close to INR 38,000 Crore due to losses resulting from traffic congestion yearly. This report has previously highlighted the hastening of commuters towards private transport, caused in part due to slower growth of a bus fleet unable to meet demand. There are quick, short-term steps BMTC and the city can take to contain congestion and move people away from low occupancy private vehicles. But there is a stronger need to prepare a long-term plan that stays in step with the nearly 50% population growth over the next 15 years, and its accompanying economic opportunities and travel demands. States and transit agencies throughout the country are going to face the growing pains of congestion, poor air quality and sprawl in the future; BMTC can take a lead in preparing a holistic plan to ensure better preparedness and efficient operations of public bus systems.

Short-term reduction of congestion can be achieved by adopting measures to improve the efficiency of bus services, increase ridership by making public bus services more affordable, and increasing financial support to BMTC. This will pay dividends in the long run as well, as a well-developed metro rail and suburban rail networks will require a high-quality bus feeder network to ensure maximum accessibility to commuters.

The scenarios in this study are presented in order of increasing ambition to increase ridership. They include strategies to improve:

1. **Operational performance**: This is addressed by increasing the utilisation of buses. An average BMTC bus has witnessed a steady decline in the distance it covers daily. Interventions to reverse this include right-of-way infrastructure in the form of BPL, and induction of ITS to monitor and improve frequency and punctuality.
2. **Ridership**: The surest way to improve ridership is by making travel more affordable, and this is imperative in Bangalore with its nationally high bus fares. Specifically, fares need to be rationalised to incentivise short and medium trips. Policies that reduce the penalty for riders forced to take multiple trips in a journey need to be prioritised.

3. **Finances**: From being one of the few profitable STUs in the country, BMTC is now regularly in the red. Reducing the burden of taxes and increasing the share of non-farebox revenue will effectively reduce the deficit and also support pro-rider fare policies.

Keeping these 3 planks of interventions in mind, the potential strategies for BMTC are:

1. Infrastructure –
    - BPL – The CMP (2019) has identified 12 major corridors to be upgraded to increase bus speed. According to Scenario 2, 200 km of BPL will contribute towards an increase of 15% in mode share by 2035, while Scenario 3 proposes setting up the network more quickly. Additionally, passenger experience can also be improved by the provision of high quality pedestrian infrastructure and transfer facilities along the routes.
    - AFC – As part of the ITS, an AFC system present in every bus and metro station will be key in enabling smart fare policies like fare capping and free transfers. Data from AFC will also be fed into travel demand models. Furthermore, by installing AFC in every new bus, BMTC can gradually reduce the number of on-board conductors.
2. Technology
    - ITS – The data collected from AFC systems should be used in ITS to rationalise routes and reduce the number of low occupancy buses. Additional operational efficiencies can be realized through such actions as optimizing bus and crew schedules and introducing 'short-loop' services to serve high demand sections of the route.
    - Electrification – With the introduction of the FAME subsidy, agencies across the country are looking into the adoption of electric buses. These buses will not only reduce the air pollution associated with public transport operations, it will also enable a reduction in the cost of operation of the fleet. However, as electric buses adoption for public transport is still in its nascent stages, transit agencies across the country are exploring various procurement models to de-risk the move in the short term, by transferring the onus of bus operations and maintenance on the OEM. BMTC should, thus, explore the possibility of a gradual induction of electric buses into their fleet such that buses are leased under the GCC model in the short term and then procured and owned in the medium and long term when the E-bus cost stabilizes in the country. This will not only ensure a reduction in operations cost, but also reduce the capital investment required to on-board the buses.
3. Fare reduction
    - Fare rationalization – Adopting a more linear fare structure will incentivise short and medium trips can potentially increase ridership by 13%.
    - Free transfer – A fare strategy popular throughout the world, this will make one transfer in a 2-hour journey free and is estimated to increase the ridership by 25%.
    - Fare capping – Similarly but more ambitiously, capping chargeable trips to 2 every day could nearly double the ridership. It would also eliminate the need to

purchase passes upfront, significantly reducing the burden for daily wage riders.

4. Financial improvement
    - Non-farebox revenue sources – The COVID-19 pandemic has stressed the need for STUs to diversify revenue sources and reduce dependency on the farebox. Following are some examples:
        - Government grant/funding:
            - Viability gap funding
            - Funding from labour department for subsidized transport of labour class (Garment industry labour)
            - Funding from rural development fund for operation of obligatory services in rural areas
            - Funding from Swachh Bharat for TTMC and depot maintenance
        - Private funding:
            - Impose mandatory chartered bus service for establishment of new tech parks
            - Impose mandatory chartered buses for school bus service
            - Employer's contribution to PT (taxes paid to govt for supply of PT services)
        - Recognising that there is a disconnect in the emissions that private vehicles produce and the total costs they incur, the city should fund public transport from -
            - Collection of parking charges
            - Introduction of congestion pricing
            - Increase in vehicle registration tax or cess
        - Other pan-city initiatives include indirect benefit instruments like -
            - Revision of advertisement policy
            - Long-term land/property leasing (only a quarter of the 800 acres that BMTC owns are occupied), or joint development of property
            - Land value capture (if BRT is implemented)
    - Taxes – Today, taxes form one of the major sources of expenditure for BMTC. Between 2016 and 2019 alone, the MV, fuel, GST, and commercial taxes were 217% of the total losses incurred by BMTC, indicating that a potential reduction in these taxes can have a significant impact on BMTC's financial status. Estimation of the reduction in MV tax in scenarios 3 and 4 have highlighted potential reduction in the deficit by INR 17/km and INR 33.7/km respectively. Such a reduction can bring BMTC close to breaking even.

    Additionally, the agency must work with the state government to avail a reduction in the tax paid on diesel. Currently, fuel tax and central excise account for 90%-95% of the total tax paid by the agency. A small reduction in the VAT paid on diesel to the state government has the potential to revive the financial status of the agency significantly.

Investing in public bus services remains the most cost-effective method of combatting traffic congestion in the city. Other methods incur a significantly higher capital outlay. It has been estimated that despite these efforts BMTC will require an operational VGF of INR 32/km, accounting for an average of INR 2600 Crores annually over the vision period, considering a gradual adoption of electric buses, which is down from INR 0.19 Crore per bus in the BAU scenario to INR 1.6 Crore per bus. There is, thus, a need for BMTC to adopt the strategies proposed in this study and commission detailed feasibility studies to accurately estimate the long term impact of these.