ITES
Part of the UK-India Net Zero Innovation Virtual Centre

India EV Bus Depot Calculator

Case study

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Contents

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1 Introduction

India is the 2nd largest urban system with 377 million urban population. It is suggested that by 2030, the number of cities with populations of more than 1 million will grow from 42 to 68. To keep India on the move, despite high levels of congestion there is an ever-increasing need for shared transport solutions. This is a vibrant sector in India, from trains and buses to ride sharing services across the country. The challenge comes when we look to the future and how to create a transport eco-system that aligns with India's, and the global, decarbonisation goals.

One promising technology is e-buses. During the Interim Budget 2024-25 speech the government pledged to promote the adoption of electric buses for public transportation by introducing a new payment security system. There are ongoing infrastructure developments on public highways to facilitate intercity e-bus transport and initiatives from manufacturers including Tata and Fiscal also supporting deployment.

The uptake of e-buses will need to go hand in hand with the rollout of suitable charging and electricity network infrastructure to support operations. Bus operators will need to develop an understanding of the potential future energy demands and the need for and costs of charging infrastructure. To explore how this might be achieved the ITES program has developed an India EV Bus Depot Calculator. This case study will explore its use through an illustrative example of a Delhi based bus operation.

2 The India EV Bus Depot Calculator

The India EV Bus Depot calculator is an Excel-based tool designed to assess the potential future daily charging demand, charging infrastructure and costs for a fleet of depot charging-based buses in India. Figure 1 below shows a high-level summary of the tools, inputs, processes and outputs. The tool uses pre-existing data which is gathered from public resources with additional information that can be provided and configured by the user. These datasets include:

- Vehicle performance & specifications
- Vehicle charge point performance
- Charging Infrastructure costs
- Seasonal environmental data

Based on the inputs selected and the scenario configured the calculator is then able to answer questions the user may have like:

- What is the impact of fleet electrification on operational service and charging infrastructure?
- What does the charge demand of a fully electrified fleet look like during weekdays and weekends?
- What are the costs to the charging infrastructure which are involved to support operations?

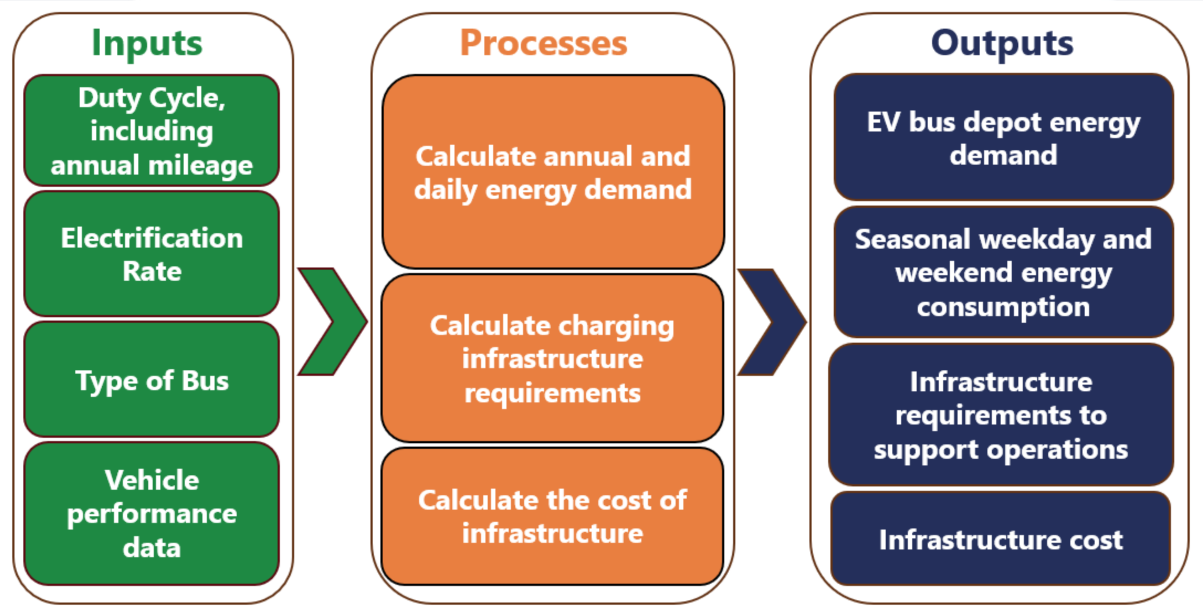

Figure 1 EV Bus Depot Demand Profiles – Proposed Methodology

3 A Delhi Bus Fleet Case Study

3.1 The Fleet

This case study is built around an illustrative Delhi bus fleet and will highlight how the India EV Bus Depot Calculator can be used to explore future fleet energy demands and infrastructure requirements. Delhi was selected based on the current momentum that the city is putting behind accelerating the adoption of electric mobility. The government of Delhi mandated that 50% of all new buses added to the government's fleet must be electric by 2024-25 with the expectation that 300 electric buses would be in operation by December 2021[i] . With this projected growth in EV fleet size across Delhi there are important factors to consider including the impact on energy demand for charging and potential costs involved with increasing the fleet electrification rate.

To configure the calculator several assumptions were made as outlined below in Table 1, to build a picture of a representative bus fleet operating in Delhi.

Fleet Attribute	Assumption
Daily bus mileage	122 km per day
Annual mileage	~ 45000km [ii]
Overall fleet size	10000 buses[iii]
Vehicle types[iv] **(see Figure 2)**	• Articulated • Biarticulated • Standard single deck • Midi (<9m x 2.5m) buses
Operations	Both day and night operations, with less than 80% of buses operating overnight
Auxiliary loads	Two types of buses, the Midi and Articulated have AC activated and installed. The extended use during the warmer months and the effects this has on vehicle charging has been considered in the calculator.
Electrification target **(see Figure 3)**	80% of its fleet electrified by 2025

Table 1 Delhi bus fleet calculator configuration

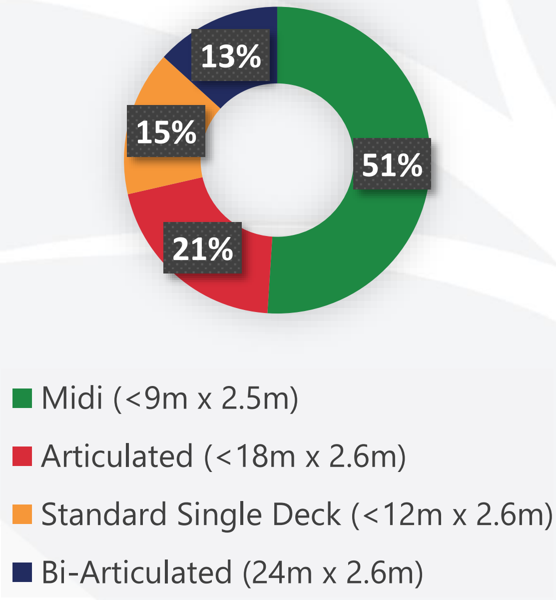

Figure 2 Fleet vehicle types

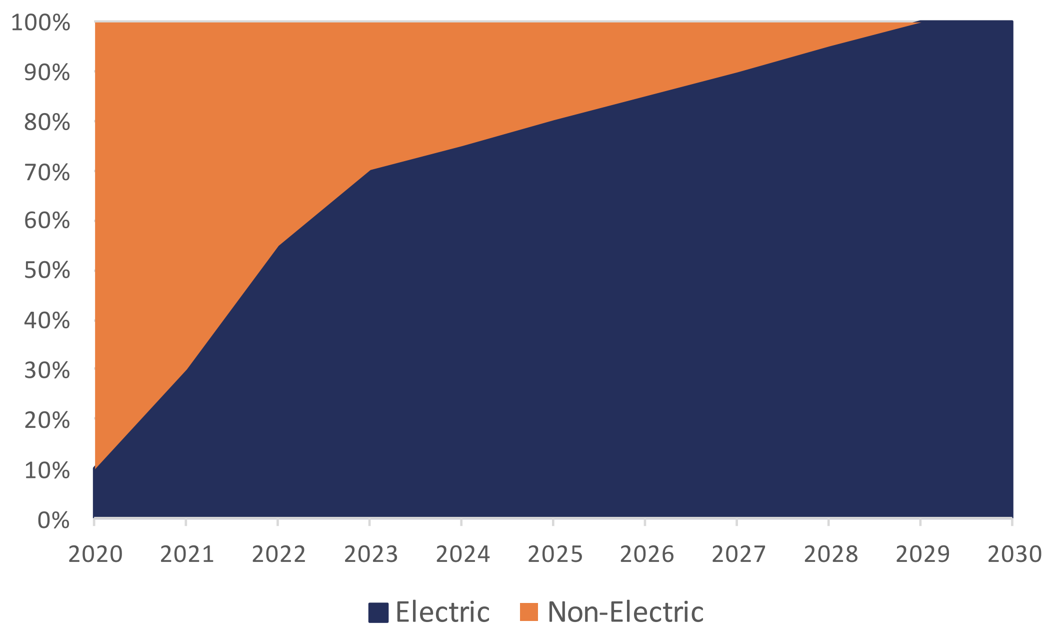

Figure 3 Fleet electrification profile

Another important configuration that the user must provide is operational information about the percentage of the fleet returning to the depots in each hour. This is used as a basis for the assumption of when an EV bus could reasonably begin a charging session. This is discussed in more detail below in Section 3.2.

The calculator assigns appropriately powered chargers for the vehicle type, this can be overwritten by the user if required. For this fleet, the Midi and Standard Single Deck buses are assumed to plug-in to the 22kW charge points whereas the Articulated and Bi-Articulated buses would charge from 43kW chargepoints.

The India EV Bus Depot calculator then combines the information provided by the user with the background embedded input data, as laid out above. From this it can build a picture of the likely energy consumption and frequency of charging.

3.2 Scenarios

To demonstrate how the EV Bus Depot Calculator can be used to explore a variety of potential future operations the profile of charging session start times has been varied. This is a customisable plug-in profile which is adapted for all bus types. This case study has explored two different assumed scenarios here:

- **Standard operations** – an assumed operations profile representative of data which has been collected from the "Peak load minimisation of an e-bus depot: impacts of user-set conditions in optimisation algorithms" report.[v] This profile is based off a dataset of when vehicles in a bus fleet return to the depot. Users of the calculator would be able to adapt this to better represent their own fleet.
- **Adapted operations** – an adaptation to bus operations has been made to replicate the effects if a bus operator were to try to mitigate dramatic peak electricity demands. Instead of charging most of the buses during nighttime, only 10% of the electrified fleet is charged around midnight, and 1-7% of the electrified fleet is put on charge throughout the day when not in use. This is purely illustrative and does not take into account whether this usage pattern would be feasible while maintaining desired fleet operations.

The difference between these assumed profiles can be seen in Figure 4 which is representative of the daytime operations and Figure 5 which represents nighttime.

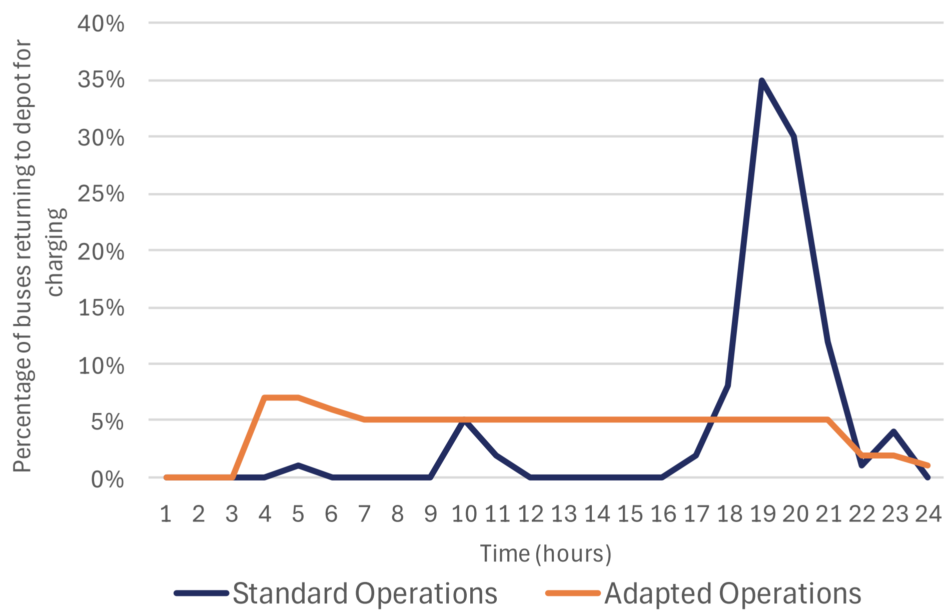

Figure 4 A comparison between the charging plug-in profiles of the electrified day buses.

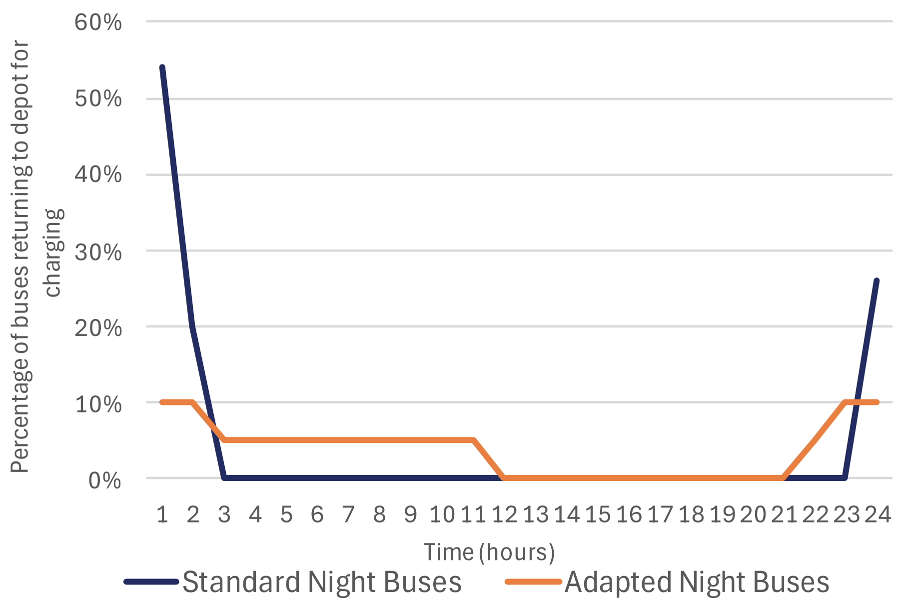

Figure 5 A comparison between the charging plug-in profiles of the electrified night buses.

3.3 Analysis

Once the calculator is configured there are a variety of outputs calculated. These include:

- Energy demand profiles
- Number of chargepoints required
- Chargepoint costs

The user of the India EV Bus Depot calculator will have the ability to evaluate the effects of their scenarios. Here we discuss the results from the scenarios outlined above.

3.3.1 Standard operations

Figure 6 represents the Standard Operations energy demand profile over a winter weekday. The shape of the charge energy consumption graph suggests that peak demand reaches almost 200MWh during the nighttime between 9pm and 11pm. The energy demand is consistently low during daytime hours which reflects the lower number of electrified vehicles on charge.

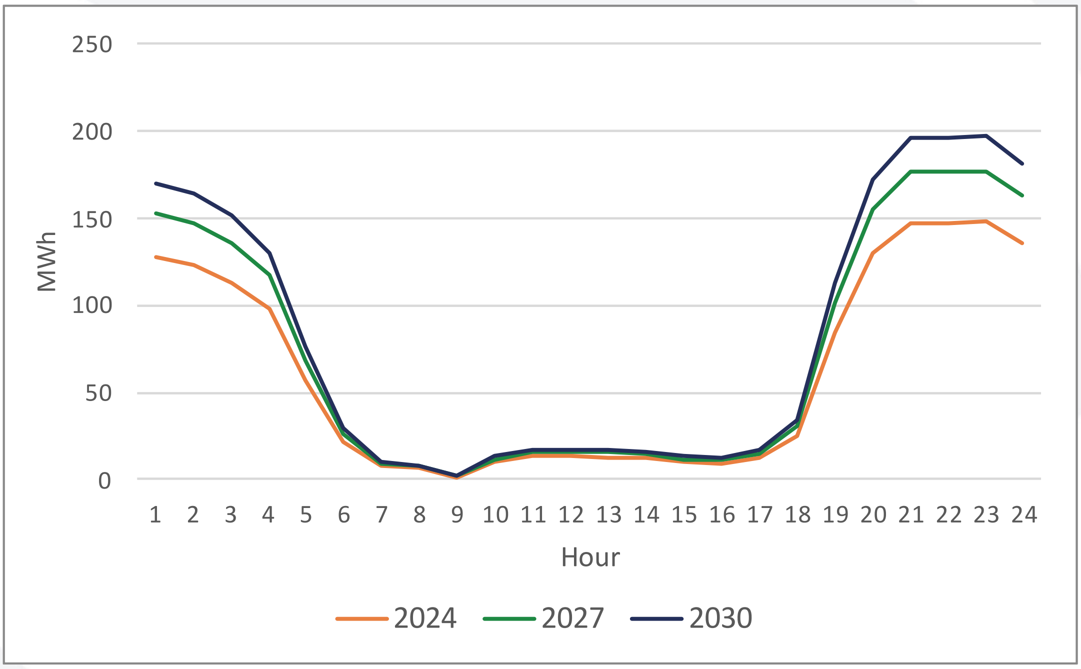

Figure 6 Winter Weekday charge energy consumption over the duration of the day and night

By charging most of the vehicles at the same time, the duration of peak demand spans for about 3 hours before dropping off. This is a significant time in which the buses will be dependent on the grid to supply the electricity. It is likely that this demand aligns with other high demands on the Delhi network. This could add significant strain to the grid and may lead to a need for network reinforcement to maintain grid stability. From 2024 to 2030 there is a clear increase of charge demand of 33%. This reflects the increased electrification rate of the fleet with the same expected duty cycle.

The calculator is able to show the change over time across its outputs. This can help the user to build a picture of the potential pathways for providing the required charging infrastructure, as shown in Figure 7. Reviewing the effects of Standard Operations, the EV Bus Depot Calculator suggests that as of 2024 approximately 5200 chargepoints would be required to support the electrification of the illustrative bus fleet in Delhi. This number is set to increase to around 7000 chargepoints by 2030 to support the continued fleet electrification.

As the electrified bus fleet grows, the more chargepoints are needed to maintain operations. The ratio of the number of chargepoints to the number of buses required to support the infrastructure of the fleets operations by 2030 is set to be 7:10. Alongside with the increased number of chargepoints, this adds to the overall infrastructure costs that provide the energy to the buses too. The increase in cost from 2024 to 2030 totals at 76.3 crore INR (£7.2 million GBP), with an expected total expenditure of 310.49 crore INR (£29.3 million).

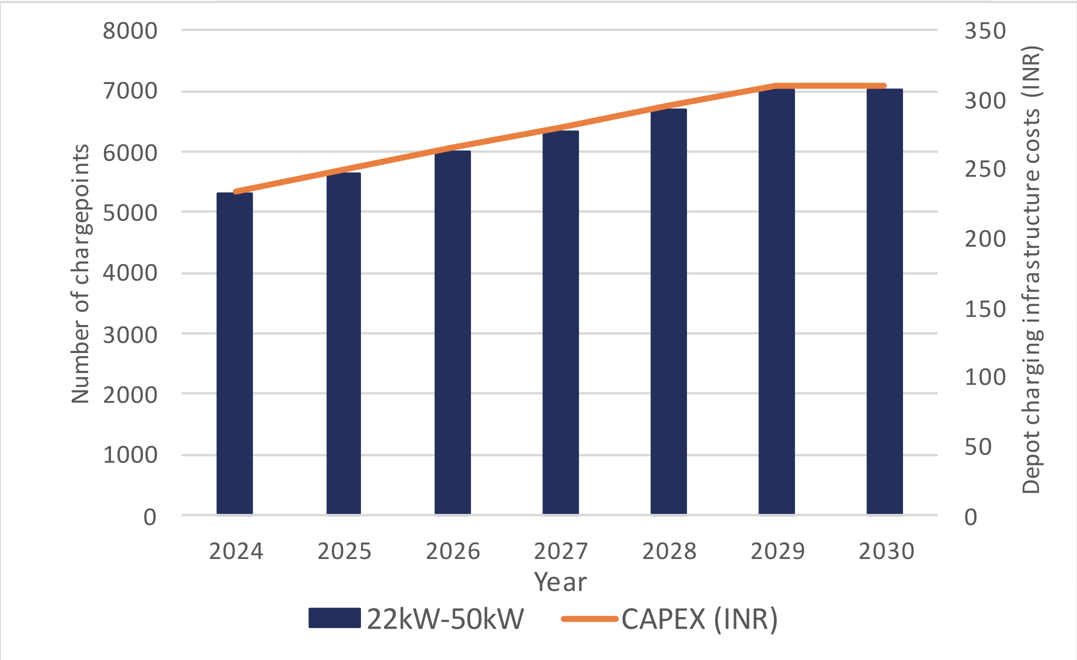

Figure 7 Represents the number of chargepoints required for Standard operation

Reviewing the effects of standard operations, the EV calculator suggests that as of 2024 approximately 5200 s to the number of buses required to support the infrastructure of the fleets operations by 2030 is set to be 7:10. Alongside with the increased number of charge points, this adds to the overall infrastructure costs that provide the energy to the buses too. The increase in cost from 2024 to 2030 totals at 76.3 crore INR (£7.2 million GBP)

3.3.2 Adapted operations

The Adapted Operations scenario was carried out using the India EV Bus Depot Calculator to demonstrate the opportunities that a planned strategy for charging buses can create. Figure 8 shows that by having a strategic approach to charging times, peak demand can be significantly decreased, in this scenario by almost 50%.

This type of reduction is likely to be beneficial for the overall electrified fleet as it reduces the need for electricity network reinforcement therefore saving cost on upgrades. During the daytime hours energy demand has increased in comparison to the standard operations but the overall energy consumption remains the same.

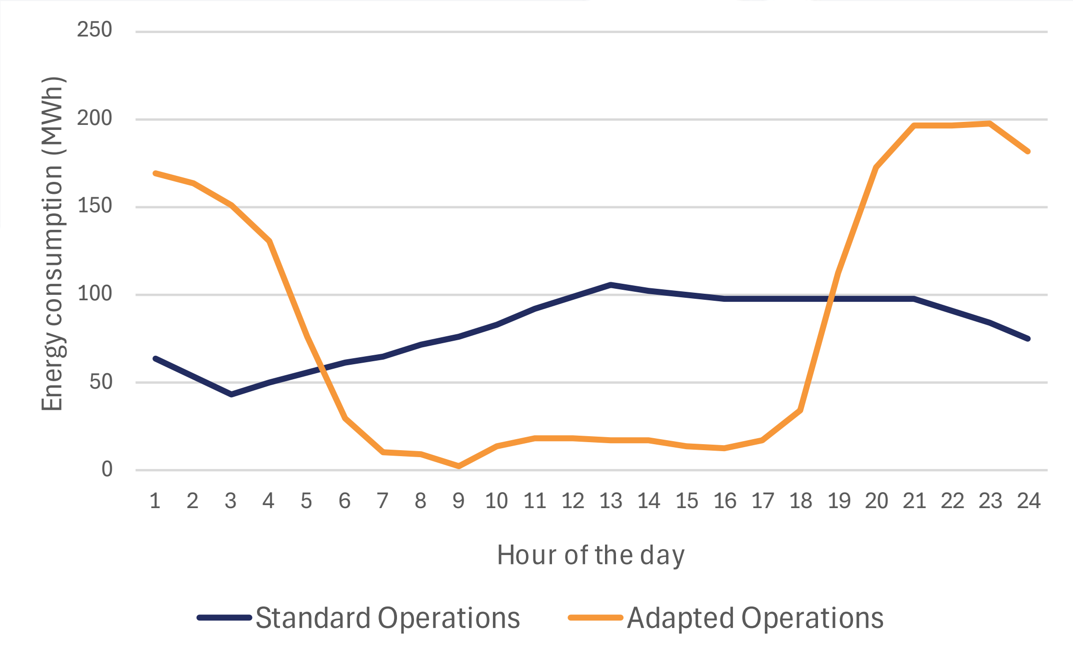

Figure 8 Comparing the Standard and Adapted operations vehicle energy demand profiles for 2030

The number of chargepoints in use during peak hours is reduced too due to less vehicles being charged at the same time. By making a change to the management of charging session there has been a reduction in the number of chargepoints required by 41% by 2030, as shown in Figure 9

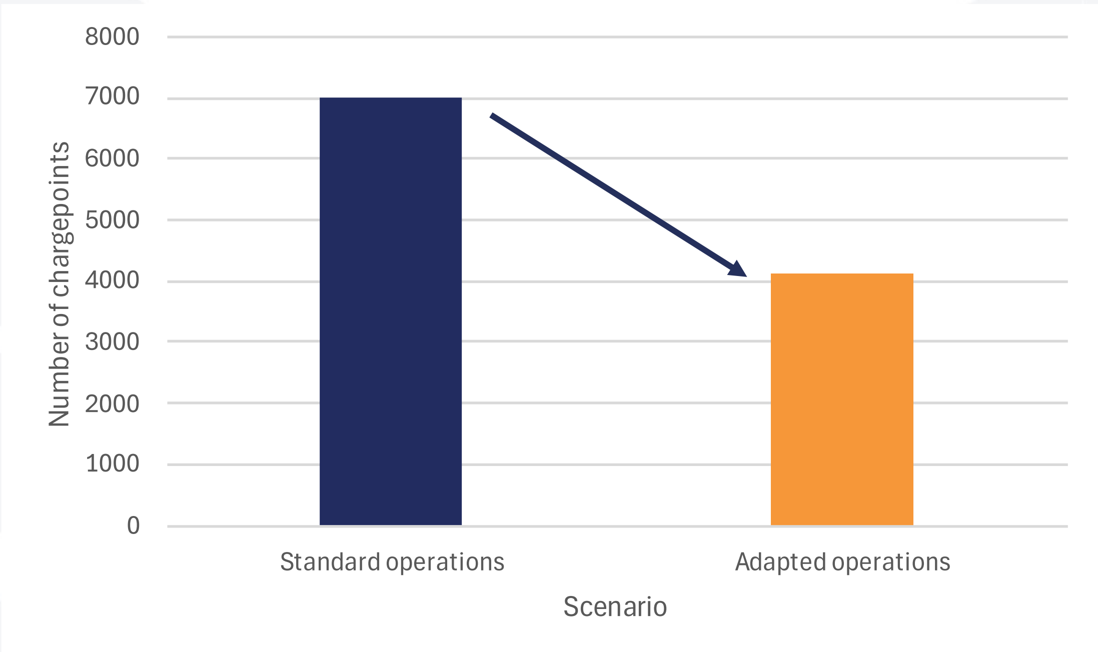

Figure 9 Total number of chargepoints required for Standard and Adapted Operations scenarios in 2030

With the reduced number of chargepoints and lower peak demands values, the Adapted Operations also reduces the depot's total charging infrastructure cost by 128.45 crore INR (£12.1 million) in 2030.

For Fleet Operators who are increasing their electrified fleet size, this data suggests that less costs and less infrastructure would be needed by following an Adapted Operations strategy. There would of course be other considerations that would need to be considered when planning such a regime. However, this case study shows how the India EV Bus Depot Calculator can be used to explore future bus electrification energy demand and infrastructure pathways.

4 How can you use it?

This case study serves to demonstrate the use of the India EV Bus Depot Calculator for the scenarios explored here. However, the potential use cases that can be explored through this calculator are wider ranging.

The calculator is a tool to help stakeholders make key decisions as we approach target years for emissions reductions and for fleet operators to have a better vision of how to operate more sustainably. Beyond what has been demonstrated here this tools could be used to explore:

- Varying chargepoint costs,
- Chargepoints with other power specifications
- Different vehicle performance data
- Different fleet vehicle types and sizes
- Different fleet operation profiles
- Seasonal variation
- Impacts of auxiliary loads
- Changes in electrification profiles and targets

The calculator offers a canvas which can be configured by a variety of EV bus operators to reflect their operations and future strategies and support their decision making and planning. If you are interested in understanding more please do get in touch with the Innovating for Transport and Energy Systems programme.

5 Annex

5.1 Assumptions

There are several underlying assumptions that support the operation of the India EV Bus Depot Calculator. They include:

- All new electrified buses are BEV
- Buses charge once a day and complete one full charge during that session
- Duration of charge is rounded up to the nearest hour
- There are six possible bus types
- There is an even distribution of mileage across the days of the year
- Battery capacities are assumed to be sufficient to meet daily charging demand
- Usable battery capacity is assumed to be 85% of total battery capacity
- Infrastructure cost estimates are for the chargepoints only

For further detail get in touch with the ITES programme.

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[i] Report by the Climate Group PDF link: https://www.google.co.uk/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwicj8K359qGAxWlXUEAHf2pCSAQFnoECB0QAQ&url=https%3A%2F%2Fwww.theclimategroup.org%2Fmedia%2F14491%2Fdownload&usg=AOvVaw1lgAyn2SAZO84ILm3xv3ZV&opi=89978449
[ii] Average Annual Vehicle Miles Traveled by Major Vehicle Category (energy.gov)
[iii] Delhi adds 350 more e-buses; 3rd biggest fleet in world: govt. - The Hindu
[iv] Explore 4 different Types of DTC buses: A Reliable Commute
[v] https://energyinformatics.springeropen.com/articles/10.1186/s42162-021-00174-4#Fig2

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