Shifting Gears Towards Cleaner Air: Modernizing Urban Fleets for a Greener Future in India's Million-Plus Cities

A Comprehensive Policy Brief

teri | The Energy and Resources Institute
Creating Innovative Solutions for a Sustainable Future

Shifting Gears Towards Cleaner Air: Modernizing Urban Fleets for a Greener Future in India's Million-Plus Cities

A Comprehensive Policy Brief

THE ENERGY AND RESOURCES INSTITUTE
Creating Innovative Solutions for a Sustainable Future

Authors

Dr Anju Goel, Fellow and ADIR

Mr Harshit Gupta, Consultant,

Dr Shashi Tiwari, Consultant

Ms Aishwarya Yadav, Consultant

Mr Nimish Singh, Fellow

Reviewer

Dr Prodipto Ghosh, Distinguished Fellow, TERI

Mr IV Rao, Distinguished Fellow, TERI

Suggested Citation

TERI 2025: Shifting Gears Towards Cleaner Air: Modernizing Urban Fleets for a Greener Future in India's Million-Plus Cities. New Delhi: The Energy and Resources Institute.

Acknowledgment

The authors of the report would like to express their appreciation to Bloomberg Philanthropies for supporting this study.

Disclaimer

Table of Contents

At A GLANCE

1

- Transport sector contributes up to 24% and 37% in winter season to ambient PM_{10} and $PM_{2.5}$ concentrations of different Indian cities, respectively.
- The NOx emission norms for BSII–BSIV heavy duty diesel vehicles are respectively 1422% to 661% higher as compared to BSVI-compliant vehicles. Similarly, PM emission norms for BSII–BSIV heavy duty diesel vehicles are respectively 1400% to 100% higher than those from BSVI-compliant diesel vehicles.
- The number of older vehicles will increase from 4.9 million in 2024 to 7.5 million in the year 2030 in 44 million plus cities.
- Between 2030 and 2035, conversion of all older vehicles to EVs will require the establishment of 45,203 EV charging stations across India's 44 million-plus cities (MPCs).
- This shift to EVs will increase the electricity demand by 148 GWh in the year 2035 in these 44 MPCs and will result in oil bills savings of 917 thousand crore INR (106.6 billion USD).
- If half of the fleet is shifted towards CNG, around 2655 additional CNG stations will be needed in these 44 million plus cities costing ₹5,130 crore (596.5 million USD).
- Around 11.5 t/d of $PM_{2.5}$ emissions will be avoided if 100% of the older fleet switches to EVs and it reduces marginally to 11 t/d if 50% of the older fleet switches to EVs and 50% switches to CNG.
- It's found that older buses are major contributors to $PM_{2.5}$ and NOx emissions among the categories of vehicles studied. The age restrictions for buses can result in 50% and 80% of total $PM_{2.5}$ and NOx emissions avoided due to fleet modernization in 2030, respectively and this share decreases to 25% and 60% in the year 2034.
- The complete switch to EVs will generate 3,73,479 additional jobs and will require 130 registered vehicle scrapping facilities.

2 Introduction

In response to extreme levels of fine particulate air pollution in India and the increasing recognition of its adverse health impacts, the Indian government launched the National Clean Air Programme (NCAP) in January 2019 (Ministry of Environment, Forest, and Climate Change, 2019). The NCAP aims to improve air quality in 131 cities, including non-attainment cities and Million Plus Cities across 24 states through a multi-stakeholder engagement approach. All 131 cities have developed city Action Plans (CAPs) and are being implemented by Urban Local Bodies. These city specific clean air action plans target air polluting sources like Soil & Road Dust, Vehicles, Domestic Fuel, MSW Burning, Construction Material and Industries within the city. Among these sectors, emission exhaust from transportation is one of the major contributors to city level air pollution (CPCB, 2011; Kothai et al., 2008) which is associated with hazardous health effects to human beings (Apte et al., 2011; Tsai et al., 2008). With the increasing population, rapid urbanisation and economic growth, the need for transportation is accelerated. As cities expand and rural areas develop, there is a growing demand for efficient mobility solutions to connect people, goods, and services. The rise of e-commerce, industrial activities, and global trade has further intensified the need for a robust transportation network. Additionally, the aspirational middle class is increasingly adopting private vehicles, while urban migration necessitates better public transport systems.

Road transport accounts for roughly 90% of passenger and 70% of freight movement in India (TERI, 2021). While the expansion and enhancement of road transport often act as a driver of socio-economic progress, as observed in many nations, it has also led to significant environmental challenges in India, with road transport contributing nearly 20–30% of urban air pollution. (IEA,2023).

Under the NCAP, urban local bodies, in collaboration with Institutes of Repute (IoR) among other assessments are responsible for conducting emission inventory analyses and source apportionment studies to identify and quantify the contributions of air pollution sources responsible for degrading the city's overall air quality. These scientific studies enable cities to implement targeted measures against specific pollution sources and plays a pivotal role in air pollution management. The major contributing sectors include residential cooking, transport, road dust, industries, and power generation. However, their impact varies by location—industrial emissions are significant in regions with a high concentration of industries but minimal elsewhere, while the power sector's contribution is substantial near thermal power plants. The residential sector plays a larger role in areas with low LPG penetration. In contrast, the transport sector remains a dominant contributor across all major cities, driven by the growing demands of an expanding population. Figure 1 and Figure 2 provide an overview of the transport sector's contribution to ambient PM_{10} and $PM_{2.5}$ concentrations across different seasons in select million-plus cities, as identified in source apportionment studies conducted under the NCAP. The data clearly indicates that the transport sector significantly contributes to the deterioration of air quality in major Indian cities.

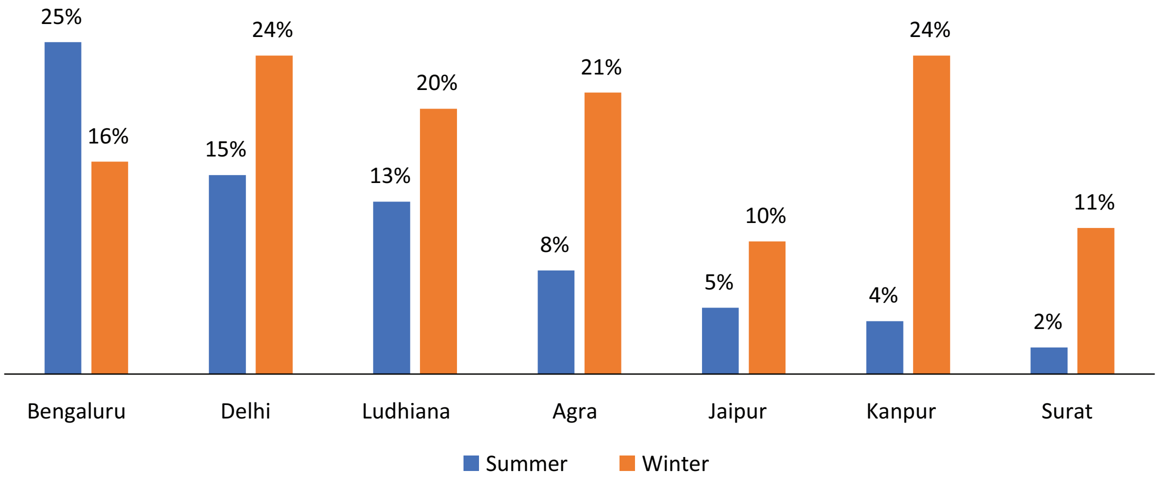

Figure 1: Contribution of transport sector to ambient PM_{10} concentration in cities

(Source: Source apportionment studies of cities as uploaded on PRANA portal)

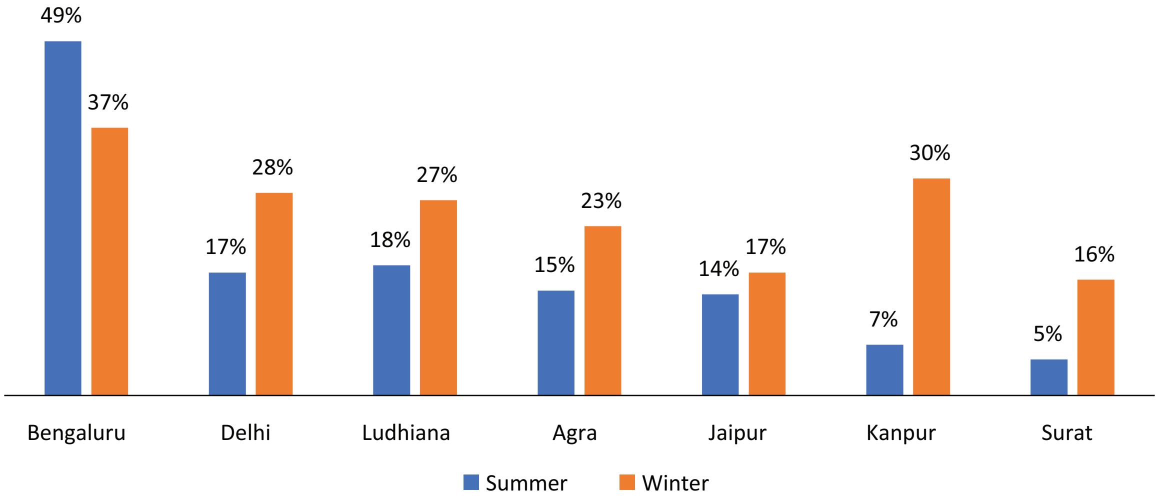

Figure 2: Contribution of transport sector to ambient $PM_{2.5}$ concentration in cities

(Source- Source apportionment studies of cities as uploaded on PRANA portal)

3 Older Vehicles: major contributor to urban air pollution

The BS norms were introduced in 2000 with BS-I for select cities, followed by BS-II in 2005 nationwide, and BS-III in 2010 with tighter emission standards. The BS-IV came into effect in 2017, targeting reductions in particulate matter (PM) and nitrogen oxide (NOx). In 2020, BS-VI was implemented, skipping BS-V and incorporating advanced technologies like selective catalytic reduction (SCR) and diesel particulate filters (DPF). Despite the transition to BS-VI, the average age of on-road vehicles estimated at around 20 years, an analysis of current fleet composition reveals that most vehicles in use today still comply with BSII, BSIII, and BSIV norms. The NOx emission norms for BSII–BSIV heavy duty diesel vehicles are respectively 1422% to 661% higher as compared to BSVI-compliant vehicles. Similarly, PM emission norms for BSII–BSIV heavy duty diesel vehicles are respectively 1400% to 100% higher than those from BSVI-compliant diesel vehicles. This clearly signifies that older vehicles are major contributors to air pollution due to their outdated technology and inefficient emission control systems. Many lack advanced features like catalytic converters and particulate filters, resulting in higher emissions of pollutants such as nitrogen oxides (NOx), carbon monoxide (CO), and particulate matter (PM).

Factors such as vehicle age and fuel type significantly influence emission levels. Notably, cities with a relatively smaller vehicle population may experience higher vehicular pollution loads if the fleet predominantly consists of older vehicles (CPCB,2015). The older diesel vehicles (aged 11 to 15 years) produce significantly higher emission loads per vehicle compared to those with age up to 10 years (CSE, 2020). These emissions significantly degrade urban air quality and are associated with severe health issues, including respiratory and cardiovascular diseases, as well as environmental challenges like smog formation and climate change.

The persistence of older, high-emitting vehicles undermines progress in air quality improvement, underscoring the need for policies that phase out these vehicles and promote cleaner alternatives like electric or CNG vehicles.

Objectives

4

This study aims to assess the impact of phasing out older vehicles and transitioning to cleaner fuels in India's 44 million-plus cities. The impact will be examined in terms of EV and CNG infrastructure and investment, fuel and energy savings, electricity demand, scrapping facilities, job creation, reduction in GHG Emission and potential improvements in air quality. This study caters to national policymakers, by providing research-backed insights and strategic solutions to foster a greener future in major cities of India.

4.1 Cities under consideration in this study

This study focuses on 44 major Indian cities, each with a population exceeding one million, based on the 2011 Census. The list of these 44 cities is provided in Annexure-1. Delhi was excluded from this study, as the age restriction for petrol and diesel vehicles is already in place for Delhi. Additionally, the lack of availability of vehicle population data for Faridabad led to its exclusion. According to the Vahan Dashboard, as of 30th November 2024, approximately 93 million vehicles were registered across these 44 million-plus cities. This figure represents nearly one-fourth of the total registered vehicles in the country.

4.2 Population statistics of older vehicles plying the road

For the purposes of this study, an older vehicle is defined as one that is over 10 years of age for diesel vehicles and over 15 years for petrol vehicles, but not yet exceeded 20 years since its registration, which has been considered as the end-of-life for a vehicle.

This study examines the population of older vehicles across two primary categories: private cars and commercial vehicles, the latter encompassing LMV-Goods, LMV-Passenger vehicles, buses, and taxis. Analysing the data sourced from the Vahan Dashboard, it is estimated that as of 31st March 2024, approximately 4.9 million older vehicles were in operation across the 44 major cities of India. The city-wise distribution of these older vehicles presented below in Figure 3.

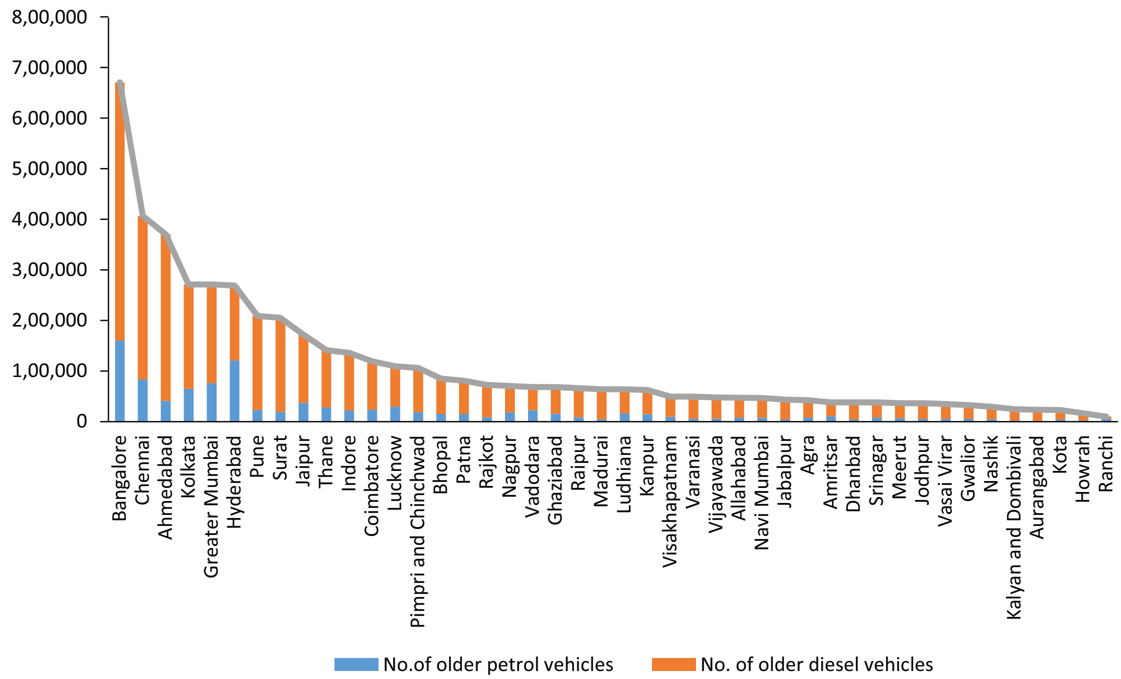

Figure 3: Population of older vehicles plying the road in 44 major cities of India (as on 31.03.2024)

Using data extracted from the Vahan Dashboard and assuming a vehicle lifespan of 20 years from the date of registration, the projected population of older vehicles on the roads as of 31st March 2030 is estimated at approximately 7.5 million. This projection reflects a CAGR of around 7.5% between 2024 and 2030, as detailed below in Figure 4.

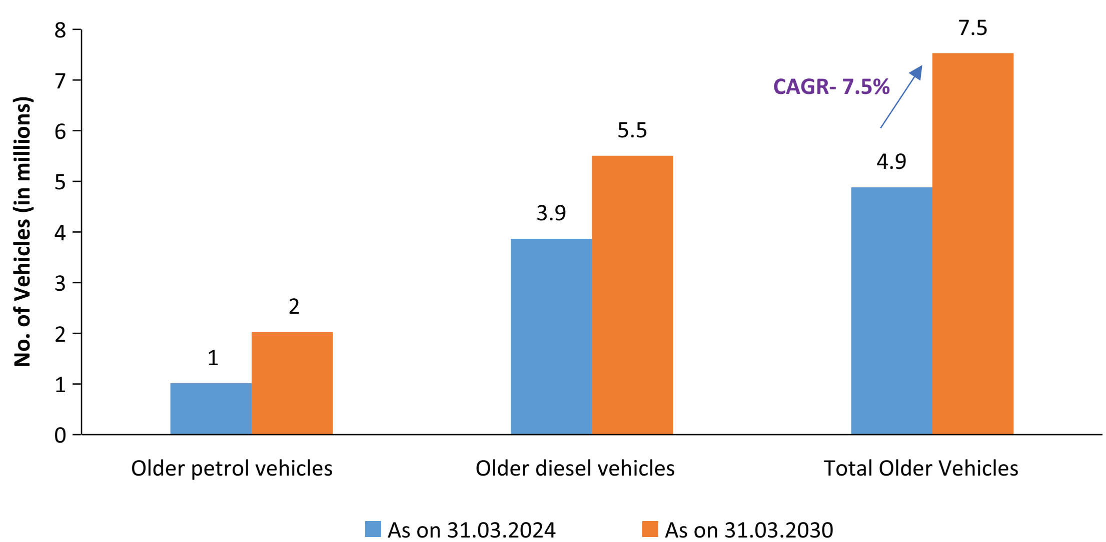

Figure 4: Projected growth of older vehicle population in 44 million plus cities of India (2024–2030)

Five-year Staggered Plan for Phasing Out Older Vehicles (2030–2035)

5

Any strategy to phase out older vehicles must ensure that the automotive manufacturing sector and supporting infrastructure, such as vehicle scrappage facilities, EV charging network, CNG infrastructure, etc., are adequately prepared to meet the surge in demand resulting from this transition. Therefore, a phased and systematic approach to retiring the older vehicles is imperative. After a thorough analysis of the data on the population of older vehicles across 44 Indian cities with populations exceeding one million, a comprehensive five-year implementation plan to facilitate a gradual and orderly phase-out of these vehicles is proposed in this paper. With the government's ambitious goal of achieving 30% EV penetration by 2030, the EV infrastructure is anticipated to be sufficiently developed by then to accommodate the surge in demand as older vehicles are phased out. Therefore, the year 2030 is chosen as the starting point for our five-year plan, as detailed below:

I. By 31st March 2030:

- **1.12 million vehicles** will be phased out.
- This includes 10-year-old diesel vehicles and 15-year-old petrol vehicles (commercial vehicles only) in the six major metro cities. (Ahmedabad, Bangalore, Chennai, Greater Mumbai, Hyderabad, Kolkata)

II. By 31st March 2031:

- **1.01 million vehicles** will be phased out.
- The phase-out of 10-year-old diesel and 15-year-old petrol vehicles (commercial vehicles only) will be extended to $PM_{2.5}$ NAAQS non-compliant million-plus cities, covering a total of 31 cities by this stage. List of $PM_{2.5}$ NAAQS non-compliant million-plus cities considered in this study is provided in Annexure-2. The list of cities is based on the CPCBs data on $PM_{2.5}$ concentrations for the year 2022.

III. By 31st March 2032:

- **1.09 million vehicles** will be phased out.
- The phase-out will be expanded to include all 44 million-plus cities for 10-year-old diesel and 15-year-old petrol vehicles (commercial vehicles only).

IV. By 31st March 2033:

- **2.75 million vehicles** will be phased out.

- The policy will now encompass both commercial vehicles and private cars (10-year-old diesel and 15-year-old petrol vehicles) in the six major metro cities. (Ahmedabad, Bangalore, Chennai, Greater Mumbai, Hyderabad, Kolkata).

V. By 31st March 2034:

- **2.9 million vehicles** will be phased out.
- The phase-out of 10-year-old diesel and 15-year-old petrol vehicles (commercial vehicles and private cars) will extend to $PM_{2.5}$ NAAQS non-compliant million-plus cities, covering 31 cities in total. List of $PM_{2.5}$ NAAQS non-compliant million-plus cities considered in this study is provided in Annexure-2. The list of cities is based on the CPCBs data on $PM_{2.5}$ concentrations for the year 2022.

VI. By 31st March 2035:

- **2.52 million vehicles** will be phased out.
- This final phase will extend the phasing out of 10 yr old diesel+15 yr old petrol (commercial vehicles+ private cars) to all 44 million-plus cities.

In total, **11.4 million older vehicles** will be retired between 31.03.2030 and 31.3.2035 as shown below in Figure 5. This staggered approach is designed to prevent abrupt disruptions to the industry and market while allowing adequate time for the development of supporting infrastructure, such as cleaner fuel vehicle systems and related services, to evolve in parallel. The plan design took into consideration the gradual growth of EV charging infrastructure, with a range of 3,000 to 5,000 stations to be added each year and the gradual increase in the scrapping infrastructure to meet the scrapping demand growth while maintaining financial and operational sustainability.

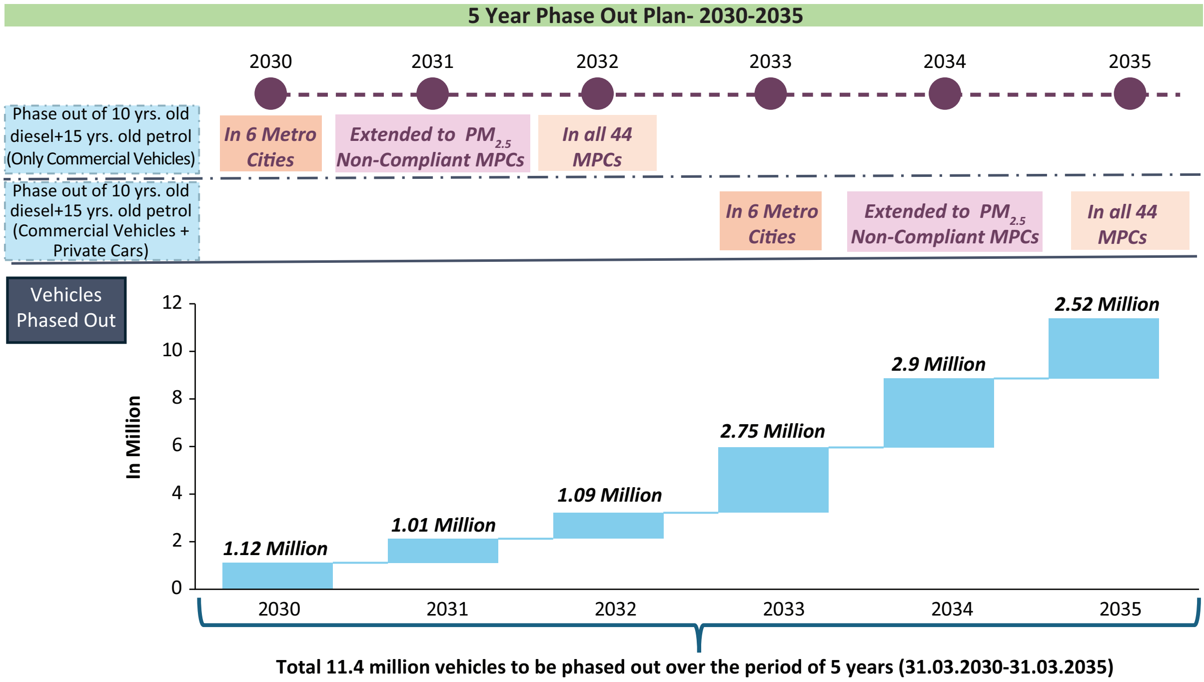

Figure 5: Older vehicles phase out plan in 44 million plus cities of India (2030–3035)

Scenarios for Vehicle Fleet Modernization with Cleaner Fuel

6

Following the implementation of the older vehicle phase-out plan, there will be a surge in demand for newer vehicles, presenting a significant opportunity for cities to replace aging petrol and diesel vehicles with electric (EV) or CNG-powered alternatives. In this brief, two different scenarios of transitioning to a cleaner fuel are explored:

- **Scenario 1- 100% Shift to EV**- all 11.4 million phased-out vehicles will be replaced by new electric vehicles (EVs).
- **Scenario 2–50% shift to CNG & 50% to EV-** half of the phased-out vehicles shall be replaced by new CNG Vehicles and other half by new EV Vehicles.

The impact of both the transitioning scenarios on the required EV and CNG infrastructure and investment, fuel and net energy savings, rise in electricity demand, job creation, reduction in GHG Emission and potential improvements in air quality is assessed in the subsequent sections. The policy instruments that facilitate and incentivize such shifts are detailed in Annexure-3.

6.1 EV charging infrastructure required

To assess the EV charging infrastructure needed in each city to replace the phased-out vehicles, key variables such as the type of EV chargers, battery capacity, daily kilometers driven, and the driving range per full charge for each category of electric vehicle have been assumed as mentioned in the Table 1 below.

Table 1: Detailed key variables for different categories of EV vehicles

EV Vehicle Segment	Daily Kms Driven	Battery capacity in kWh	Driving range in km/full charge	Daily charging demand in kWh per vehicle	Type of Charger
E-3W (passenger/ cargo)	120	7	100	8.40	Single phase-15A charger/220V, Max Power=3.3kW
E-4W-6W (passenger/ cargo)	75	21.2	181	8.78	Type-2 AC-22 kW (50%); 50kW DC charger (50%)
E-car (personal)	40	30.2	312	3.87	Type-2 AC -22 kW (50%); 50kW DC charger (50%)

EV Vehicle Segment	Daily Kms Driven	Battery capacity in kWh	Driving range in km/full charge	Daily charging demand in kWh per vehicle	Type of Charger
E-car (commercial)	100	21.2	181	11.71	Type-2 AC-22 kW (50%); 50kW DC charger (50%)
E-Bus	180	250	200	225.00	DC High Power (250 kW)
50kW DC charger & DC High Power (250 kW) are fast chargers.					

(Sources: NITI Aayog, 2021, Handbook for EV Charging Infrastructure Implementation; Ministry of Power,2022. Charging Infrastructure for Electric Vehicles: The Revised Consolidated Guidelines & Standards; TERI Transport Model)

Design of EV Charging Stations: The proposed EV charging station includes three distinct configurations to accommodate different types of electric vehicles.

A. **Design A** consists of two charging points for 4–6-wheeler vehicles and four charging points for 3-wheelers, ensuring a balanced allocation of resources for mixed-vehicle usage.

B. **Design B** incorporates six charging points exclusively for 3-wheelers to address the excess demand in this category.

C. **Design C** is a dedicated bus charging area designed with four charging points, ensuring that buses have exclusive access to charging infrastructure without interference from smaller vehicles.

Using the data on vehicles phased out each year, along with the energy requirements for EV charging and the design configuration of EV charging station as mentioned above, city wise requirement of EV charging points and stations were calculated. The cumulative number of required charging points and charging stations to support the charging requirements of new EV vehicles in both scenarios for all 44 million plus cities is shown in Figure 6.

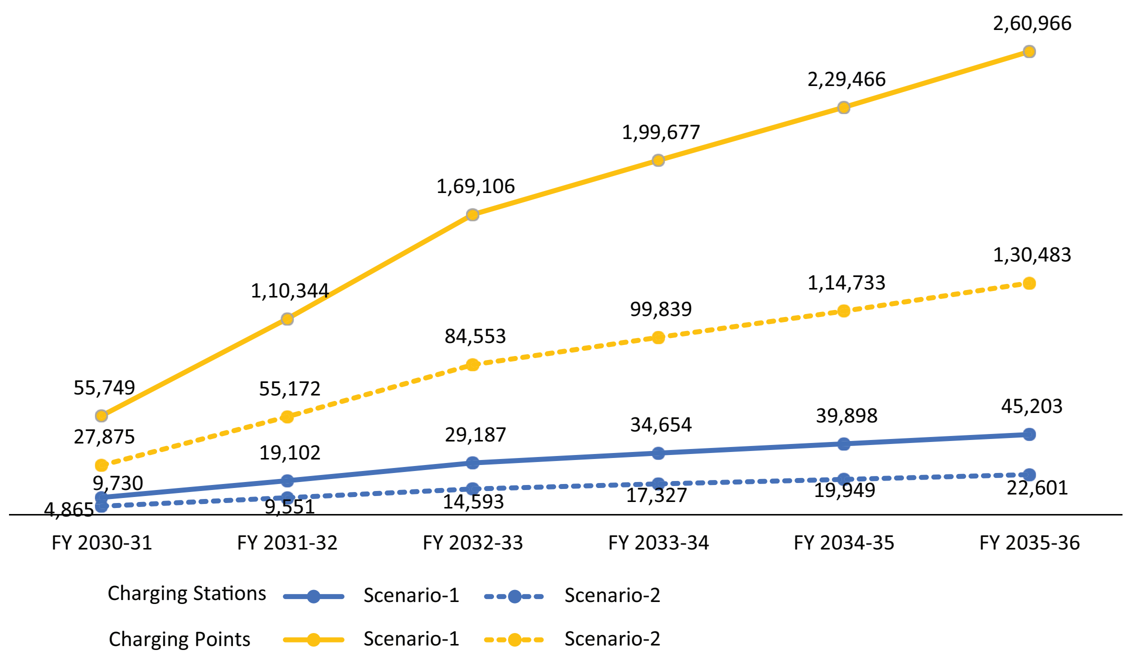

Figure 6: Projected cumulative requirement for no. of charging points and charging stations at the start of each financial year (FY 2030–31 to FY 2035–36)

Hence, between 2030 and 2035, Scenario-1 requires the establishment of 45,203 EV charging

stations across India's 44 million-plus cities. This includes 22,411 stations designed under Design A, 19,258 stations following Design B, and 3,534 stations based on Design C, collectively providing 2,60,966 charging points. **In comparison, Scenario-2 requires the setup of 22,601 EV charging stations in these cities**, comprising 11,205 stations of Design A, 9,629 of Design B, and 1,767 of Design C, with a total of 1,30,483 charging points.

6.2 Investment required by the EV industry

The transition to electric vehicles (EVs) is critical to reducing urban air pollution and meeting India's clean mobility goals. To support this transition, an estimated investment of **₹8800 crores (1023 million USD)** will be required over the five-year period from **2030 to 2035**. Based on market rates and industry surveys, the average cost of EV charging infrastructure has been calculated. The cost includes AC chargers such as the **Single-phase 15A charger (220V, Max Power 3.3 kW)** priced at ₹30,000 per unit and **Type-2 AC (22 kW)** at ₹60,000 per unit. Additionally, DC chargers such as the **50 kW DC charger** cost ₹7,50,000 per unit, while the **High Power DC Charger (250 kW)** costs ₹35,00,000 per unit. The Annual Maintenance Charges (AMC) for AC chargers amount to 10% of the capital cost, while for DC chargers, it is 7% of the capital cost. An additional cost of approximately Rs 1,50,000 can be accounted for amenities like washrooms, drinking water facility, covered waiting areas per EV station wherever required.

To meet the infrastructure demands of 11.4 million EVs, approximately 45,203 EV charging stations will be established, tailored to different vehicle categories. The infrastructure includes chargers suitable for E-3Ws, E-4Ws, personal and commercial E-cars, and E-buses, with charging designs optimized for specific needs as elaborated in the above sections. The year-wise phased-out vehicle projections highlight the peak investment requirement in 2030, amounting to ₹2003 crores (232.92 million USD), tapering off to ₹1145 crores (133.18 million USD) in 2035. The year-wise planned investment is elaborated in the graph below.

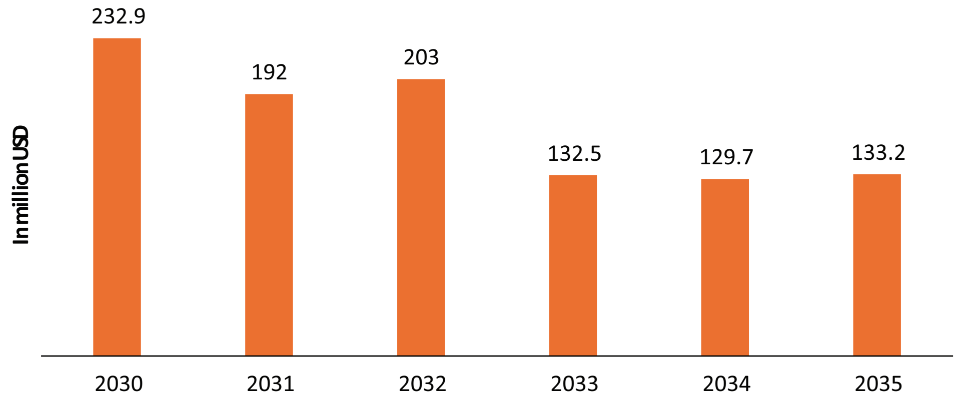

Figure 7: The year-wise planned investment is elaborated in the graph.

6.3 Investment and infrastructure requirements in CNG industry for Scenario-2

To Perform this calculation, firstly the number of Vehicles being phased out is determined. Based on this, the corresponding fuel savings were estimated using the average daily distance travelled per vehicle. Fuel Consumption savings were computed separately for petrol and diesel, followed by the estimation of energy savings for both fuels. Additionally, the fuel consumption transition from petrol and diesel to CNG is analysed. The station capacity was estimated based on specific assumptions: the number of dispensers was set to four, each with a flow rate of 5kg/minute, and the station operated for 20 hours per day. This assumption is based on stakeholder consultations and insights from individuals operating CNG stations. The daily CNG dispensing capacity was then calculated using the formula:

Daily Capacity= Number of Dispensers× flow rate per Dispensers× Operational hours

Based on the given assumptions, the estimated daily capacity of a CNG station is 24,000 kg. Using this capacity, the required number of stations needed to replace petrol and diesel vehicles was determined. Accordingly, the total additional CNG stations required for Scenario 2—where 50% of the shift is to CNG and 50% to EV—was calculated. By analysing the number of vehicles phased out annually and the corresponding CNG station requirements, city-wise estimates for the necessary CNG infrastructure were derived. The detailed CNG station requirements are provided in Annexure 4. The cumulative number of CNG stations required to accommodate 50% of the phased-out vehicles for each financial year from FY 2030–31 to FY 2035–36 is calculated, with the figures presented in Figure 8.

In FY 2030–31, an estimated 138 CNG stations would be needed to support a 50% shift to CNG for phased-out vehicles in six major metro cities. In FY 2031–32, an additional 253 CNG stations would be required under Scenario 2. Similarly, for the subsequent years, the additional CNG stations needed would be 374 in FY 2032–33, 501 in FY 2033–34, 633 in FY 2034–35, and 756 in FY 2035–36. This results in a cumulative requirement of 2,655 CNG stations by the end of FY 2035–36.

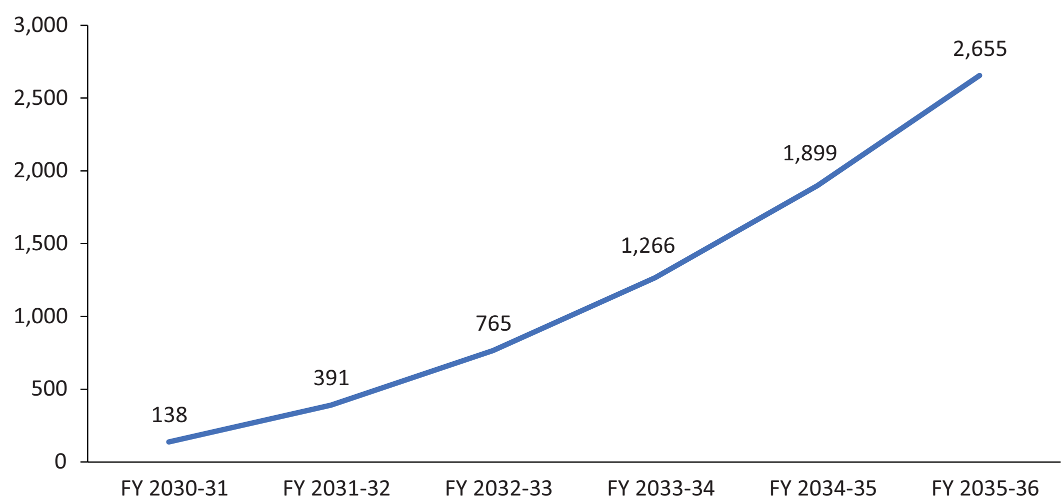

Figure 8: No. of CNG stations needed to support 50% of the phased-out vehicles in all 44 million-plus cities.

According to market data and insights from CNG station operators, establishing a CNG station in India requires an investment ranging from ₹1 crore to ₹2.5 crore (0.1 million USD to 0.3 million USD), depending on factors such as location, land costs, and equipment requirements, with an average estimated cost of approximately ₹1.5 crore (0.2 million USD). To facilitate the 50% replacement of phased-out vehicles with CNG fuel and develop the necessary infrastructure, an estimated cumulative investment of ₹5,130 crore (596.5 million USD) will be required over the five-year period from 2030 to 2035 including 6% inflation cost each year. This includes the establishment of approximately 2,655 CNG stations across 44 cities in India. The projected investment requirements, based on the phased-out vehicle estimates, indicate an initial yearly investment of ₹208 crore (24.19 million USD) in 2030, rising to ₹1,608 crore (186.9 million USD) for the year 2035. The year-wise planned investment distribution is presented in the accompanying graph in Figure 9.

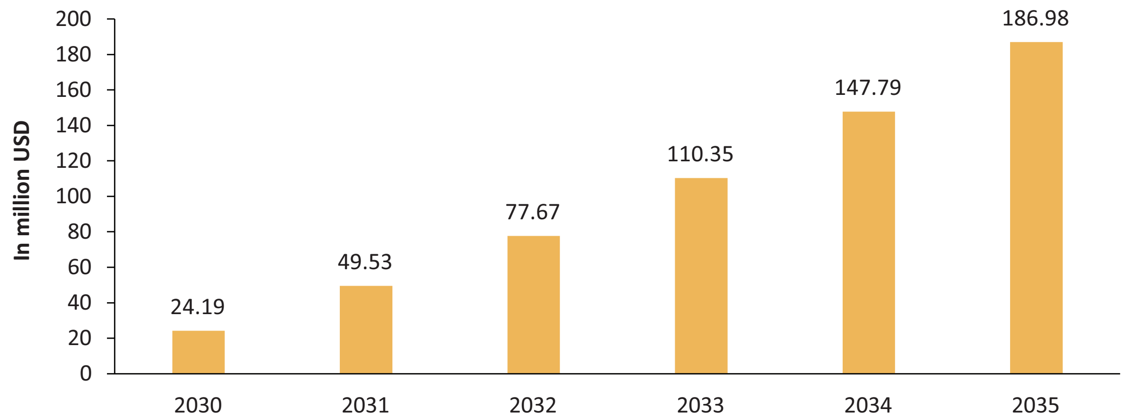

Figure 9: Year-wise planned investment required for CNG Infrastructure.

6.4 Increase in electricity demand

The increasing adoption of electric vehicles (EVs) is revolutionizing transportation by reducing dependency on fossil fuels and lowering greenhouse gas emissions. However, this shift is accompanied by a significant rise in electricity demand, which poses challenges and opportunities for energy systems worldwide. **It is estimated that by the end of the fiscal year 2035–36, the daily energy demand for charging the new EVs in these 44 million plus cities shall be nearly 148 GWh for Scenario-1 and shall be 74 GWh for Scenario-2**. The yearly growth of the electric energy demand is shown below in Figure 10.

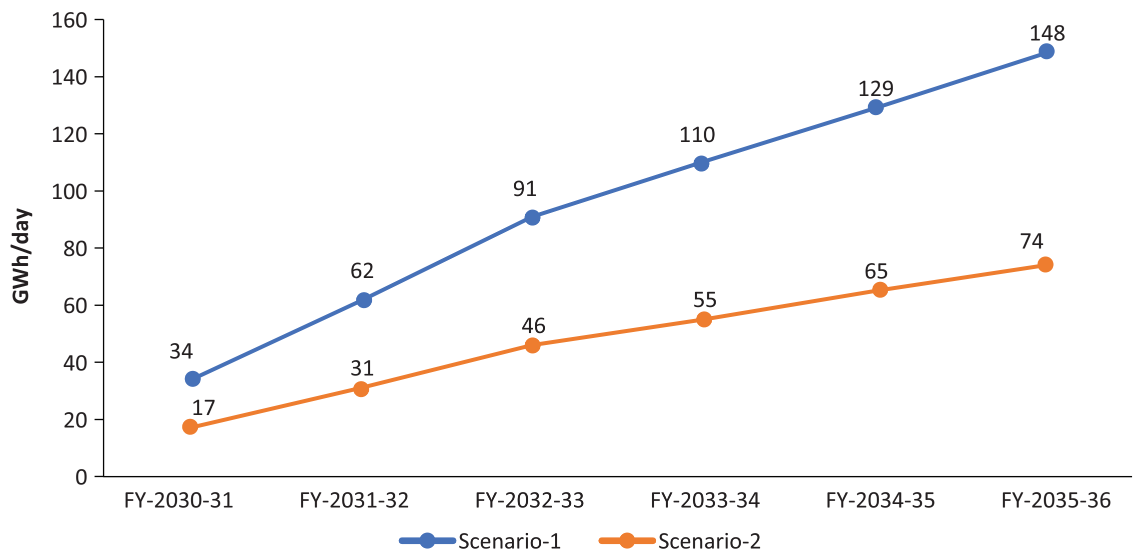

Figure 10: Projected increase in demand for electrical energy to support EV charging infrastructure (in GWh/Day)

6.5 Savings in fuel

The phase-out of 11.4 million older vehicles from 44 major cities across India is projected to bring about substantial fuel savings by the end of the fiscal year 2035–36, with both scenarios demonstrating the same effect. This initiative will result in **a cumulative savings of approximately 5,517 million liters of petrol and 45,467 million liters of diesel** over the period. These significant reductions in fuel consumption will have a profound impact on the country's expenditure on oil imports. **By the end of FY 2035–36, these fuel savings are expected to translate into a monetary benefit of nearly Rs. 9.17 lakh crores (106.6 billion USD)**, substantially easing the burden on India's import bill and contributing to energy security. The yearly breakdown of fuel savings, as illustrated in Figure 11, underscores the incremental benefits of this transition, highlighting the economic and environmental advantages of phasing out outdated, fuel-inefficient vehicles in favor of modern, energy-efficient alternatives.

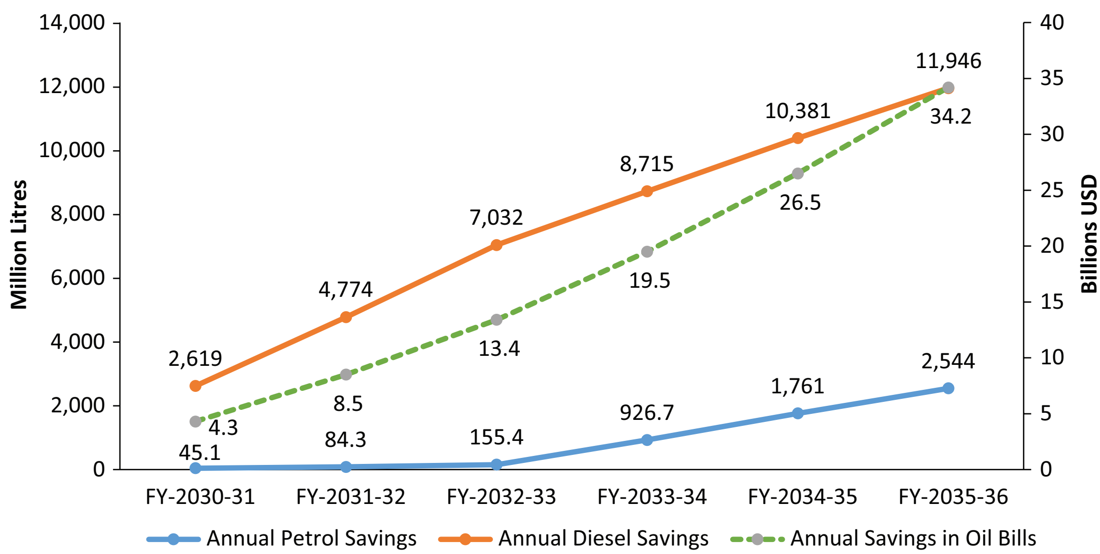

Figure 11: Projected annual fuel savings & its monetary value (FY 2030–31 to FY 2035–36)

6.6 Utilization of rooftop solar-powered EV charging stations and net energy savings

The growing adoption of EVs is a critical step toward reducing greenhouse gas emissions and combating climate change. However, the environmental benefits of EVs are maximized only when their charging infrastructure is powered by renewable energy sources. Rooftop solar-powered EV charging stations offer a sustainable and decentralized solution to the challenges posed by the current energy landscape. Over time, rooftop solar-powered stations can offer lower operating costs by reducing electricity bills and benefiting from incentives for renewable energy deployment. Additionally, evaluating the effectiveness of the fleet modernization plan requires calculating the net energy savings achieved through the initiative.

Hence, for fleet modernization, if rooftop solar-powered EV charging stations supply half of the electric energy requirements outlined in Section 7.4, **under Scenario-1, approximately 17.7 GW of**

Rooftop solar PV capacity will need to be installed by 31st March, 2035. This installation is expected to result in a net energy savings of 1,686 Tera Joules (TJ) by the end of FY 2035–36. Alternatively, under Scenario-2, around 8.8 GW of Rooftop solar PV capacity will need to be installed by 31st March, 2035, leading to a net energy savings of 812 Tera Joules (TJ) by the end of FY 2035–36. The yearly requirement for rooftop solar power capacity that needs to be installed and the net energy savings is shown below in **Figure 12.**

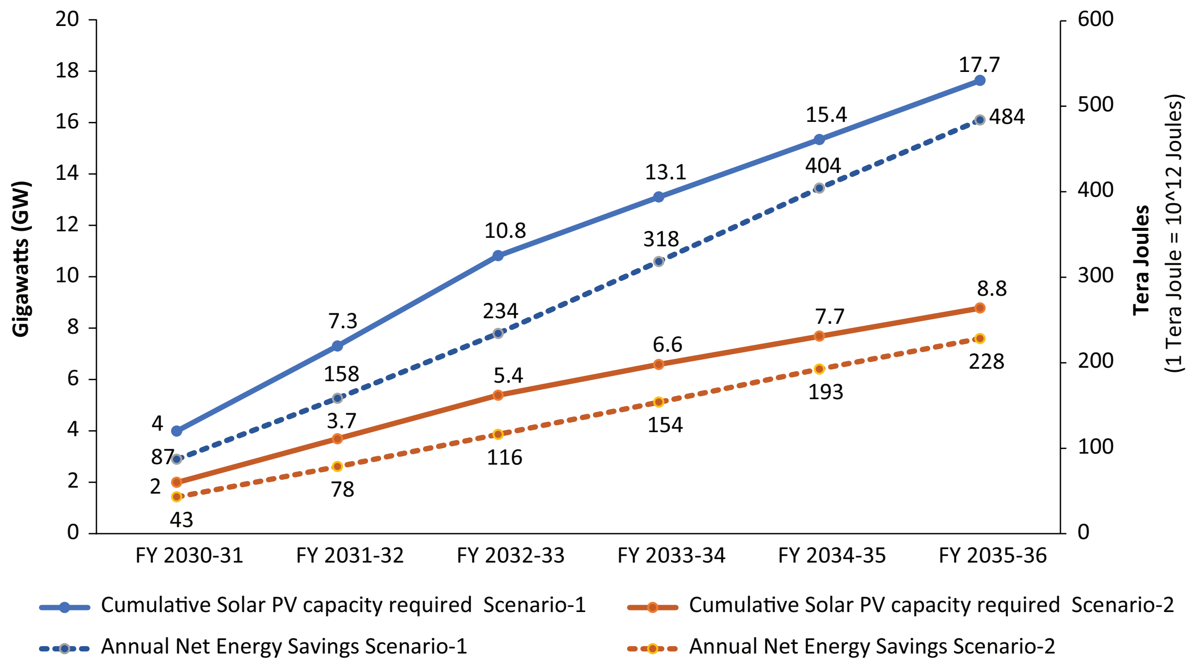

Figure 12: Cumulative Rooftop solar PV installed capacity required and projected yearly net energy savings due to vehicle fleet modernization (FY 2030–31 to FY 2035–36)

Investing in rooftop solar-powered EV charging stations is not only a step toward a cleaner energy future but also a critical infrastructure development to support the ongoing EV revolution. By integrating renewable energy into the charging ecosystem, we can create a greener, more sustainable transportation network. Considering the trend of prices of Rooftop solar PV panels over the past 6 years, **it is estimated that nearly Rs.55,000 crore (6.42 billion USD) investment shall be needed for Scenario-1, while for Scenario 2, Rs.27,500 crore (3.21 billion USD) investment shall be needed until 2035 to meet half the demand of electric energy required by the new EVs.**

6.7 GHG emission reduction

Greenhouse gas (GHG) emissions from vehicles significantly contribute to climate change, making up a large share of transportation emissions. These emissions, mainly CO_2, CH_4, and N_2O, result from fossil fuel combustion in engines. Gasoline and diesel produce higher emissions than alternatives like natural gas, biofuels, or hydrogen, while electric vehicles powered by renewables have near-zero operational emissions. Fuel efficiency also impacts emissions, with modern, advanced vehicles emitting less CO_2 per kilometer than older models. Vehicle fleet modernization is a key strategy for reducing GHG emissions.

Utilizing the vehicular emission factors (India GHG Program) and emission factor of the grid electricity (CEA 2023), the net emissions saved in both the scenarios was calculated. **The phased removal of 11.4 million older vehicles across 44 major cities in India, with a complete replacement by electric vehicles (EVs) in Scenario-1, is projected to achieve a cumulative reduction of 61 million tonnes of CO_2 equivalent in GHG emissions from FY 2030–31 to FY 2035–36. Meanwhile, in Scenario-2 i.e. a 50% shift to EVs and 50% to CNG vehicles is projected to result in a cumulative reduction of 41.3 million tonnes of CO_2 equivalent in GHG emissions during the same period, relative to a business-as-usual scenario.**

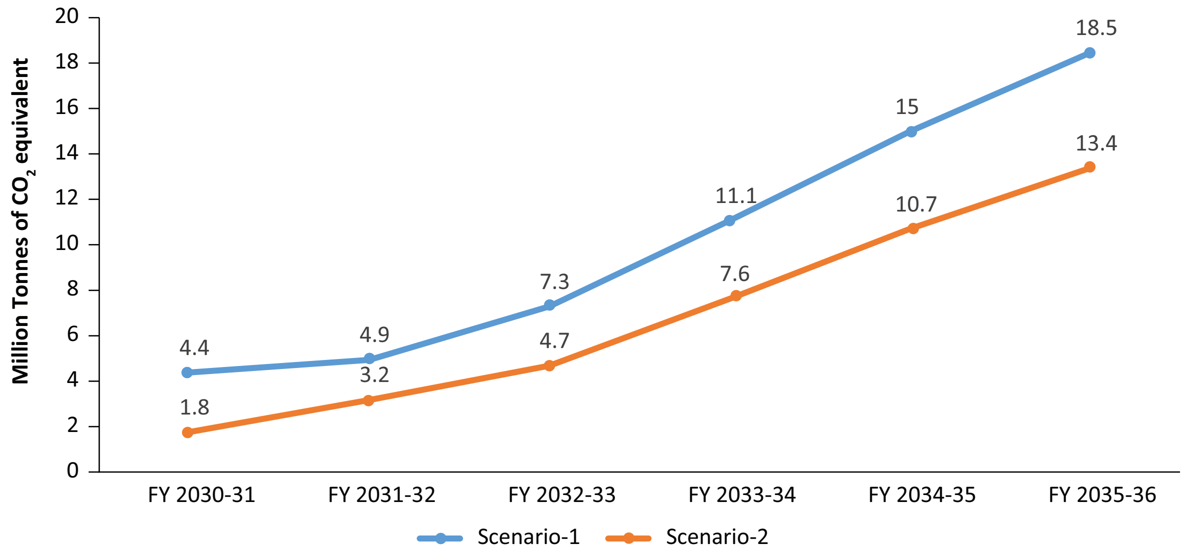

Figure 13: Projected yearly reduction in GHG Emissions due to vehicle fleet modernization (FY 2030-31 to FY 2035–36)

6.8 Potential impact on air quality

In order to estimate the impact of fleet modernization in two proposed scenarios, the energy consumption for different categories of vehicles and emission factor database of ARAI has been used for the emission assessment. The weighted emission factors have been estimated as per the age and Bharat Stage norm distribution and is provided in the Annexure-5. Further, two sets of weighted emission factors have been estimated for cities with advanced BS norms and for cities without the advanced BS norms. The estimated $PM_{2.5}$ and NOx emissions avoided from the proposed phasing out of vehicles is shown in Figure 14.

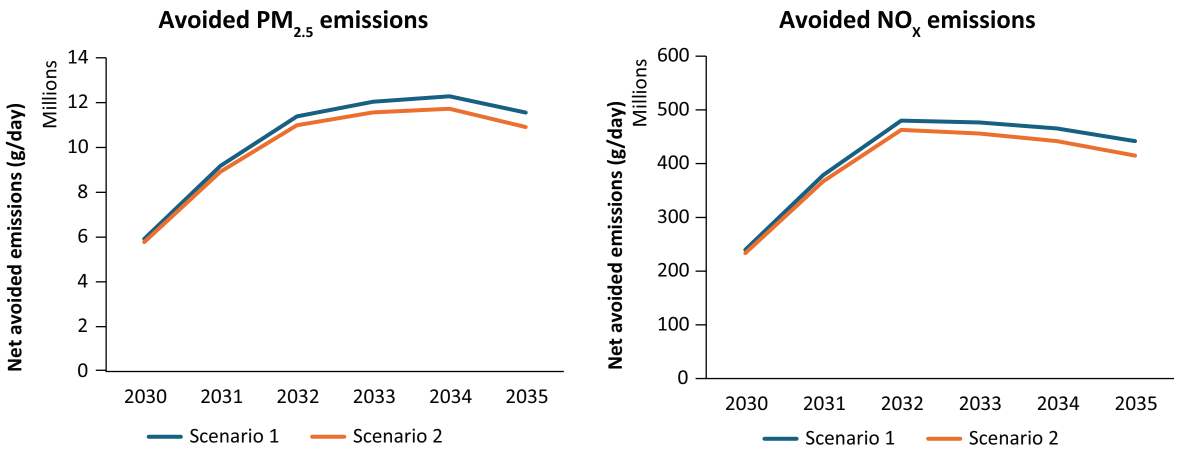

Figure 14: Estimated $PM_{2.5}$ and Nox emission reductions from proposed vehicle phase-out

In the year 2030, $PM_{2.5}$ emissions of around 6 tonne/day will be avoided and this benefit increases to 11.5 t/d in the year 2035. The avoided $PM_{2.5}$ emissions due to phasing out of older vehicles will increase till the year 2034 and thereafter it will decrease as the weighted emission factor for older fleet is reducing over the time. The avoided NOx emissions increase from 239 t/d in the year 2030 to 441 t/d in the year 2035. The category wise distribution of $PM_{2.5}$ and NOx emissions are similar in both the scenarios. It's found that older buses are major contributors to $PM_{2.5}$ and NOx emissions among the categories of vehicles studied. The age restrictions for buses can result in 50% and 80% of total $PM_{2.5}$ and NOx emissions avoided due to fleet modernization in 2030, respectively and this share decreases to 25% and 60% in the year 2034 (Figure 15 and Figure 16).

Figure 15: $PM_{2.5}$ Emissions avoided in Scenario 1 by different vehicle segments

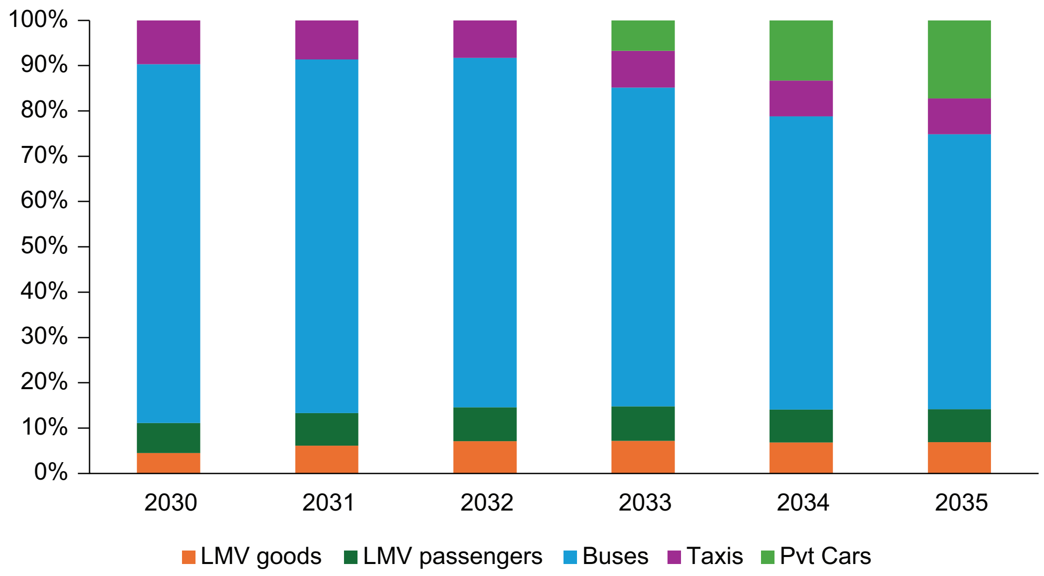

Figure 16: NOx Emissions avoided in Scenario 1 by different vehicle segments

6.9 Job creation

The fleet modernization plan is poised to generate significant employment opportunities in both the electric vehicle (EV) and rooftop solar energy sectors. Industry experts suggest that each EV charging station established creates approximately five direct and indirect jobs in the EV ecosystem and each CNG station will create approximately 32 more jobs in the CNG ecosystem. Direct roles typically include site engineers, deployment specialists, and service technicians, while indirect employment spans areas such as battery production and EV manufacturing. Furthermore, rooftop solar-powered charging stations are expected to bolster job creation in the rooftop solar energy sector. Development and installation of 1 MW of rooftop rooftop solar systems result in approximately 25 job-years, owing to the labor-intensive nature of rooftop rooftop solar projects (CEEW, 2017). Nearly 20 people per 1,000 vehicles are employed in the service and repair of conventional ICE vehicles. However, EVs and CNG vehicles require a smaller workforce for maintenance, leading to potential job losses in the vehicle servicing and repair sector. (Sources: FICCI 2019, iFOREST 2024). Additionally, this study accounts for job losses due to reduced oil consumption (0.13 jobs/crore) and job gains from the increased demand for grid electricity generation (0.71 jobs/MW) (CEEW, 2020).

Using these employment metrics as a benchmark, it is estimated that within 5 years (2030–35), the fleet modernization plan under **Scenario-1 will generate approximately 3,73,479 jobs, while under Scenario-2 about 45,554 jobs shall be generated across these sectors**.

Scrapping Infrastructure Required

7

Registered Vehicle Scrapping Facility (RVSF) is a critical support infrastructure required for implementation of the vehicle-fleet modernization plan. RVSFs promote environment friendly scrapping of vehicles, enhances value recovery from scrapping of vehicles and formalizes the informal vehicle scrapping industry. The rules for registration and functions of Vehicle Scrapping Facility were notified by Ministry of Road Transport and Highways on 23rd Sept.2021. As of Sept. 2024, India has 63 operational Registered Vehicle Scrapping Facilities (RVSFs), 60 under construction, and 40 in the pipeline.

The phase-out of 11.4 million vehicles over a five-year period (2030–2035) will necessitate significant expansion of scrapping facilities in India's 44 million-plus cities. Assuming that each RVSF has a capacity to handle approximately 18,000 vehicles per year, an additional 130 RVSFs will be required in these cities to manage the scrap from the phased-out vehicles. The city-wise requirements are outlined below in Figure 17.

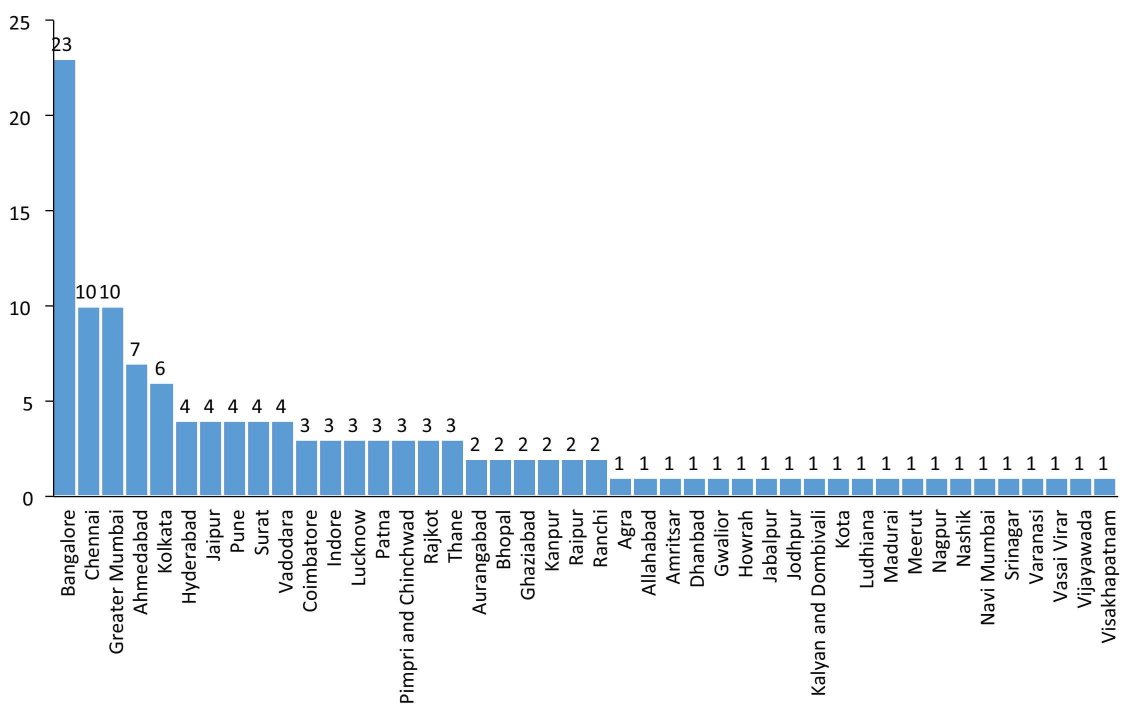

Figure 17: No. of RVSF required in each city

Limitations of the study

While this policy brief provides valuable insights into the impact of phasing out older vehicles and transitioning to cleaner fuels certain limitations should be acknowledged to contextualize the findings and inform future research. Firstly, the study focuses exclusively on the development of EV infrastructure for intracity travel.. Secondly, the assessment assumes that only public charging stations will be used to meet the growing demand for EVs. Lastly, the fuel study is limited to a tank-to-wheel analysis, which evaluates emissions and energy consumption from the point of refueling to vehicle operation, without considering the broader well-to-wheel impact that includes fuel production, refining, and distribution processes.

8 Conclusions and Recommendations

The transport sector significantly contributes to air pollution in Indian cities, with emissions from older vehicles playing a major role. While stringent BSVI norms have drastically reduced emissions compared to older BSII–BSIV vehicles, the growing number of aging vehicles poses a challenge. Addressing this issue requires a large-scale transition to cleaner alternatives like EVs and CNG.

A balanced approach with a 50% adoption of EVs and 50% CNG could lead to a significant reduction of 11 t/d in $PM_{2.5}$ emissions from the transport sector compared to a complete transition to EVs. However, the mixed approach would achieve 30% lower GHG emission savings than a full EV shift. A complete transition to EVs could offer substantial environmental and economic advantages, including a reduction of 11.5 t/d in $PM_{2.5}$ emissions, oil bill savings of ₹9.17 lakh crore (106.6 billion USD) by 2035, and the generation of 3,73,479 new jobs. Nevertheless, this shift requires major infrastructure development, necessitating over 45,000 EV charging stations and 130 scrapping facilities by 2035.

Older buses emerge as the most critical category for targeted intervention, as restricting their age could eliminate a significant portion of $PM_{2.5}$ and NOx emissions. Given these insights, a strategic and phased approach to fleet modernization—through accelerated EV adoption, targeted policy interventions, and infrastructure expansion—will be crucial in mitigating transport sector emissions and improving urban air quality in India.

9 Bibliography

TERI 2021. Decarbonization of transport sector in India, Present status and future pathways, New Delhi, The Energy and Resources Institute.

IEA 2023. Transitioning India's road transport sector realising climate and air quality benefits, Paris, International Energy Agency

CPCB 2015. Status of Pollution Generated from Road Transport in Six Mega Cities, New Delhi: Central Pollution Control Board.

CSE 2020. What to do with old vehicles? Towards effective scrappage policy and infrastructure, New Delhi, Centre for Science and Environment

CPCB 2015. Status of Pollution Generated from Road Transport in Six Mega Cities, New Delhi, Central Pollution Control Board.

NITI Aayog, 2021. Handbook for EV Charging Infrastructure Implementation, New Delhi, National Institution for Transforming India.

Ministry of Power, 2022. Charging Infrastructure for Electric Vehicles- the revised consolidated guidelines & standards, New Delhi, Ministry of Power.

CEEW, 2017. Greening India's workforce: Gearing up for expansion of solar and wind power in India, New Delhi, Council on Energy, Environment and Water.

India GHG Program, Emission Factors Database. Accessed December 2024.

CEA. 2023. CO_2 Baseline Database for the Indian Power Sector, December 2023, New Delhi, Central Electricity Authority.

CEEW 2020. India's Electric Vehicle Transition: Can Electric Mobility Support India's Sustainable Economic Recovery Post COVID-19? New Delhi: Council on Energy, Environment and Water.

FICCI 2019. Indian Automobile Sector Slowdown. New Delhi: Federation of Indian Chambers of Commerce & Industry, September 2019.

iFOREST 2024. ICE to EV: Challenges, Opportunities, and the Roadmap for Just Transition in India's Automobile Sector (2024). International Forum for Environment, Sustainability and Technology, New Delhi, India

TERI 2023: Paul A. (2023). Vehicle Scrappage Policy in India, New Delhi: The Energy and Resources Institute.

TERI 2024. Roadmap for India's Energy Transition in the Transport Sector. New Delhi, India: The Energy and Resources Institute.

ICCT 2024. Real-World Motor Vehicle Exhaust Emissions in Delhi and Gurugram Using Remote Sensing. Washington, DC: International Council on Clean Transportation, August 2024

PIB 2023. Ministry of Heavy Industries. "Faster Adoption and Manufacturing of Hybrid & Electric Vehicles in India (FAME India) Scheme Phase-II." Press Information Bureau, July 2023.

PIB 2024. Ministry of Road Transport & Highways. "Vehicle Scrappage Policy." Press Information Bureau, August 2024.

PIB 2024. Ministry of Heavy Industries, Government of India. "Schemes for Accelerating the Adoption of Electric Vehicles." Press release, August 2, 2024. Press Information Bureau.

PIB 2025. Ministry of Heavy Industries. "Enhancement of E-Vehicles." Press release, February 11, 2025, Press Information Bureau.

MNRE. Ministry of New and Renewable Energy. "National Green Hydrogen Mission." Government of India. Accessed March 26, 2025. https://mnre.gov.in/en/national-green-hydrogen-mission/.

Annexure

Annexure-1

List of 44 million-plus cities under consideration in this study for vehicle fleet modernization

1. Agra
2. Ahmedabad
3. Allahabad
4. Amritsar
5. Aurangabad
6. Bangalore
7. Bhopal
8. Chennai
9. Coimbatore
10. Dhanbad
11. Ghaziabad
12. Greater Mumbai
13. Gwalior
14. Howrah
15. Hyderabad
16. Indore
17. Jabalpur
18. Jaipur
19. Jodhpur
20. Kalyan and Dombivali
21. Kanpur
22. Kolkata
23. Kota
24. Lucknow
25. Ludhiana

26. Madurai
27. Meerut
28. Nagpur
29. Nashik
30. Navi Mumbai
31. Patna
32. Pimpri and Chinchwad
33. Pune
34. Raipur
35. Rajkot
36. Ranchi
37. Srinagar
38. Surat
39. Thane
40. Vadodara
41. Varanasi
42. Vasai Virar
43. Vijayawada
44. Visakhapatnam

Annexure-2

List of $PM_{2.5}$ NAAQS non-compliant million-plus cities considered in this study.
(The list of cities is based on the CPCBs data on $PM_{2.5}$ concentrations for the year 2022).

1. Agra
2. Ahmedabad
3. Allahabad
4. Amritsar
5. Aurangabad
6. Bhopal
7. Ghaziabad
8. Greater Mumbai
9. Gwalior
10. Howrah
11. Indore
12. Jabalpur
13. Jaipur
14. Jodhpur
15. Kalyan and Dombivali
16. Kanpur
17. Kolkata
18. Kota
19. Lucknow
20. Ludhiana
21. Meerut
22. Nagpur
23. Navi Mumbai
24. Patna
25. Pune
26. Surat
27. Thane
28. Visakhapatnam

Annexure-3

Policy Instruments Enabling and Incentivizing the Transition to EVs and CNG in India

India has implemented several policy instruments to support the transition to Electric Vehicles (EVs) and Compressed Natural Gas (CNG) vehicles. These measures include financial incentives, regulatory mandates, infrastructure development, and taxation benefits to promote cleaner mobility solutions.

The Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) scheme is a key financial initiative, launched in two phases. FAME I (2015–2019) provided subsidies for electric two-wheelers, three-wheelers, four-wheelers, and buses, while FAME II (2019-Present) offers higher incentives, focusing on public and commercial transport (PIB, 2024). PM E-Drive and PM e-Bus Sewa are some other government initiatives promoting electric mobility and sustainable transport in India. PM E-Drive accelerates EV adoption through incentives, policy support, and infrastructure development, reducing fossil fuel dependence and emissions. PM e-Bus Sewa strengthens public transport by deploying electric buses with financial aid to states, ensuring eco-friendly and cost-effective mobility. Both initiatives support India's vision of a net-zero emissions future. (PIB, 2025)

Additionally, the Production Linked Incentive (PLI) Scheme for Advanced Chemistry Cell (ACC) Batteries supports domestic battery manufacturing, reducing costs and import dependency. Various states have introduced their own EV policies, offering purchase subsidies, road tax exemptions, and registration fee waivers. For CNG, some state governments provide subsidies for vehicle purchases and retrofitting (PIB, 2024).

Regulatory mandates also play a significant role in promoting green mobility. Corporate Average Fuel Efficiency (CAFE) norms enforce fuel efficiency improvements, indirectly encouraging EV adoption. The Renewable Energy Purchase Obligations (RPOs) for EV charging ensure that a portion of the electricity used for charging comes from renewable sources. The Vehicle Scrappage Policy (2021) encourages the phasing out of old, polluting vehicles, which indirectly boosts demand for EVs and CNG vehicles (PIB, 2023). The Auto Fuel Policy and BS-VI norms further promote cleaner fuels and vehicle technologies, making CNG vehicles a viable alternative.

Infrastructure development is another critical area of focus. The National Electric Mobility Mission Plan (NEMMP) aims to establish EV charging infrastructure and facilitate the adoption of electric mobility. Under the Charging Infrastructure Policy, FAME II supports the setting up of public charging stations, with private sector participation encouraged through incentives. Meanwhile, the expansion of the City Gas Distribution (CGD) network ensures the availability of CNG refuelling stations nationwide, supporting the growth of CNG adoption.

Taxation benefits and custom duty reductions also contribute to the affordability of EVs and CNG vehicles. The Goods and Services Tax (GST) on EVs has been reduced to 5% from the standard 28%. Section 80EEB of the Income Tax Act provides deductions of up to ₹1.5 lakh on interest paid for EV loans. Additionally, lower excise duties and customs exemptions on EV components, battery packs, and CNG kits help reduce overall vehicle costs.

Public transport electrification and fleet conversion are key aspects of India's green mobility transition. Under FAME II, financial support is provided for state transport undertakings to procure electric buses. Policies also mandate fleet conversion to EVs and CNG for cab aggregators and e-commerce delivery services. Green Urban Mobility Initiatives ensure that metro projects and last-mile connectivity solutions increasingly adopt electrification.

Research, development, and localization initiatives further strengthen the transition. The PLI Scheme for Auto & Auto Components encourages domestic production of EV components, reducing import reliance. Government support for battery swapping technologies and research in energy storage solutions plays a crucial role in advancing EV technology. Additionally, the National Hydrogen Mission explores hydrogen-based mobility as a future alternative, complementing existing EV and CNG policies (Source: MNRE).

Raising awareness and encouraging behavioural shifts are also part of the strategy. Public awareness campaigns promote the benefits of EVs and CNG through government and industry partnerships. Green number plates help distinguish EVs and provide easy access to incentives like free parking and toll exemptions. Proposed urban low-emission zones restrict conventional fuel vehicles in certain areas, favouring the adoption of EVs and CNG vehicles.

India's transition to cleaner transportation is supported by a combination of financial incentives, infrastructure development, regulatory mandates, and technological advancements. While EVs are gaining momentum, CNG continues to play a crucial role in reducing vehicular emissions, particularly in public and commercial transport. Continued policy refinements and infrastructure investments will be key to achieving sustainable and widespread adoption of green mobility solutions in India.

The channelizing mechanism for ELVs should facilitate the sustainable movement from its source to recycling, treatment, and disposal, which will translate to better recovery and recycling. Reverse logistics for the collection, recycling, and disposal should be a part of EPR operations for ELVs and these activities should be legally supported by clear policy targets. The vehicle design should promote reuse, disassembly, and recycling by OEMs by creating recycling-oriented vehicles. The government should assist in the establishment of RVSFs and provide continuous customer awareness about the vehicle scrappage policy and various other incentives. Cluster-based pilots can also be established by the government in collaboration with the OEMs, to showcase ELV management as a successful business model under an appropriate scientific and conducive environment (Source: TERI, 2023).

Annexure 4: City wise detailed CNG station requirements

S. No.	City	FY 2030–2031	FY 2031–2032	FY 2032–2033	FY 2033–2034	FY 2034–35	FY 2035–36
1	Agra		2	2	3	5	6
2	Ahmedabad	10	12	16	28	32	38
3	Allahabad		4	4	5	7	8
4	Amritsar		1	1	2	4	4
5	Aurangabad		10	12	13	15	16
6	Bangalore	90	96	110	151	162	176
7	Bhopal		3	3	4	9	10
8	Chennai	16	19	25	43	49	57
9	Coimbatore			6	7	8	14
10	Dhanbad			1	2	2	5
11	Ghaziabad		4	5	5	11	12
12	Greater Mumbai	14	16	20	37	41	47
13	Gwalior		1	2	2	4	4
14	Howrah		1	1	2	3	3
15	Hyderabad	4	5	7	12	15	17
16	Indore		3	4	5	11	13
17	Jabalpur		1	2	2	4	4
18	Jaipur		7	10	12	20	23
19	Jodhpur		3	4	5	7	8
20	Kalyan and Dombivali		2	2	3	5	5
21	Kanpur		3	4	4	8	9
22	Kolkata	5	5	7	20	22	25
23	Kota		1	2	2	3	4
24	Lucknow		4	5	6	12	14
25	Ludhiana		2	3	3	6	7
26	Madurai			3	4	4	7
27	Meerut		3	3	3	5	6
28	Nagpur		4	5	6	8	9
29	Nashik			6	7	7	10
30	Navi Mumbai		3	4	5	7	8
31	Patna		9	11	12	17	18
32	Pimpri and Chinchwad			9	10	11	18
33	Pune		14	16	17	26	29
34	Raipur			4	5	5	9
35	Rajkot			7	7	8	14
36	Ranchi			2	2	3	7

S. No.	City	FY 2030–2031	FY 2031–2032	FY 2032–2033	FY 2033–2034	FY 2034–35	FY 2035–36
37	Srinagar			1	1	2	4
38	Surat		4	6	7	15	17
39	Thane		7	11	13	18	21
40	Vadodara			9	10	11	19
41	Varanasi			6	7	8	9
42	Vasai Virar			2	2	2	4
43	Vijayawada			4	4	5	6
44	Visakhapatnam		3	4	4	6	7

Annexure-5

Weighted emission factors for old vehicles (kt/PJ)						
$PM_{2.5}$	2030	2031	2032	2033	2034	2035
Diesel Buses	0.020272	0.016814	0.013751	0.010165	0.007763	0.005538
Diesel Cars and Taxis	0.026272	0.023494	0.020709	0.017928	0.015419	0.012815
Petrol Cars and Taxis	0.00113	0.00113	0.00113	0.00113	0.00113	0.00113
Diesel LMV	0.020664	0.018079	0.015577	0.013313	0.011379	0.009384
Petrol LMV	0.00113	0.00113	0.00113	0.00113	0.00113	0.00113
For cities which are one norm ahead						
Diesel Buses	0.020272	0.016814	0.013751	0.010165	0.007763	0.005538
Diesel Cars and Taxis	0.02586	0.023146	0.020427	0.017712	0.015257	0.012713
Petrol Cars and Taxis	0.00113	0.00113	0.00113	0.00113	0.00113	0.00113
Diesel LMV	0.02033	0.017805	0.01536	0.014121	0.011249	0.009298
Petrol LMV	0.00113	0.00113	0.00113	0.00113	0.00113	0.00113

Weighted emission factors for old vehicles (kt/PJ)						
NOx	2030	2031	2032	2033	2034	2035
Diesel Buses	1.3	1.116094	0.950154	0.774794	0.63983	0.51664
Diesel Cars and Taxis	0.395931	0.360289	0.324557	0.288883	0.25677	0.223382
Petrol Cars and Taxis	0.0688	0.0688	0.0688	0.061127	0.055674	0.052181
Diesel LMV	0.396251	0.354083	0.313261	0.276405	0.244981	0.212468
Petrol LMV	0.0688	0.0688	0.0688	0.066926	0.05736	0.054569
For cities which are one norm ahead						
Diesel Buses	1.3	1.116094	0.950154	0.774794	0.63983	0.51664
Diesel Cars and Taxis	0.385	0.35108	0.317091	0.283153	0.252459	0.220658
Petrol Cars and Taxis	0.0344	0.0344	0.0344	0.0344	0.0344	0.0344
Diesel LMV	0.385	0.344848	0.305964	0.290848	0.240595	0.209563
Petrol LMV	0.0344	0.0344	0.0344	0.0344	0.0344	0.0344

THE ENERGY AND RESOURCES INSTITUTE
Creating Innovative Solutions for a Sustainable Future

Published by:
The Energy and Resources Institute (TERI)
Darbari Seth Block,
IHC Complex, Lodhi Road,
New Delhi - 110 003, INDIA

Tel: (+91 11) 2468 2100
Fax: (+91 11) 2468 2144, 2468 2145
Email: pmc@teri.res.in
Web: www.teriin.org