



**DELHI**

# MULTI-SECTOR ACTION FOR CLEAN AIR





**DELHI**

# **MULTI-SECTOR ACTION FOR CLEAN AIR**



**Centre for Science and Environment**

**AUTHOR AND RESEARCH  
DIRECTOR**

Anumita Roychowdhury

**RESEARCH AND INVESTIGATION**

**Clean Air and Vehicle Technology**

Kalyani Tembhe, Shambhavi Shukla,  
Sharanjeet Kaur, Jyoti Kumari  
and Dr M P George

**Transport and Mobility**

Shubham Srivastava, Sayan Roy,  
Kalyani Tembhe, Caleb Philip, Richa Pandey  
and Moushumi Mohanty

**Industry**

Nivit Kumar Yadav, Shreya Verma,  
Santosh Kumar and Shobhit Srivastava

**Municipal Solid Waste**

Atin Biswas, Kaifee Jawed, Kuldeep Choudhary,  
Minakshi Solanki, Aniket Chandra,  
Dr Tribhuwan Singh Bisht and Shrotik Bose

**Construction and Demolition Waste**

Rajneesh Sareen, Mitashi Singh,  
Sugeet Grover and Gargi Dwivedi

**Multi-sector Energy and  
Emission Analyst**

Kalyani Tembhe

**EDITORS**

Souparno Banerjee, Archana Shankar,  
Rituparna Sengupta, Mohini Chandola  
and Yashita Mishra

**COVER AND DESIGN**

Ajit Bajaj

**GRAPHICS**

Vineet Tripathi, Tarun Sehgal

**LAYOUTS**

Kirpal Singh, Shri Krishan  
and Surender Singh

**PRODUCTION**

Rakesh Shrivastava and Gundhar Das



© 2025 Centre for Science  
and Environment

Although Delhi is still battling an air pollution crisis, it has demonstrated the importance of regulatory mandates and targets in achieving upscaled implementation of multi-sector solutions to bend the pollution curve.

Delhi's clean air action precedes the NCAP programme. The interventions from the Supreme Court and EPCA have catalysed the substitution of diesel fuel with CNG in public transport and local commercial transport; restrictions on truck entry; imposition of pollution tax on daily truck entry, diesel fuel sold, and diesel cars sold with 2000 cc engines; and phase-out of 10-year-old diesel and 15-year-old petrol vehicles.

Post 2020, CAQM has further restricted entry of pre-Bharat Stage IV inter-state buses and diesel generator sets and initiated hotspot action on dispersed sources. Delhi government's EV policy has attained fleet electrification level of 12 per cent.

Polluting industrial fuels are banned and only legally defined approved fuels are permitted.

The cumulative impact of restrictions on diesel and industrial coal is evident in the massive reduction in their consumption with commensurate emission-reduction benefits. But Delhi still requires 60 per cent reduction in PM<sub>2.5</sub> levels to meet the national clean air standards.

More aggressive upscaling of mobility strategies, zero-emission vehicles, robust waste management, action on unregulated industry and use of solid fuels in households, and regional airshed-level interventions are needed.

# CONTENTS

<b>THE NATIONAL CLEAN AIR PROGRAMME (NCAP)</b>	6
Interpreting Good Practices to Drive Clean Air Action	
<b>DELHI</b>	38
Multi-sector Action for Clean Air	
<b>VARANASI</b>	102
Leveraging Urban Renewal for Clean Air	
<b>VEHICULAR EMISSIONS</b>	126
Technology Roadmap and Urban mobility Strategies	
<b>INDUSTRY</b>	206
Best Practices to Mitigate Air Pollution	
<b>MUNICIPAL SOLID WASTE</b>	260
Urban Reforms for Cleaner Air	
<b>CONSTRUCTION AND DEMOLITION (C&amp;D) WASTE</b>	304
Addressing Dust Pollution and Circularity	
<b>ANNEXURE</b>	332
<b>REFERENCES</b>	337

Delhi is designated as a non-attainment city under the National Clean Air Programme (NCAP). But Delhi is not a recipient of the fund from the 15th Finance Commission meant for cities with more than a million population. However, between FY 2019–20 and 2024–25, Delhi received Rs 42.69 crore under the NCAP programme of the Ministry of Environment and Forests and Climate Change (MoEFCC) out of which Rs 13.94 crore or 32.64 per cent has been spent.

Clearly, the nominal action that Delhi may have taken with this small amount of funding cannot capture the magnitude of the multi-sector action that Delhi has implemented over time impacting the long term air quality trend. But it is important to capture the cumulative and evolving nature of Delhi's action in different sectors to understand and demonstrate what it takes to make a difference to the air quality.

Delhi is the only city that has undergone long and successive phases of clean air action to combat one of the toughest and the longest air pollution battles in this country. In the early 1990s, Delhi started experiencing the choking haze of pollution. Since then a lot has happened to improve the air quality. But despite the improvement the challenge remains. Other cities need to recognize the scale of multi-sector action in Delhi to understand the magnitude of change needed for sustained improvement in air quality.

Delhi is a unique case study because it has a strong legacy foundation of clean air action that has preceded the NCAP period. In most other non-attainment cities (barring a few mega and capital cities), the NCAP programme has been the prime driver for seeding and starting a clean air programme.

Currently, Delhi is required to report progress in action on the CPCB's PRANA portal. Delhi is also evaluated for controlling the annual average  $PM_{10}$  levels under NCAP and is ranked for taking sectoral action under the Swachh Vayu Sarvekshan. But this reveals a curious paradox – while Delhi is among the top ten cities for taking sectoral action, it is at the bottom for not improving the  $PM_{10}$  levels. It is therefore more important to understand the full spectrum of systemic changes that have over time contributed to the current long-term air quality trends.

Delhi is also unique because nearly all clean-air-related interventions have been driven primarily by air pollution concerns stemming from the directives of the Supreme Court in the ongoing public interest litigation. These are further complemented by the directives from the National Green Tribunal and Delhi High Court from time to time. The executive measures under the convergence framework have also contributed to the trend. This city has also witnessed some of the sharpest public and media campaigns to empower change.

Multiple forces have come into play to catalyse the clean air action in Delhi. The Supreme Court of India had first intervened in response to the ongoing public interest litigation that had started during the late 1980s (the M.C. Mehta case). This case has built further momentum from late 1990s onwards when more strident public campaign and voices began to demand clean air. After that, for more than two decades and until 2020, the Supreme Court has monitored and directed this process. The Environment

Pollution (Prevention and Control) Authority (EPCA) was appointed under the direction of the Supreme Court and set up under Section 5 of the Environment Protection Act 1986, in 1998, to advise the Supreme Court on the pollution matter and also monitor implementation of the Court directives.

Subsequently, in the second phase, post 2021, the Government of India created the unified executive authority called the Commission for Air Quality Management (CAQM) for the NCR and adjoining areas and beyond in 2020 under the Commission for Air Quality Management in National Capital Region and Adjoining Areas Act, 2021, as an empowered executive body with Central government oversight. However, parallelly, the PIL in the Supreme Court has also continued.

Delhi helps to answer a few critical questions around the scale and scope of multisector action to make a difference to the air quality, and the new action agenda needed to address the current gaps in action to meet the clean air benchmark. A substantial number of measures have been initiated targeting the technology and energy transition in transport and industry (primarily targeting coal and diesel). However, major gaps remain with respect to the mobility transition, waste management for circularity, unregulated industries in non-conforming areas, and energy poverty in households. This is an important learning curve for all the other cities embarking on air quality management. Delhi has demonstrated how the problem of pollution cannot be won with incremental action but needs a leapfrog agenda that is cross-sectoral with a stringent compliance framework. Delhi has witnessed stabilisation and reduction in particulate pollution levels over time even while experiencing urban growth, motorisation, prolific construction, mushrooming of enterprises and piling up of waste dumps. Yet much stronger action is needed to stay ahead of the growth curve for clean air.

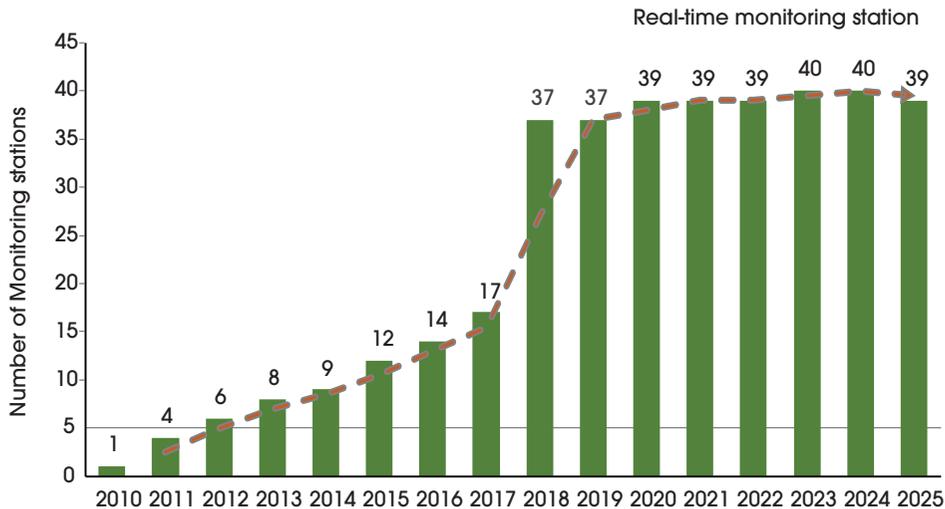
## EXPANSION OF AIR-QUALITY MONITORING

**Expansion of air-quality monitoring network:** During the last decade Delhi witnessed massive expansion of air quality monitoring to provide real-time data to inform policy action. Until 2010, Delhi had very few monitoring stations and that too manual monitors capable of monitoring only coarse dust – the total suspended particulate matter or at best the larger-sized particulate matter less than 10 micron ( $PM_{10}$ ).

From one real-time monitoring station in 2010, the numbers of real-time monitoring stations capable of monitoring finer  $PM_{2.5}$  and other toxic gases increased rapidly to 37 real-time monitoring stations by 2018. Thereafter, three more stations were added to become 40 stations (see *Graph 1: Progress in expansion of real-time air-quality monitoring in Delhi*).

As of 2025, Delhi has 39 continuous air quality monitoring stations spread across an area of approximately 1,500 sq. km. Delhi does not require more monitoring stations but the existing ones can be better distributed for an improved population coverage. Most stations are concentrated in the central areas while southern, northwest and peripheral regions remain inadequately-monitored (see *Map 1: Spatial spread of air-quality monitors in Delhi*). An additional six stations have been proposed in green campus of Jawaharlal

**Graph 1: Progress in expansion of real-time air-quality monitoring in Delhi**



Note: New Moti Bagh station is not operational since Sept 2024.

Source: CSE analysis

Nehru University (JNU), Indira Gandhi National Open University (IGNOU), Delhi Cantonment, Netaji Subhash University (Waste Campus, Jaffarpur) and Commonwealth Games Village.

Availability of improved data helps to assess longer-term year-on-year changes in air quality and also pollution hotspots in the city. This also allows dynamic estimation for implementation of the Graded Response Action Plan to respond to pollution emergency situations.

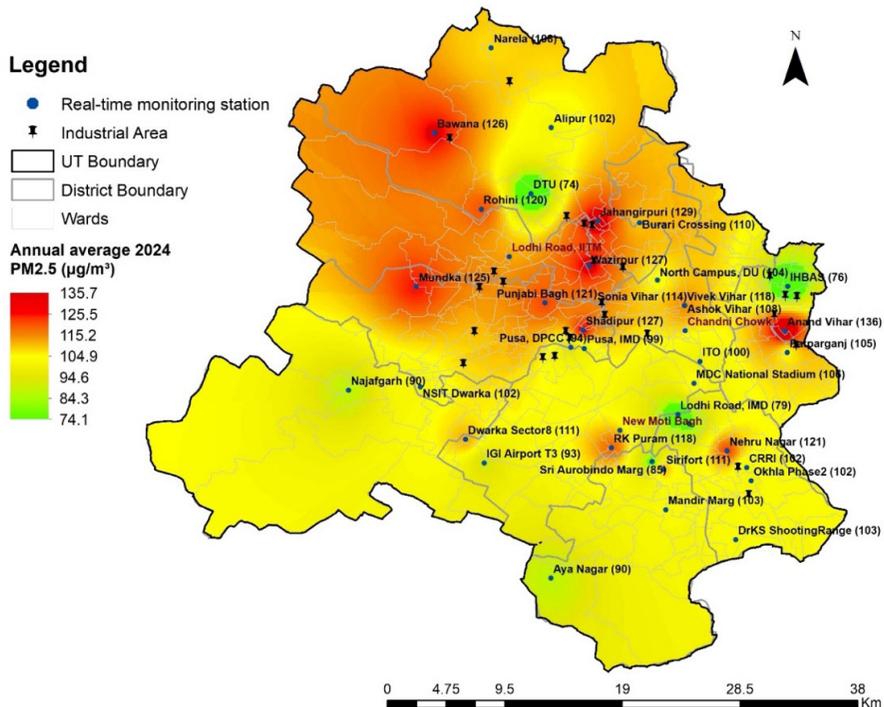
**Need further rationalisation of the monitoring network:** Further rationalisation of the monitoring network is needed for optimum coverage of population and land-uses. Despite such large number of monitors, these are not well distributed to cover population in all land uses and there are still some “shadow zones” with low station density. Currently, the monitoring stations in Delhi are mainly centred in and around the southern and central part of Delhi (see *Table 1: District-wise distribution of 39 monitoring stations*).

The southwest and northwest peripheries have minimal monitoring stations, leading to gaps in air quality monitoring. The stretch between Mundka, Bawana and Narela should have more number of monitoring stations as these are the areas that record some of the highest PM<sub>2.5</sub> levels (see *Map 1: Spatial spread of air-quality monitors in Delhi*). Moreover, with a fully established monitoring network the focus now has to be on the auditing of the monitoring system to improve quality of the data and rationalisation of siting of monitors.

**Table 1: District-wise distribution of 39 monitoring stations**

City	District	No. of monitoring stations
Delhi	Central	7
	East	1
	New Delhi	5
	North	6
	North-east	0
	North-west	2
	Shahadra	2
	South	4
	South-west	1
	West	5
	South-east	6

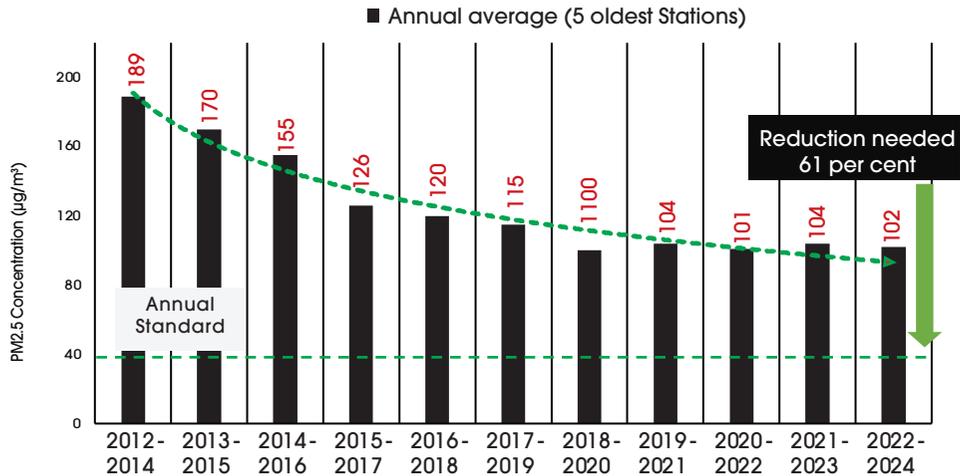
**Map 1: Spatial spread of air-quality monitors in Delhi**



Note: Average PM2.5 concentration is based on mean of daily values recorded at the 37 CAAQM stations given it has adequate data. Chandni Chowk and Lodhi Road IITM do not have adequate data for the year. New Moti Bagh station has not been operational since Sept 2024.

Source: CSE analysis

**Graph 2: Three-year rolling average of PM<sub>2.5</sub> concentration based on the five oldest stations since 2012**



Note: i. The five stations are ITO, IHBAS, Mandir Marg, Punjabi Bagh and RK Puram  
 ii. The three-year average provides better view of the longer-term change and addresses high annual variation.

Source: CSE analysis of CPCB’s real-time air-quality data

**DATA ENABLES TRACKING OF AIR-QUALITY TRENDS**

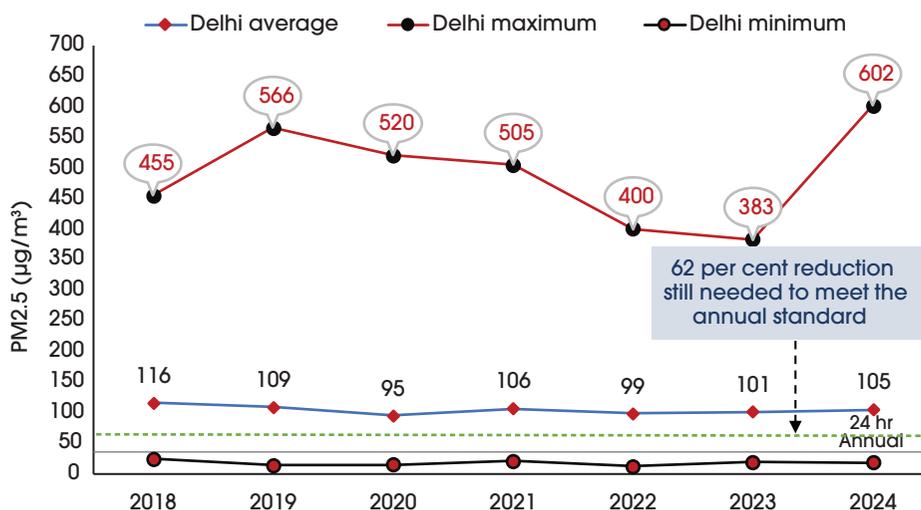
**Long-term trend is downward:** Even though most of the monitoring stations were set up between 2016 and 2019, five stations had come up around 2012–13. The rolling three-year average trends (more suitable to build long-term trend) in these stations show the change in the long term. There is a notable decline and the concentration level has dropped by 46 per cent over a span of 11 years (see *Graph 2: Three-year rolling average of PM<sub>2.5</sub> concentration based on the five oldest stations since 2012*). A series of multi-sector action spread over the two decades has contributed towards this trend.

More recent year-on-year air-quality trend since 2018, when most of the air quality monitoring stations were set up show that the average annual PM<sub>2.5</sub> levels (based on 38 stations) show a 10 per cent improvement since 2018 overall.

However, after the pandemic year of 2020–21, the levels have increased, stayed elevated and the curve turned upward in during 2023–24. The maximum values in 2024 has been the highest in the past few years (see *Graph 3: Long-term trend in PM<sub>2.5</sub> annual average since 2018*). Delhi requires as much as a 62 per cent reduction in its annual PM<sub>2.5</sub> annual average level to meet the national ambient air quality standard.

Usually, every year, burning of crop residues in the surrounding states of Punjab and Haryana are blamed for poor air quality during early part of winter. However, over the years the fire incidents have declined.

**Graph 3: Long-term trend in PM<sub>2.5</sub> annual average since 2018**



Note: Average, maximum and minimum PM<sub>2.5</sub> concentration is based on mean of daily values recorded at the 37 CAAQM stations given it has adequate data since 2018.

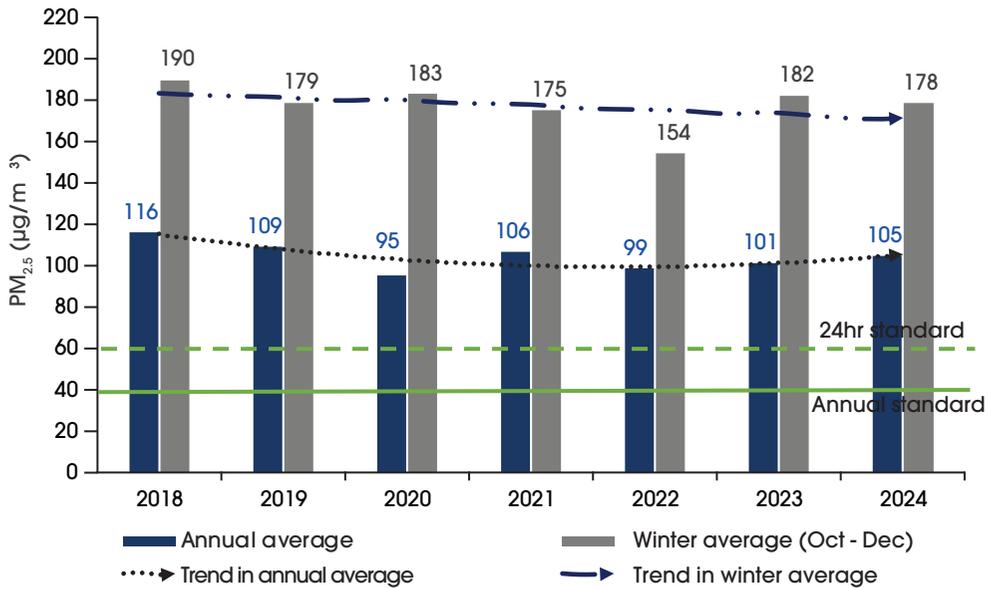
Source: CSE analysis

During the winter of 2024–25, the air quality of Delhi had turned poor to very poor even when for most part, the contribution of farm fires remained low. Between Oct 8 and November 30 – the main crop-residue burning season – farm fires contribution was 20–25 per cent on on five days, and 30 per cent and above on four days. On most days the contribution had been less than 10 per cent or even 5 per cent. This shows the pronounced impact of pollution sources in the city and the surrounding areas. Delhi cannot hide behind the smokescreen of farmfires any more (see *Graph 4: Trend in PM<sub>2.5</sub> winter average and annual average*).

**Monitoring enables identification of hyperlocal pollution hotspots:** In 2018, the Supreme Court had directed implementation of pollution hotspot plans for hyperlocal action across different neighbourhoods to reduce high exposures. The definition of the hotspots area after location-wise air-quality analysis showed that while the overall ambient concentration of PM<sub>2.5</sub> in the city was much higher than the national ambient air quality standards, the levels in some locations were higher than even the city average level. About 13 such hotspots were identified by EPCA and mandated to implement plans to address local pollution sources, which included unpaved and poor road conditions, open burning of waste including industrial waste and congestion among others.

These original hotspots continue to show a mixed air quality trend. In the meantime, however, more and newer hotspots have proliferated indicating rapid spatial spread of polluting activities in the city (see *Graph 5: Air quality trend in the pollution hotspots of Delhi*).

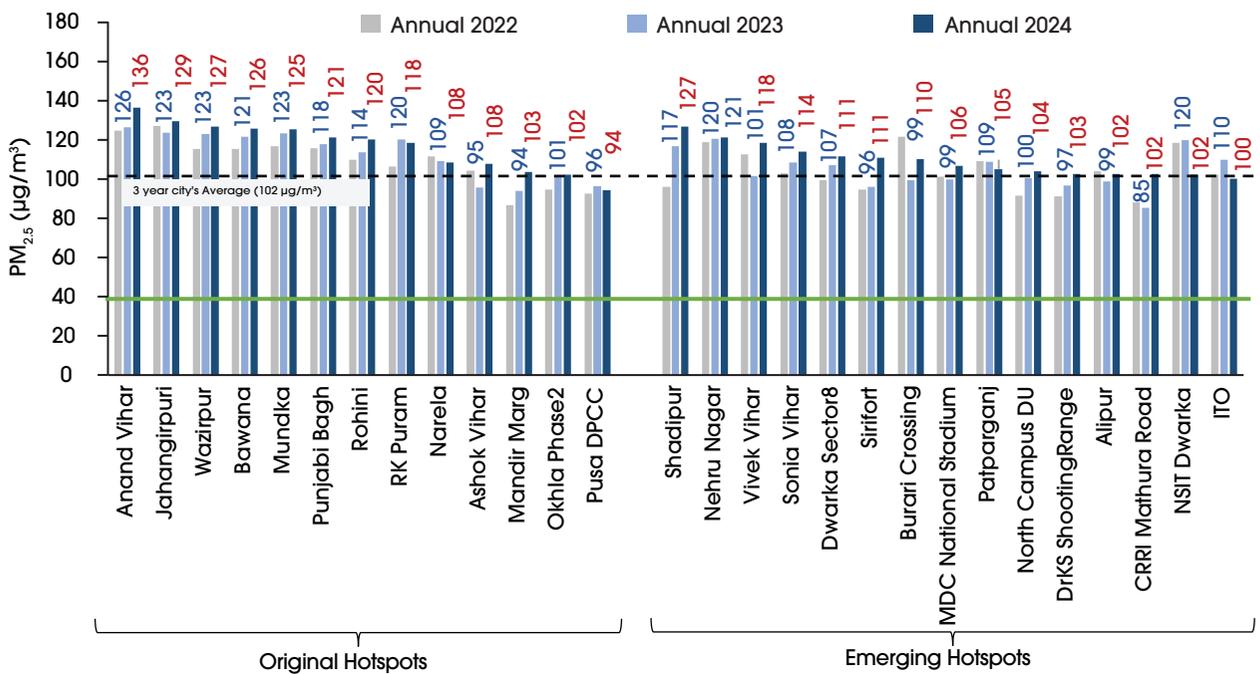
**Graph 4: Trend in PM<sub>2.5</sub> winter average and annual average**



Note: Average PM<sub>2.5</sub> concentration is based on mean of daily values recorded at the 37 CAAQM stations given it has adequate data since 2018.

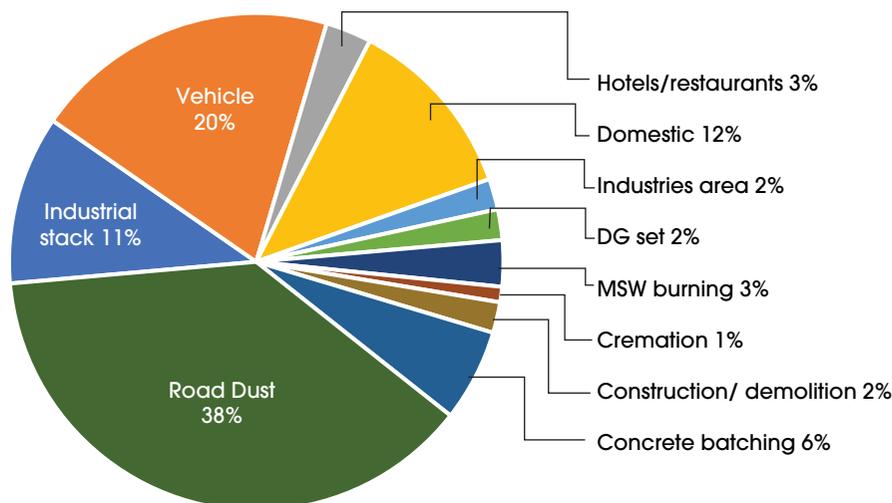
Source: CSE analysis

**Graph 5: Air quality trend in the pollution hotspots of Delhi**



Source: CSE analysis

**Graph 6: Delhi emission inventory of PM<sub>2.5</sub>**



Source: IIT Kanpur, 2015

Between 2022 and 2025, identification of hotspots has enabled local action to address widely dispersed hyper-local sources of pollution.

## **BUILDING SCIENCE FOR AIR QUALITY MANAGEMENT: ASSESSING AIR POLLUTION SOURCES**

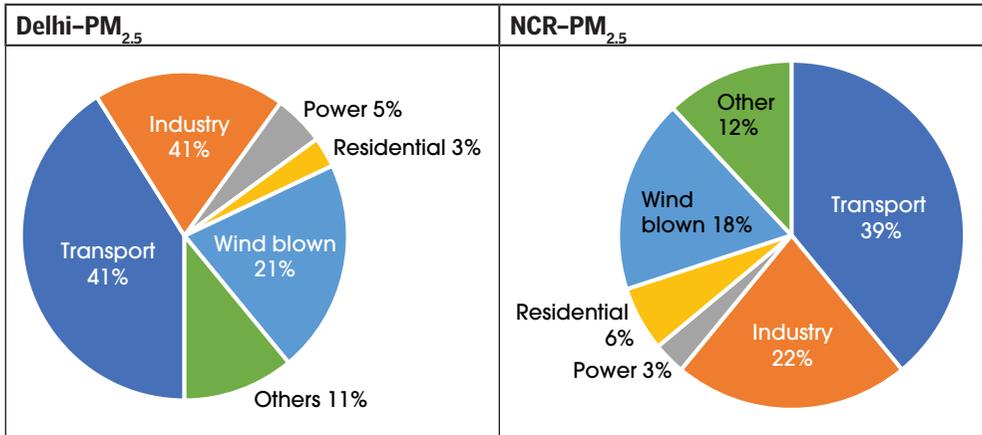
**Profiling air pollution sources and relative contribution to air quality:** Air pollution science has evolved in the city and several studies have been carried out in 2015–18 to assess the contribution of different pollution sources to ambient air pollution concentration (source apportionment) and pollution load (emissions inventory) in the city.

In 2015, a source inventory and source apportionment study was carried out by the Indian Institute of Technology (IIT), Kanpur under the aegis of the Delhi government. The study assessed 13 key pollution sources and their relative contribution to different pollutants (see *Graph 6: Delhi emission inventory of PM<sub>2.5</sub>*).<sup>1</sup>

The recent study for Delhi NCR in 2018 by SAFAR shows that the emission load from vehicles to PM<sub>2.5</sub> is 41 per cent in Delhi and 39.1 per cent in NCR (see *Graph 7: Emission inventory of PM<sub>2.5</sub> based on the 2018 SAFAR study for Delhi-NCR*). The PM<sub>2.5</sub> emission from transport sector was 25.4 per cent in 2010 which increased to 41 per cent in 2018 (an increase of 40 per cent). This could be due to overburden with four-wheeler cars. Emission inventory of NO<sub>x</sub> shows that 62.5 per cent is contributed by vehicles.<sup>2</sup>

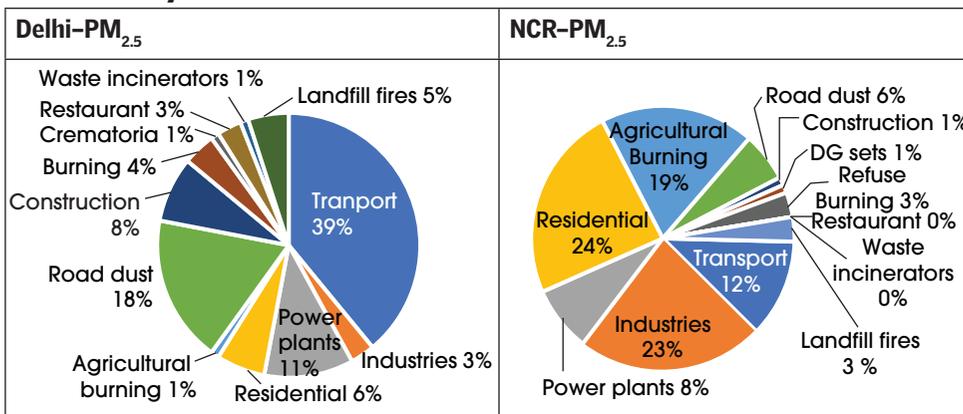
Another study by TERI-ARAI showed that transport sector contributes 38.8 per cent to PM<sub>2.5</sub> in Delhi and 12.6 per cent in NCR (see *Graph 8: Emission inventory of PM<sub>2.5</sub> based on the 2018 TERI-ARAI study*). The transport sector contributes 81.3 per cent to NO<sub>x</sub> emissions in Delhi.<sup>3</sup>

**Graph 7: Emission inventory of PM<sub>2.5</sub> based on the 2018 SAFAR study for Delhi-NCR**



Source: SAFAR, 2018

**Graph 8: Emission inventory of PM<sub>2.5</sub> based on 2018 TERI-ARAI study**



Source: ARAI and TERI, 2018

While these assessments have contributed substantially towards the decision-making process already, more updated assessments are needed to understand the changes on ground for further calibration of action. As a next step, Delhi requires new source inventory and apportionment studies for updated assessment of current profile of pollution sources to inform next-generation action.

**Understanding seasonality of pollution patterns:** Science has further deepened the understanding of the seasonality of pollution. There is also a strong seasonality in the pollution source profile. While influence of dust is very high – at 34 per cent – during summer months it can reduce drastically to 15 per cent during winter. But the relative share of combustion sources increase substantially during winter months. The share of vehicles can increase from 9–18 per cent in summer to 23–25 per cent in winter. The share

of biomass burning can increase from 12–15 per cent in summer to 22–26 per cent in winter. It may also be noted that construction sector is an important contributor to the dust sources (see *Table 2: Percentage contribution of pollution sources to PM<sub>2.5</sub> concentration in Delhi*).

**Significance of secondary pollutants:** Delhi has the evidence on the magnitude of the problem of secondary particulates that enhance the overall particulate concentration in the city. Both the studies have pointed towards high impact of secondary particulates that are formed in the air when a range of gases that come from combustion sources react with each other to form secondary particulate. Their share can increase dramatically from 15–17 per cent in summer to 26–30 per cent during winter.

These studies have helped to understand the significance of the combustion sources and their contribution to both primary and secondary pollution. But it is more important to integrate this matter in the decision making process to target the combustion sources adequately to reduce primary emissions of gases.

**Table 2: Percentage contribution of pollution sources to PM<sub>2.5</sub> concentration in Delhi**

	Summer		Winter	
	IITK 2015 (in %)	TERI-ARAI 2018 (in %)	IITK 2015 (in %)	TERI-ARAI 2018 (in %)
Secondary particulate	15	17	30	26
Vehicles	9	18	25	23
Industrial	1	11	1	10
Coal + flyash	26		5	
Biomass burning	12	15	26	22
Construction dust	3	34	2	15
Soil + road dust	27		4	
Solid waste burning	7		8	
Others		5	4	

Source: IIT Kanpur, 2015, PM<sub>2.5</sub> apportionment study, TERI-ARAI 2018: Source apportionment study

## AIR-POLLUTION FORECASTING AND EMERGENCY ACTION

**Genesis of air quality forecasting:** The Indian Institute of Tropical Meteorology (IITM) developed the ‘Air Quality Early Warning System’ (AQEWS) around 2018 to provide dynamic daily air quality forecast for Delhi-NCR. This enabled advanced decision on emergency action during periods of anticipated adverse air quality.

Further, the System of Air Quality and Weather Forecasting and Research (SAFAR) estimated the contribution of farm fires to Delhi’s air quality. By 2018–19, the SAFAR system was used to forecast air quality. The system provided location-specific information on air quality in near real-time and forecasts up to one to three days in advance. This could also assess the daily contribution of the crop fire in neighbouring states on Delhi’s air quality. The

implementation of emergency action as part of the Graded Response Action Plan (GRAP) during that period was linked with this forecast system. Subsequently, a dynamic model and meteorological forecast system was developed by the India Meteorological Department (IMD) and IITM-SAFAR in 2022. The modified system now forecasts pollution levels for the next three days. This advancement facilitates pre-emptive and preventive measures.

However, currently, GRAP is implemented with some variation now. If air quality index (AQI) forecasts do not indicate a threshold breach but extreme meteorological conditions or episodic events leading to an unexpected spike, the corresponding stage of GRAP is immediately implemented. As pollution levels are still very high with high winter average levels, the invocation of harsher measures are becoming frequent, unpredictable and more disruptive.

**Assessing regional influence on local air pollution:** It has now been possible to understand the transboundary movement of air pollution and the impact of regional pollution on the local air quality of Delhi. This had first emerged from the 2018 TERI-ARAI study that had shown that while the NCR can contribute up to 23–24 per cent of the Delhi's  $PM_{2.5}$  concentration, Delhi also contributes to the air quality of Noida downwind – as much as 28 per cent during summer and 40 per cent during winter.

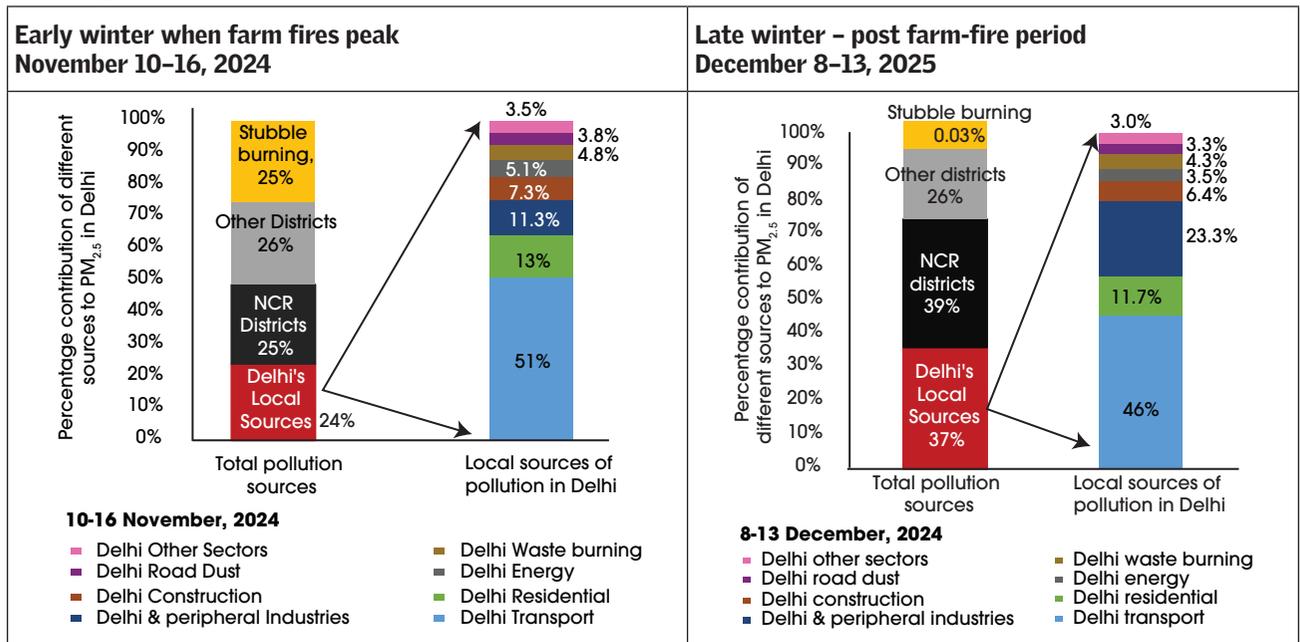
Subsequently, more dynamic assessment has become possible. The forecasting system has been further integrated with a Decision Support System (DSS) of IITM that provides both qualitative and quantitative information regarding contribution of different emission sources in the region during winter.

This provides quantitative information on contribution of emissions from Delhi's own pollution sources and that of the surrounding 19 districts in the National Capital Region (NCR), and also the contribution from biomass-burning in the neighbouring states.

This provides good insight into the changing nature of contribution of pollution sources to Delhi's air quality during winter (see *Graph 9: Dynamic forecasting in the relative contribution of pollution sources to  $PM_{2.5}$  concentration during winter in Delhi*). For instance, during the early part of the winter when farm fires peak, the share of farm fire is about a quarter, followed by NCR districts and other districts at 51 per cent and Delhi's own contribution at a quarter. But post crop burning season, the share of crop fire is less than 1 per cent, the share of NCR and other districts is 64 per cent and contribution of local pollution sources in Delhi increase further to 36.54 per cent.

According to this dynamic forecasting of IITM, among the local sources, the top concerns are vehicles, Delhi and peripheral industries, construction, waste burning and residential fuel. The share of road dust is negligible during winter. Analysis of sample data from DSS shows that a substantial amount of pollution comes from outside. But even at 30 per cent, the contribution of local sources is significant, especially when it is considered that the city needs to reduce  $PM_{2.5}$  levels by 62 per cent from a very high annual level of 105 microgram per cubic metre.

**Graph 9: Dynamic forecasting in the relative contribution of pollution sources to PM<sub>2.5</sub> concentration during winter in Delhi**



Source: CSE analysis based on data from the Decision Support System for Air Quality Management in Delhi of IITM

This science will have to be taken forward to strengthen regional airshed-level action in the larger airshed.

Data is from the Decision Support Systems (DSS) of IITM, which is part of their Air Quality Early Warning System and provides information on the potential emission sources to air quality in Delhi. This uses the online chemistry transport model Weather Research and Forecasting with Chemistry (WRF-Chem), and its modelling uses the available emissions inventory for Delhi and its surrounding 19 districts as well as the PM<sub>2.5</sub> data from the Central Pollution Control Board (CPCB) monitoring stations and satellite imaging of pollution (see *Graph 9: Dynamic forecasting in the relative contribution of pollution sources to PM<sub>2.5</sub> concentration during winter in Delhi*).

### INITIATION OF GRADED RESPONSE ACTION PLAN (GRAP)

Responding to the winter pollution crisis in 2014–16, the Supreme Court had directed the framing of a Graded Response Action Plan (GRAP) for emergency response during smog episodes in winter. GRAP was notified in January 2017 to classify action according to different grades of air quality (good, satisfactory, moderate, poor, very poor and severe) as per the National Air Quality Index (AQI) developed by the Ministry of Environment and Climate Change (MoEFCC).

The intent and the purpose of this was to ensure that when pollution is trapped and cannot disperse due to adverse atmospheric conditions, drastic temporary measures can prevent further loading of pollution. But it was also expected that the need for these

harsh temporary measures that are disruptive and adversely affect business, earnings and livelihoods will diminish as the round-the-year efforts to reduce emissions gather momentum. However, GRAP measures have continued to remain the primary focus of clean air action.

At the early stages of GRAP when there was no forecasting system, measures earmarked for severe AQI category were implemented when severe pollution levels persisted for a minimum three consecutive days. This system gradually got linked with the Air Quality Early Warning System (AQEWS) of the Indian Institute of Tropical Meteorology (IITM).

Currently, GRAP measures are connected with continuous changes in AQI levels. This needs to be modified to be informed by the forecasting system to prevent disruptive action.

The GRAP framework that has originated in Delhi has been mandated for adaptation by CPCB in clean air action plans of all non-attainment cities under the NCAP programme.

## MULTI-SECTOR ACTION

### Industry and power plants

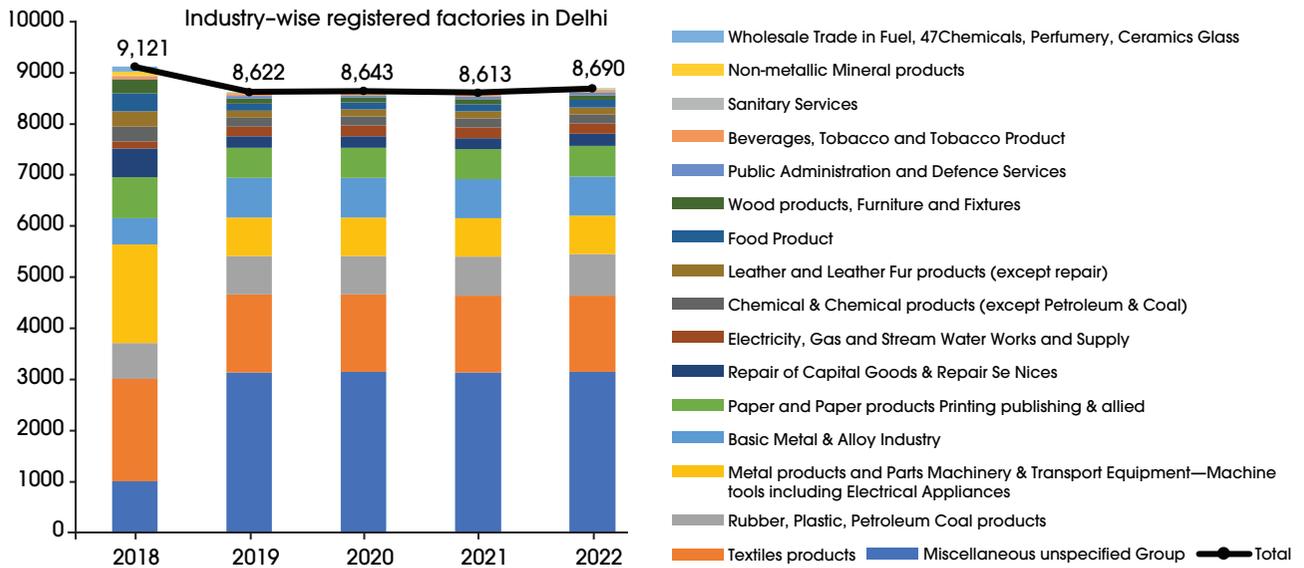
#### *Relocation of polluting industries*

The earliest effort to curb industrial pollution had started following the Supreme Court directives to shift big polluting industries out of Delhi. The Supreme Court had directed closure of 1,328 units in the hazardous category, which included hot mix plants, lead-smelting units, stone crushers, pesticides, heavy foundries, steel rolling mills, etc. Subsequently, the Delhi Pollution Control committee (DPCC) also issued closure orders to 118 more industrial units.

In fact, earlier, in 1987, the Central government issued the notification GSR 106(E) which declared the Union Territory of Delhi an “Air Pollution Control Area” under the Air (Prevention and Control of Pollution) (Union Territories) Act, 1981 Section 19 Sub-section (I) following which the Supreme Court issued a series of notifications in 1996–96 to phase out the polluting fuels from the capital region starting with the industry sector in the region. In 2000, the Supreme Court further directed closure of polluting industrial units in non-conforming/industrial areas under the supervision of Ministry of Urban Development. Based on the criteria of polluting industries, developed by this ministry and an expert committee of the government, 5,046 more units were closed down. DPCC had also identified 557 more units for closure and directed several industrial units to install pollution-control devices.

It was reported in the Delhi Economic Survey of 1990–2000 that immediately after that the ambient air pollution levels of suspended particulate matter in the industrial areas of Delhi reduced from 420 mg/m<sup>3</sup> in 1995 to 365 mg/m<sup>3</sup> in 1999 and in the residential areas it decreased from 409 mg/m<sup>3</sup> in 1995 to 351 mg/m<sup>3</sup> in 1999.<sup>4</sup> Those not meeting the various environmental norms have either closed or shifted out of Delhi to other neighbouring states.

**Graph 10: Industry-wise registered factories in Delhi as on December 31, 2022**



Source: Office of the Labour Commissioner, GNCTD, 2025

It may also be noted that this action had coincided with the introduction of unleaded petrol. Therefore as a combined effect, there was a drastic decline in the ambient air pollution levels of lead. In the industrial areas of Delhi lead levels reduced from 110 mg/m<sup>3</sup> in 1995 to 58 mg/m<sup>3</sup> in 1999 and in the residential areas it decreased from 155 mg/m<sup>3</sup> in 1995 to 46 mg/m<sup>3</sup> in 1999.<sup>5</sup>

Delhi has a number of industrial estates spread over an area of 4,647 acres. Currently the infrastructure and institutional setup is created and redeveloped through redevelopment of conforming and non-conforming industrial areas through Delhi State Industrial & Infrastructure Development Corporation Limited (DSIIDC) & Delhi Development Authority (DDA) in some of the industrial areas across the City.

There are 29 planned industrial areas and four flatted factory complexes and the state government has notified 25 non-conforming areas for redevelopment. As on December 31, 2022, there were total 393,877 MSMEs registered in Delhi. This includes 365,849 micro enterprises, 25,091 small and 2,937 medium enterprises<sup>6</sup> (see Graph 10: Industry-wise registered factories in Delhi as on December 31, 2022).

There are no major industries in Delhi and the large-scale establishments not meeting the various environmental norms by the Central Pollution Control Board and Delhi Pollution Control Committee are either closed or shifted out of Delhi to other neighbouring states.

It is evident, however, that there are about a lakh of small unorganized units and large numbers of small-scale units, including plastic recycling units, that are not in the listed

legal industrial estates but in unauthorized areas and peripheral areas that are challenging to monitor. Strategic interventions are needed to address these units.

## **CLEAN INDUSTRIAL FUELS – ENFORCEMENT OF APPROVED FUEL LIST**

One big thrust of the judicial and executive action in Delhi so far has been to push for clean fuels in the industrial sector. Several measures have been taken in this direction, the driver being the issuance of the approved fuel list.

The regulation of permissible fuels in Delhi and the National Capital Region (NCR) has undergone significant changes since the initial notification on August 27, 1996.

On August 27, 1996, the Delhi Pollution Control Committee (DPCC) issued a notification under the Air (Prevention and Control of Pollution) Act, 1981, specifying a list of approved fuels for the National Capital Territory (NCT) of Delhi.<sup>7</sup>

The approved fuels included coal with low sulphur content (less than 0.4 per cent); fuel oil, light diesel oil (LDO), low sulphur heavy stock (LSHS) with sulphur content not exceeding 18,000 parts per million (ppm); motor gasoline (petrol); diesel; liquefied petroleum gas (LPG); compressed natural gas (CNG); kerosene; naphtha (for power generation); aviation turbine fuel; firewood (restricted to domestic use in rural areas and crematoriums); and biogas. This list had originally aimed to control air pollution by limiting the use of high-sulphur fuels.

The Supreme Court directive of October 2017 to prohibit the use of furnace oil and pet coke in Delhi, Haryana, Uttar Pradesh and Rajasthan catalysed the revision of the older approved fuels list to exclude these high-pollution fuels.

On June 29, 2018, the government of National Capital Territory of Delhi issued an updated notification amending the original 1996 list.<sup>8</sup>

The revised list of approved fuels included Bharat Stage VI compliant petrol and diesel with 10 ppm sulphur; LPG; natural gas/CNG; aviation turbine fuel; firewood for crematoriums and other religious purposes; wood charcoal for tandoors and grills in hotels, restaurants, banquet halls, and eateries equipped with emission control systems; biogas; refuse-derived fuel (only for waste-to-energy plants); and any other clean fuels notified by the Government of NCT of Delhi or the Government of India.

This has virtually banned use of coal, pet coke, furnace oil, and other dirty downstream fuels and recycled fuels like tyre oil. A small concession had to be made for use of charcoal only in tandoors and grills of hotels/restaurants/banquet halls/eating houses as there was strong plea to protect certain kinds of traditional cuisine. But the notification has asked for some kind of emissions control systems.

This action in Delhi was subsequently extended to include the entire NCR to harmonise the approved fuel list. In 2022, the Commission for Air Quality Management (CAQM)

## Approved fuels in Delhi

The Delhi Pollution Control Committee published a public notice with the approved fuel list on 29 June 2018. This is a list of fuels that can be used in Delhi. Anything not on the list is banned.

- Petrol (BS VI with 10 ppm sulphur) as per the notification of Government of India as amended from time to time
- Diesel (BS VI with 10 ppm sulphur) as per the notification of Government of India as amended from time to time
- Liquid petroleum gas
- Natural gas/CNG
- Aviation turbine fuel
- Firewood for crematoriums and for other religious purposes
- Wood charcoal for tandoors and grills of hotels/restaurants/banquet halls/eating houses having emission channelization or control system
- Wood charcoal for use in ironing clothes
- Biogas
- Refuse-derived fuel (only for waste-to-energy plants)
- Any other clean fuel notified by the govt of NCT of Delhi/Govt of India subsequent to this notification

More recently in December 2022, the Commission for Air Quality Management in NCR and Adjoining Areas (CAQM) reminded all sectors including industries/industrial units to desist from using unapproved fuels including coal (except coal with low sulphur in thermal power plants) w.e.f. 01.01.2023 or face straightaway closure along with imposition of heavy Environmental Compensation (EC). The statutory directions of the Commission require complete elimination of use of coal and other unapproved fuels for various operations/ applications across all sectors (including industrial, commercial and miscellaneous applications), w.e.f. January 1, 2023 in the entire NCR.

Statutory directions have already been issued by the Commission regarding permissible fuels for industrial/ domestic/ miscellaneous applications in the NCR in terms of Direction nos. 64 dated 02.06.2022 and 65 dated 23.06.2022.

Statutory directions have already been issued by the Commission regarding permissible fuels for industrial/ domestic/ miscellaneous applications in the NCR in terms of Direction nos. 64 dated 02.06.2022 and 65 dated 23.06.2022.

**Approved fuels mentioned in the Standard List mandated by the Commission in entire NCR are as follows:**

- Petrol (BS VI with 10 ppm sulphur) as per Notification of Government of India as amended from time to time – vehicular fuel
- Diesel (BS VI with 10 ppm sulphur) as per notification of Government of India as amended from time to time – vehicular fuel
- Hydrogen/methane – vehicular and industrial purposes.
- Natural gas (CNG/PNG/LNG) – vehicular, industrial and domestic purposes
- Liquefied petroleum gas (LPG) /propane/butane – vehicular, industrial and domestic purposes
- Electricity – vehicular, industrial, commercial and domestic purposes
- Aviation turbine fuel
- Biofuels (bio-alcohols, bio-diesel, bio-gas, CBG, bio-CNG) – for industrial/ vehicular/domestic purposes as applicable.
- Refuse-derived fuel (RDF) for power plants, cement plants, waste-to-energy plants.
- Firewood/biomass briquettes for religious purposes.

As per Direction No. 65 of the Commission, fuels permissible for selective industrial applications in NCR, only beyond the jurisdiction of NCTD, are as follows:

- Biomass/ agriculture refuse and pellets/ briquettes – for industrial boilers, power plants, biofuel projects, cement industry, waste to energy plants, etc.
- Biomass pellets/ briquettes – for tandoors and grills of hotels/ restaurants/ banquet halls (along with mandatory emission channelization/ control system) and for open eateries/ dhabas.
- Metallurgical coke – for industrial purposes in standalone cupola-based foundries.
- Low-sulphur fuels, namely LSHS, very low sulphur fuel oil and ultra-low sulphur fuel oil – for industrial purposes in metal smelting/melting/ refining/ heating furnaces and kilns

The Flying Squad of the CAQM are under instructions to conduct incognito visits to ensure compliance of Directions regarding use of approved fuels in the entire NCR. Violations and non-compliance of the directions issued by the Commission including use of unapproved fuels will straight away lead to closure apart from imposing Environmental Compensation (EC) and initiating prosecution action against the defaulters flouting the statutory directions.

issued a standardised approved fuel list in June 2022 for the NCR.<sup>9</sup> This additionally included hydrogen/methane and electricity. By 2023, out of 7,759 fuel-based industries in the NCR, 7,449 had transitioned to approved fuels, with the remaining 310 industries facing closure for non-compliance.<sup>10</sup>

Currently, coal is banned in entire NCR (except coal with low sulphur in thermal power plants) and use of unapproved fuels can lead to closure along with imposition of heavy Environmental Compensation (EC) w.e.f. January 1, 2023.

## **ELIMINATION OF POLLUTING INDUSTRY FUELS**

Around the time when the approved fuel list was revised, in a landmark intervention against industrial pollution, the Supreme Court of India responding to the recommendations of EPCA, curbed the use of highly polluting petcoke and furnace oil. An investigation by the Centre for Science and Environment (CSE) had revealed alarmingly high sulphur content in these fuels – 74,000 ppm in petcoke and 24,000 ppm in furnace oil – both widely used in industries without emissions control systems. The court issued a far-reaching directive on October 24, 2017, banning the use of petcoke and furnace oil as industrial fuels for combustion in Delhi, Haryana, Rajasthan, and Uttar Pradesh. However, exemptions were granted to four specific end-user industries: cement, calcium carbide, lime kilns, and gasification who used petcoke as feedstock.

The ruling ignited further legal debates, with aluminium producers, calciners, and iron and steel manufacturers petitioning the court for permission to import petcoke. The matter remains under judicial review. Meanwhile, on November 17, 2017, the Supreme Court urged all Indian states to implement similar bans on these high-sulphur fuels.

The impact of these directives extended beyond domestic regulations. A decision was formalised to prohibit the import of petcoke into India, through a notification by the Director General of Foreign Trade on August 24, 2018. Additionally, the Ministry of

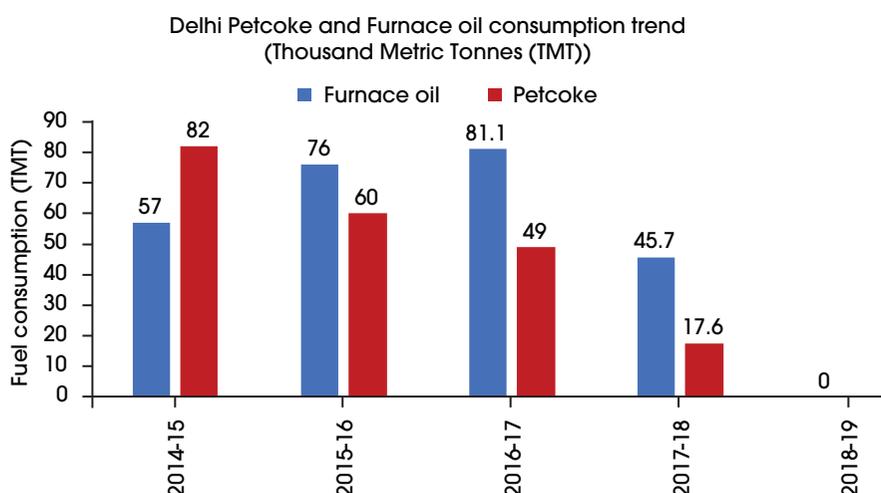
Environment, Forest and Climate Change (MoEFCC) initiated measures to restrict domestic use of petcoke to align with World Trade Organization (WTO) guidelines on keeping domestic policies aligned with the trade or import policy.

The Supreme Court's intervention on use of high sulphur fuels also exposed a significant regulatory gap – most industries in India lacked standards for sulphur oxides (SO<sub>x</sub>) and nitrogen oxides (NO<sub>x</sub>) emissions. This raised serious concerns about the impact of sulphur-rich fuels on air quality, particularly their contribution to sulphur dioxide (SO<sub>2</sub>) emissions and secondary particulate pollution. Recognizing the urgency of the issue, the Supreme Court issued another directive on December 31, 2017, mandating SO<sub>x</sub> and NO<sub>x</sub> emission standards for 34 industrial sectors nationwide. In response, the MoEFCC introduced the country's first-ever SO<sub>x</sub> and NO<sub>x</sub> regulations for 16 industrial sectors, marking a significant policy shift towards pollution control. However, challenges remain in ensuring enforcement, as State Pollution Control Boards (SPCBs) currently face capacity constraints in monitoring compliance with these new standards.

Since 2018–19, as per the data from the Ministry of Petroleum and Natural Gas (MoPNG) Delhi has reported zero consumption of both furnace oil and petcoke. The consumption of petcoke gradually reduced from 82,000 tonnes in 2014–15 to around 18,000 tonnes in 2017–18 and zero since 2018–19 (see *Graph 11: Delhi petcoke and furnace oil consumption trend (2014–18)*).

However, it is unclear if these fuels are discontinued in the unauthorised areas and in the small-scale units.

### Graph 11: Delhi petcoke and furnace oil consumption trend (2014–18)



Source: MoPNG

## MASSIVE EXPANSION OF PIPED NATURAL GAS (PNG) IN INDUSTRIAL AREAS

Before the approved fuels list, there was stiff competition from alternative fuels prices such as furnace oil (FO)/diesel, which had come down drastically due to lower crude prices. The crude oil prices continued its downward trend, recovering only after touching a low of US \$26/barrel in February 2016. This led to a growing competition from alternative fuels in commercial and industrial segments of the city.

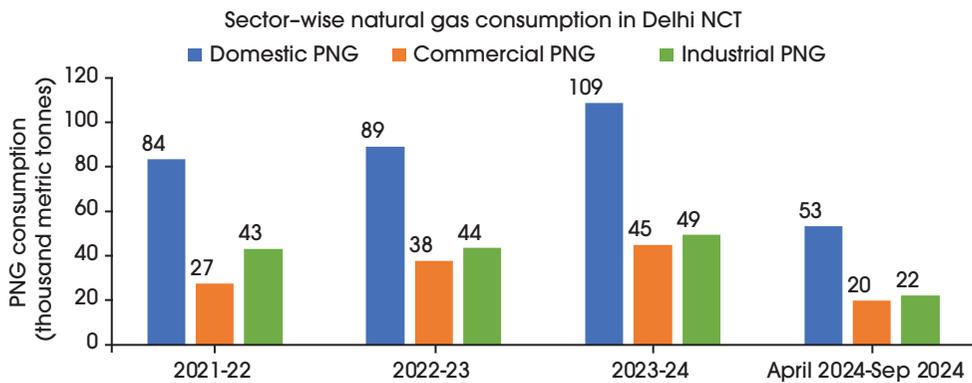
However, the government’s decision to place City Gas Distribution (CGD) companies on the priority list for allocation of low-cost domestic gas for transport and PNG-domestic was a game changer. This gave an advantage to the CGD companies in competition with alternative fuels and also increased the preference for CNG vehicles.

Moreover, Delhi Pollution Control Committee (DPCC) has banned all other industrial fuels except PNG and has advised all industrial customers (wherever PNG is available) to switchover to PNG. Indraprastha Gas Limited (IGL), the authorized CGD entity in Delhi has efficiently coordinated to implement the mandate.

Correspondingly, the PNG consumption in Delhi’s industry sector increased by 14 per cent between 2021-22 and 2023-24, increasing from 43,000 tonnes in 2021-22 to 49,000 tonnes in 2023-24, while in the commercial sector it increased by 67 per cent (see *Graph 12: Consumption trend for PNG in Delhi*).

Commercial PNG primarily serves industries like hotels, restaurants, shopping malls, hospitals, bakeries, small dairies, educational institutions, canteens and small-scale manufacturing units where large volumes of cooking, heating and power generation are needed.

**Graph 12: Consumption trend for PNG in Delhi**



Note: Data for 2024 is limited to six months

Source: MoPNG

**Captive power generation and diesel generator sets:** The additional challenge of pollution from use of captive use of diesel generator sets in the industry sector was addressed by the moving diesel genset segment to PNG. In 2023, CAQM directed switching over of DG sets to PNG and dual fuel (PNG and diesel) mode in Delhi and NCR.<sup>11</sup> IGL's PNG network is widely available among various Industrial and commercial clusters of Delhi with a focused approach to further expand/strengthen pipeline network by providing last-mile connectivity to the industrial and commercial establishments in existing areas where pipeline grid is available and expanded pipeline network can cater to other industrial areas. This has also been extended to residential areas.

In industrial and commercial segment 2,967 new registrations were completed during the FY 2023-24 and pipeline laying was started in new areas Chandni Chowk and Paharganj in Delhi.

IGL is also working in a collaborative and participatory approach with the state Pollution Control Boards, so as to work out an action plan to convert all industrial and commercial units to PNG (wherever IGL's PNG network is available).

According to Delhi's Economic Survey 2023-24, 1,866 industries were converted to PNG/ approved fuel and use of unapproved fuels to check industrial emissions.

During the last decade significant action has been taken to accelerate energy transition in the industry sector to eliminate dirty fuels, including coal, furnace oil and petcoke. The next steps need to target unregulated industries in non-conforming areas and peripheral areas.

## **CLOSURE OF THERMAL-BASED POWER PLANTS**

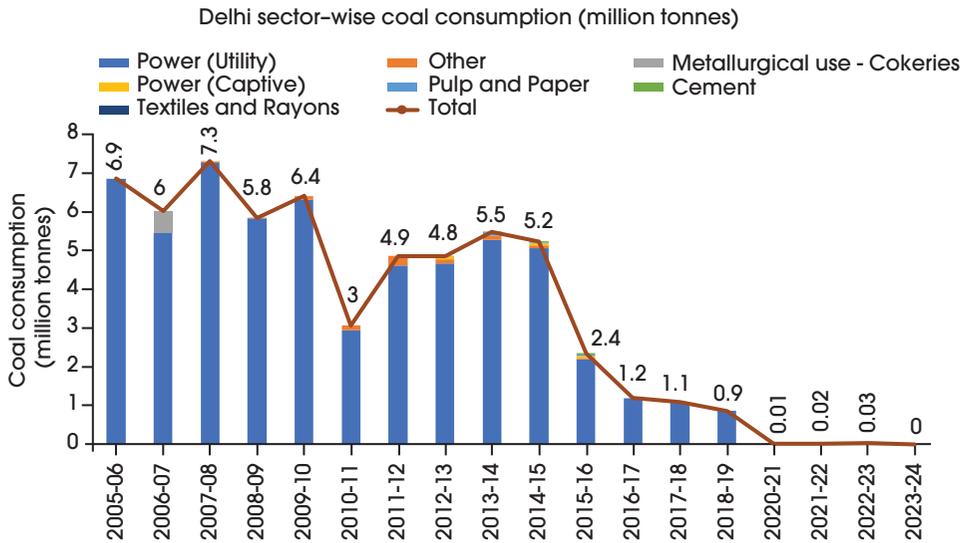
Over the years, Delhi has witnessed a drastic decline in coal consumption and this has been largely determined by the permanent closer of the three coal-based power plants in Delhi. The Indraprastha power plant was closed in 2009, the Rajghat plant closed in 2015 and, finally, the Badarpur plant was closed in 2018 as part of measures to control air pollution.

Currently, there are six gas turbine units that run on natural gas to generate electricity in Delhi. The installed capacity of this station is 282 MW. This action has enabled massive reduction in coal consumption in the city.

According to the data available from the Coal Controller's Organization, Ministry of Coal, there has been dramatic decline in coal consumption in Delhi. Its use has now been virtually eliminated (see *Graph 13: Consumption trend for coal in Delhi (2006-24)*).

This is the impact of implementation of closure of coal power plants and implementation of the revised approved fuel list of the Delhi government in the city. The impact of these measures are reflected in Delhi's coal consumption trends. Coal consumption has decreased significantly and in 2024 there is virtually no coal consumption reported in Delhi.

**Graph 13: Consumption trend for coal in Delhi (2006–24)**



Source: Coal Controller’s Organization, Ministry of Coal

## INDUSTRY AND POWER SECTOR – THE NEW AGENDA

### Addressing industrial units in non-conforming and peripheral areas

While substantial energy transition has been achieved in the legal industrial areas of Delhi, there are challenges of industrial units, largely small and medium scale in non-conforming areas. The energy mix and process description of these units is still undocumented and unaccounted for and further investigation is required to enable affordable energy transition in these areas.

Implementation of the approved fuel list has remained challenging in unauthorized areas and in small-scale units. Delhi will have to make the mechanism for intercepting entry of dirty fuels and stopping their illegal use much stronger. This requires a thorough profiling and inventorisation of the air-polluting industries in the informal and non-confirming areas. The fact that their contribution still shows up as the second- or the third-highest contributor to air pollution during winter in the dynamic assessment of hourly changes in source contribution by the Indian Institute of Tropical Meteorology (IITM) requires immediate attention.

The basic requirement is to bring these units into the monitoring network by clarifying who owns it and to mandate them to display the consent to operate the certificate from the DPCC. Once in the monitoring network, they must adhere to authorised fuel and basic pollution-control norms.

### ADDRESSING BURNING OF NON-HAZARDOUS INDUSTRIAL WASTE

In 2018 a field investigation by EPCA in Nagloi, Mundka, Tikri, Kamrudin Nagar, Ranshola, Hiran Kudana, Baprola and Bahadurgarh revealed the problem of illegal dumping and

burning of plastic and rubber waste on agricultural lands in Tikri, Ghavera and Mundka, contributing significantly to local air pollution. The unorganised plastic market and dumping of municipal solid waste in Nangloi were identified as major pollution sources.

This led to the direction to the DPCC to close, penalise and ensure compliance that no waste would be burnt and the waste would be taken for safe incineration. Some pilot efforts were made to tie up with the incineration industry to collect the waste for disposal.

This matter will require continuous monitoring and vigilance and the requisite infrastructure to eradicate the problem of industrial waste burning. All industrial zones require an inventory of industrial waste generation. DPCC along with the industries and industry association need to develop industrial zone-wise waste management plan for safe disposal and ensure development of the requisite infrastructure for targeted recycling or safe disposal.

## **IMPROVE POWER CONSUMPTION MIX TO INCREASE SHARE OF CLEAN ELECTRICITY**

Even though coal-based power generation in Delhi has been phased out, Delhi's increasing electricity demands are still met predominantly by coal-based power sourced from outside the city. Delhi currently has four main electricity distribution companies (DISCOMs): BRPL (BSES Rajdhani Power Limited), BYPL (BSES Yamuna Power Limited), TPDDL (Tata Power Delhi Distribution Limited) and NDMC (New Delhi Municipal Corporation), which purchase electricity from various power generators to meet the city's electricity demands (see *Graph 14: Source-wise power purchase in Delhi*).

It is however important to note that the share of RES and hydro-based power in the consumption mix is steadily increasing, which is an encouraging trend. This requires the stated policy to accelerate sourcing of renewable energy and increase its share in the grid in a time-bound manner. This is needed to reduce pollution impact of the growing energy needs in Delhi in the larger airshed.

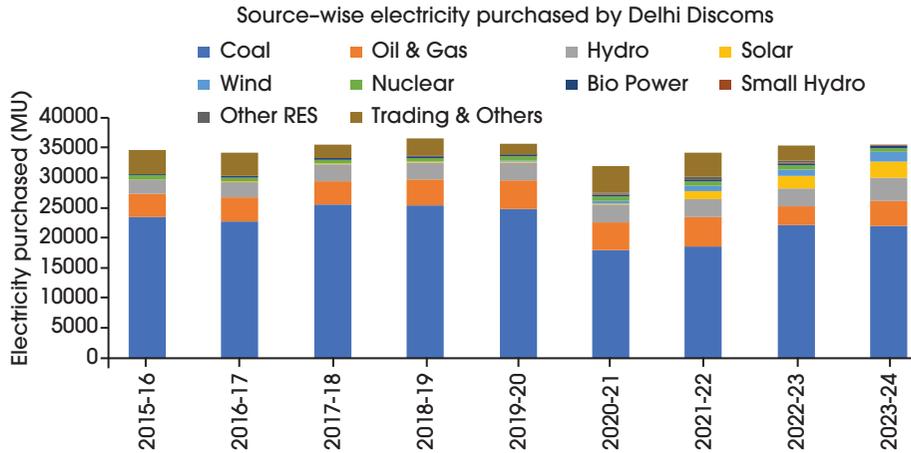
## **CURBING VEHICULAR EMISSIONS**

While the year-long comprehensive emissions inventory and source apportionment studies in Delhi show that vehicles are among the top two pollution sources, IITM's dynamic estimates of hourly changes in source contribution during winter show that vehicles are the top contributors among the local sources of pollution in Delhi. This is also responsible for very high toxic exposures.

Currently, the transport sector of Delhi is the highest contributor to Delhi's local pollution. Since 2001-02, over 1.135 crore vehicles have been registered in Delhi. Since 2015-16, the yearly registration has been 600,000-715,000 vehicles per year, with a drastic dip during the COVID years due to the strict restriction levied nationally (see *Graph 15: Vehicle registration trend in Delhi*).

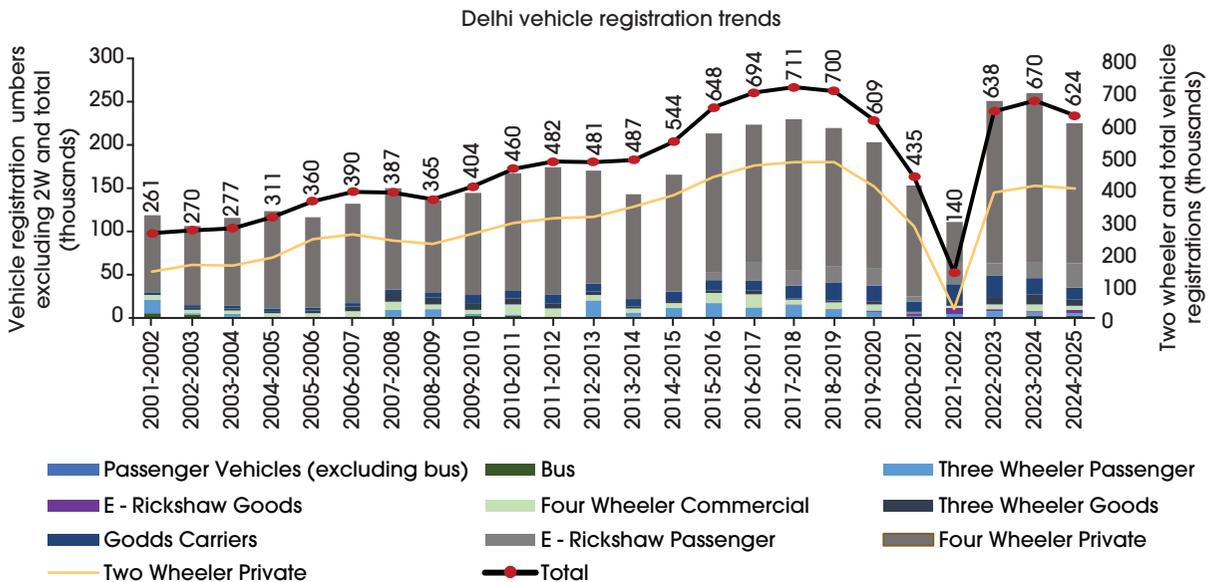
Owing to the quantum of vehicles added on the roads of Delhi, Delhi government had taken some of the most aggressive measures to improve the emission levels of the vehicles.

**Graph 14: Source-wise power purchase in Delhi**



Source: CEA

**Graph 15: Vehicle registration trend in Delhi**



Source: VAHAN database

**THE LEAPFROG - ADVANCEMENT IN EMISSIONS STANDARDS**

When clean air advocacy had started in the 1990s there was virtually no mass emissions standards for new vehicles in the country. During late 1990s, when rapid increase in the number of diesel cars was noted and the entire public transport and commercial transport were running on diesel, CSE’s global review of evidence showed that the advanced countries were either cleaning up diesel rapidly or discouraging its use. Diesel emissions were considered one of the strongest carcinogens and high polluters.

When this matter was taken up in the Court by EPCA, the Supreme Court directed enforcement of Bharat Stage I emissions standards in March 1999 and subsequently Bharat Stage II in March 2000. This pushed the automobile industry to leapfrog within a short time span. As a result of this intervention in Delhi, other mega and capital cities also benefitted. Since then Delhi has always stayed ahead of other regions and introduced in advance the Bharat Stage III in 2005, Bharat Stage IV in 2010 and finally Bharat Stage VI (BS VI) for vehicles in 2020.

The submission from oil companies and the Ministry of Petroleum and Natural Gas (MoPNG) to the Supreme Court committing to the nation-wide introduction of 10 ppm sulphur fuels by 2020 had enabled the decision to introduce BS VI-compliant vehicles nation-wide from 2020 onwards. In January 2016, the Government of India had decided to skip BS V emission norms altogether and leapfrog directly to BS VI norms by April 2020. The 2017 notification asked for nation-wide introduction of BS VI emissions standards from April 1, 2020.

This also meant a dramatic improvement in the fuel quality. In 1998 the sulphur content in diesel fuel was 2,500 ppm; this has now reduced to 10 ppm, a 250 times reduction. Before BS VI-compliant fuels were introduced nation-wide in 2020, Delhi took the lead to become the first city in the country to switch to BS VI fuel (10 parts per million sulphur diesel) from April 1, 2018, two years ahead of the national schedule. This enabled the introduction of advanced emissions control systems in vehicles.

This leapfrog, like in the rest of the country, helped to reduce particulate emissions in new BS VI diesel cars by 91 per cent and in BS VI heavy duty vehicles by 94 per cent compared to BS III vehicles that were introduced in 2005. Similarly, nitrogen oxide levels in diesel heavy duty vehicles reduced by 91 per cent. The BS VI norms spearheaded adoption of more advanced diesel emissions control systems. These include advanced particulate filters to control particulate emissions and lean NOx traps, selective catalytic reducing system, and exhaust gas recirculation systems for NOx emissions control.

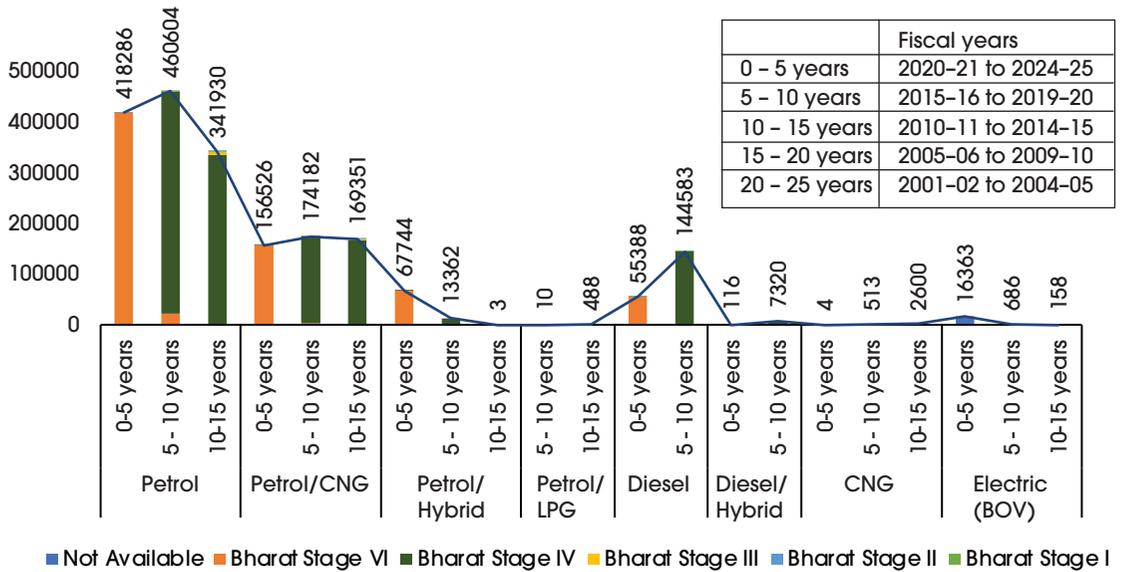
## **MASSIVE FLEET RENEWAL**

The adoption of cleaner technology by Delhi's fleet is evident through its registration trends. In the last five years (2020–25), all the new private four-wheelers, two-wheelers, buses and goods carriers registered were predominantly BS VI. Pre-2010 vehicles including BSI, BSII and BSIII are nearly fully gone. The current fleet is dominated by the BS IV vehicles and a growing number of BS VI vehicles (see *Graph 16: Age-wise, fuel-norm-wise and fuel-wise registration of private four-wheelers in Delhi and Graph 17: Age-wise, fuel-norm-wise and fuel-wise registration of goods carriers in Delhi and Graph 18: Age-wise, fuel-norm-wise and fuel-wise registration of two-wheelers in Delhi*). The fleet renewal based on tighter standards has reduced tailpipe emissions substantially in Delhi.

## **RESTRAINING DIESEL VEHICLES AND DIESEL FUEL CONSUMPTION**

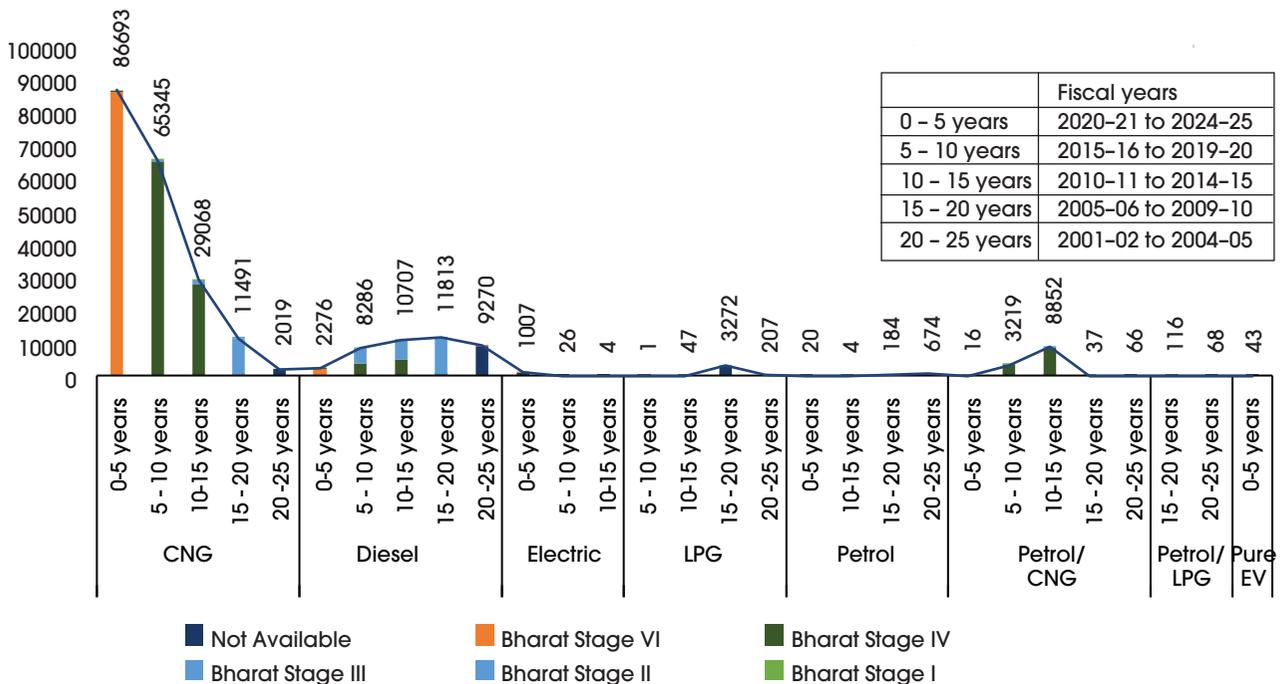
One of the key strategies for energy transition in the transport sector has been to reduce dieselisation of the vehicle segment and high speed diesel consumption in vehicles. This

**Graph 16: Age-wise, fuel-norm-wise and fuel-wise registration of private four-wheelers in Delhi**



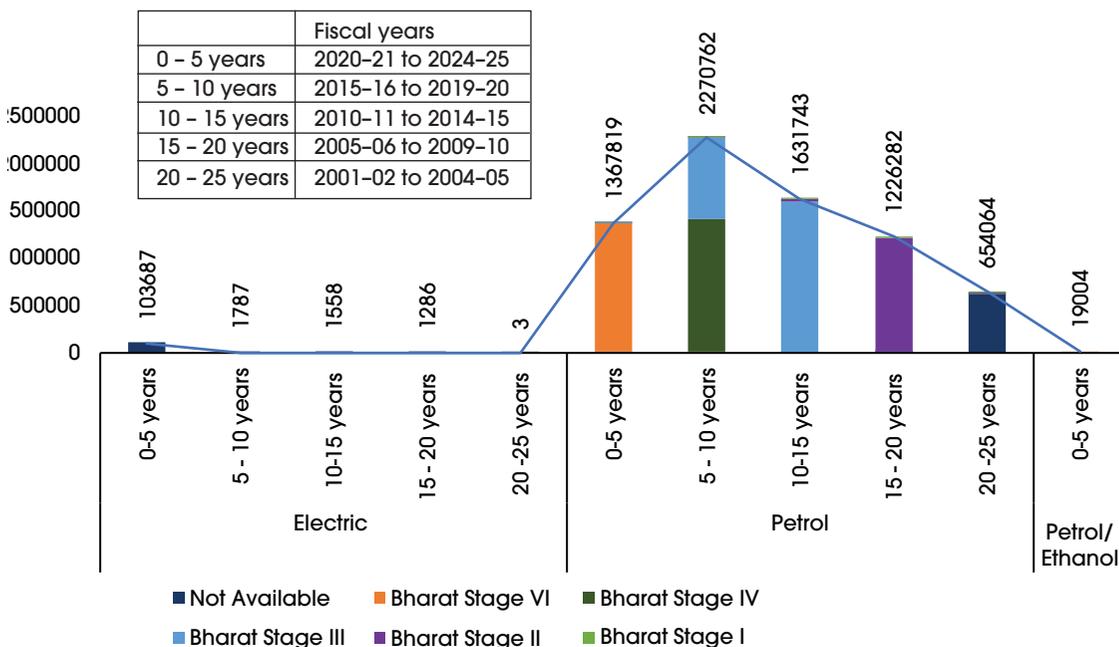
Source: VAHAN database

**Graph 17: Age-wise, fuel-norm-wise and fuel-wise registration of goods carriers in Delhi**



Source: VAHAN database

**Graph 18: Age-wise, fuel-norm-wise and fuel-wise registration of two-wheelers in Delhi**



Source: VAHAN database

has led to targeted measures over time to disincentivise diesel vehicles, restrict operation of diesel buses and diesel-operated heavy-duty trucks, disincentivise diesel cars and other commercial vehicles, as well as transport diesel consumption.

### TRANSITION TO CNG TO CURB DIESELISATION OF VEHICLES

During 1998, when EPCA's deliberations with the state and central government departments brought out that it would not be possible to introduce Bharat Stage II emissions standards requiring 500 ppm sulphur diesel to align with the Euro II standards in force in Europe, a consensus decision was taken to recommend to the Supreme Court that compressed natural gas (CNG) be introduced for vehicles in the city.

In response, the Supreme Court in 1998 directed moving public transport stage carriage buses to CNG, increase the bus fleet to 10,000, replace pre-1990 autos and taxis with new vehicles using clean fuel, and set up 80 CNG stations by 2001. To counter opposition to the move from the automobile industry, bus operators and other detractors, the Supreme Court in 2001 deemed diesel bus operations as violation of court order and imposed penalty of Rs 1,000 per bus per day to be deposited in the Court itself. This led to the full establishment of the CNG bus programme in the city.

During the successive years, this programme was further expanded to include other local commercial vehicles. CNG also gained popularity in private cars as CNG prices were cheaper than diesel fuel. This also provided substantial emissions gains.

Due to combined and consistent action on diesel vehicles during the last two decades including advancement in emissions standards, CNG transition, environment cess on diesel fuel, big diesel cars and trucks and phase-out of 10-year-old diesel vehicles, have led to significant renewal of vehicle fleet and massive decline in the share of diesel vehicles in new vehicle sales.

Diesel car registrations had peaked in 2013–14, when it was as much as 41.36 per cent of all car registration in the capital. Since then the share of diesel cars has declined drastically and currently accounts for 5.87 per cent in 2023–24.

Moreover, with a massive CNG transition, a great part of the local commercial vehicles have also moved out of diesel. According to the Vahan database, the share of diesel commercial vehicles in the total commercial vehicle registration that was as much as 36 per cent in 2013–14 (when CNG transition was already underway) has now reduced to 4 per cent in 2023–24.

The overall reduction in diesel vehicles has reduced direct toxic diesel emissions drastically.

## RESTRAINING DIESEL TRUCKS

The contribution of the heavy-duty diesel vehicles have been found to be significantly high in Delhi. According to the 2015 emissions inventory study of the IIT Kanpur, these vehicles contributed as much as 46 per cent of the total particulate load from vehicles in the city.

**Since 2001, a series of directives from the Hon'ble Supreme Court have set a roadmap for addressing diesel emissions from heavy duty trucks in Delhi, which include:**

- 6.12.2001 and 16.12.2015 directives banning entry of non-destined commercial traffic from entry into Delhi.
- 1.2.2005, 11.3.2005, 1.8.2005 directives to build the Western and Eastern Peripheral Expressway to provide alternative routes to trucks.
- 9.10.2015 directive imposing environment compensation charge (ECC) on all commercial light-duty vehicles and trucks entering Delhi.
- 16.12.2015 directive banning entry of vehicles registered in 2005 or earlier.
- 5.1.2016 directive on weigh in motion bridges and machines at the entry points of Delhi to check overloading.
- 22.8.2016 directive to SDMC to set up RFID based collection system at 13 entry points that cover 80 per cent of the commercial traffic.

As part of the Graded Response Action Plan, emergency restrictions on trucks are imposed during smog episodes in winter. As a combined impact of all these measures the real time data on truck entry monitored by SDMC has shown substantial reduction in truck numbers in Delhi.

Currently out of 124 entry points into Delhi, handheld RFID technology for cashless collection of ECC and toll tax has been introduced at all locations, including 13 border points being equipped with fully automated RFID systems. The CAQM directive of November 9, 2021 had asked SDMC to install automated infrastructure at additional

10 entry points – Noida Major, Loni Main, Dhansa border, Kundli II, New Seemapuri, Bajghera, New Kondli, Chander Nagar, Jharoda and Pul Prahladpur. Though handheld RFID is available at these locations, these are not as efficient and lead to congestion and pollution.

The cordoning of Delhi for regulated entry of trucks and payment of ECC is a step towards treating Delhi as a low-emissions zone. As the trucks largely operate under national permit, there are limited strategies available at the state level other than regulating their entry and overloading and rationalising logistical centres for trade. This segment requires attention.

In addition to the local regulations of truck entry and intra-city movement, the ongoing initiative of expanding highway-based CNG/LNG refuelling systems and charging infrastructure for electric vehicles needs to be accelerated to encourage shifting a substantial segment of long-haul trucking and other commercial vehicles to gas and electricity over the next five years.

## **IMPOSITION OF ENVIRONMENT COMPENSATION CHARGE ON TRUCKS**

In 2015, the EPCA-CSE survey using round-the-clock monitoring video recording at fixed spots near selected entry points between June 29 and July 18, 2015 showed that a massive number of non-destined commercial vehicles were entering and leaving Delhi and criss-crossing the length of the city. It also came out that passing through Delhi was cheaper as the municipal toll to enter Delhi was lower than the toll rates on the alternative routes.

In response, on October 9, 2015, the Supreme Court imposed the Environment Compensation Charge (ECC) on daily entry of commercial goods vehicles entering Delhi. The Court fixed differential rates for vehicles that were empty/laden with goods, and also permitted exemptions for vehicles carrying “essential” goods.

To ensure efficient implementation and prevent malpractices in manual collection of ECC, on August 10, 2016, and in response to the EPCA recommendations, the Supreme Court directed installation of Radio Frequency Identification (RFID) for effective and credible ECC collection. Each vehicle seeking to enter Delhi would have to pay online or make deposits at issuing points; vehicles would be pre-registered and this would allow for pre-2006 registered vehicles to be barred entry. It would also ensure that vehicles entry is tracked for destination. Thirteen key entry points which bring around 80 per cent of the truck traffic were identified to install RFID. EPCA had recommended implementation of RFID project for an additional 111 entry points.

Another follow-up survey by CSE in 2016 showed a decrease in truck traffic after the introduction of the system leading to reduction of as much as 30–35 per cent in PM and NO<sub>x</sub> levels in this vehicle category.

Subsequently, ECC collection has been expanded to 124 entry points by CAQM. But this is done by a handheld system. The RFID collection system is yet to be expanded.

There is no official data on the total amount collected from the ECC. According to media reports, however, until December 2021, about Rs 1298.38 crore has been collected. This would have multiplied significantly by now and is available for pollution control in the city.

## **PHASE-OUT OF OLD VEHICLES AND SCRAPPAGE OF END-OF-LIFE VEHICLES**

A series of directives from the Hon'ble Supreme Court and the NGT have regulated the age of vehicles in Delhi. The NGT order of April 2015 has banned diesel vehicles older than 10 years and petrol vehicles older than 15 years in Delhi-NCR.

To maximise the emissions gains from this strategy and to reduce environmental impact from the unsafe disposal of junk vehicles, the state governments may additionally implement state-level scrappage policy for the end-of-life vehicles that cannot be used any more. The directives implemented so far in this direction are as follows:

- The Government of NCT of Delhi issued guidelines dated 20/02/2024 for impounding/seizure/scrapping/release (with certain conditions and penalty) of end of life vehicles in public places to improve the air quality of the national capital. As per the guidelines, a penalty of Rs 10,000 for four-wheelers and Rs 5,000 for two-wheelers have been stipulated for owners of impounded vehicles before being released.
- Commission for Air Quality Management vide letter dated 25/05/2023 directed that appropriate action may be initiated against all End-of-Life Vehicles/ overaged vehicles either plying on roads or parked in public places in the NCT of Delhi.
- The Ministry of Road Transport and Highways on 15 March 2021 has issued G.S.R. 653(E) regarding the Motor Vehicles (Registration and Functions of Vehicle Scrapping Facility) Rules, 2021, dated 23-09-2021.
- G.S.R 220(E) regarding Concession in Motor Vehicle Taxes against submission of Certificate of Vehicle Scrapping, dated 26-03-2021.
- Sec 59 of the CMV(A) Act, 2019 that provides for fixing age and restricting plying of unfit vehicles.
- AIS 129 that defines the standards for manufacturers on reuse, recycling and material recovery from vehicles.

As of March 2023, over 5 million vehicles were deregistered in Delhi. Of the 5,338,045 vehicles deregistered, 4,698,391 were petrol-run, 415,362 had diesel engines, and 41,311 ran on CNG. There are concerns that these might still be operating. To address this, the Transport Department has now installed cameras in petrol pumps to introduce the programme of “No fuel to deregistered vehicles”. Delhi government has also set up a vehicle scrappage centre for end-of-life vehicles and adopted a scrappage policy. But screening of vehicles to identify end-of-life vehicles is still weak. Thus the programme is unable to scale.

Due to advancement in emissions standards and quicker fleet renewal, fleet renewal has been quicker and there is already a sizeable shift to cleaner technologies. Analysis of vehicle fleet by age and by their status of emission standards show that BSI, BSII and BSIII – all pre-2010 vehicles – are nearly fully gone. The fleet is now dominated by the

BSIV vehicles and the growing number of BSVI vehicles. Due to unadjusted VAHAN database registration of a few old vehicles – older than 15 years – are still showing up.

But as per the order of the National Green Tribunal (NGT), more than 10-year-old diesel vehicles and 15-year-old petrol vehicles are not legally allowed in Delhi. The two-wheeler fleet has also shown significant shift to cleaner technologies.

In both private and commercial vehicles, the share of older vehicles has dropped significantly. Most of the vehicles are in the five-to-10-years age bracket while the number of vehicles below five years is also growing. Even though petrol and diesel vehicles older than 15 years and 10 years respectively are showing up in VAHAN database, technically and legally these vehicles are not permitted to ply anymore.

However, even though large number of vehicles have been deregistered it is said that enforcement is not that stringent and these vehicles might still be running in the city.

**Old interstate buses:** In 2023, the CAQM has banned entry of pre-BSIV interstate buses to Delhi. Its enforcement is being monitored with the help of cameras in interstate bus terminus. The non-compliant buses are turned back (see *Graph 19: Age-wise, fuel-norm-wise and fuel-wise registration of buses in Delhi*)

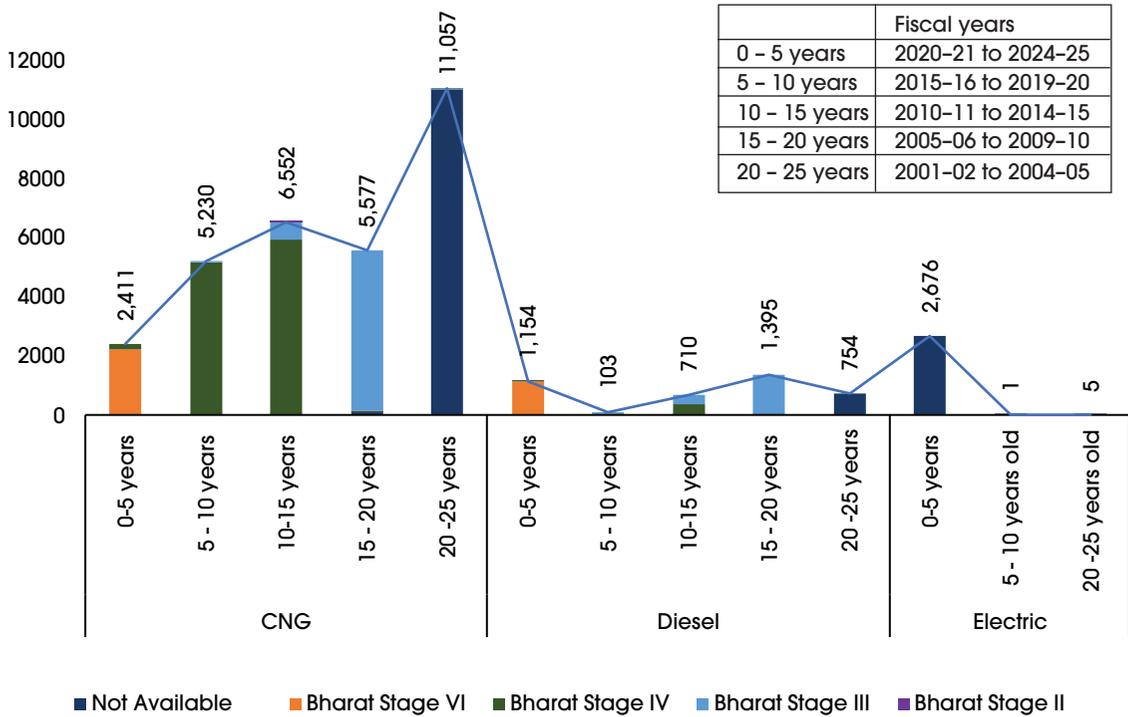
## **DISINCENTIVISING DIESEL FUEL AND VEHICLES WITH POLLUTION CESS**

Toxic potential of diesel emissions was well recognized and the polluter pay principle was accepted by the Supreme Court and the city government.

**Air ambience cess on diesel fuel:** The Environment Department of the Government National Capital Territory of Delhi created the Air Ambience Fund in 2008 by levying 25 paise cess on per litre diesel sale. This was imposed under the Air Act, 1982. A part of this fund has now been shifted to the Transport Department to fund the electric vehicle programme. It is interesting that during the time of peak dieselisation years of 2015–17, the annual collection from this cess was around Rs 61.85–56.62 crore. With lower diesel consumption now, the collection has reduce to Rs 36 crore.

**Environment pollution charge on big diesel cars and SUVs:** The Supreme Court order in December 2015 had directed imposition of environment pollution charge of 1 per cent of the price of the cars and SUVs with 2000 cc engines and above in Delhi and NCR. This is collected at the time of the purchase. These measures have helped to create dedicated funds. Despite strong opposition from the automobile industry, the apex court had imposed environment pollution charge on purchase of SUVs and diesel cars with more than 2000 cc engines. The revenue from this cess goes to the Central Pollution Control Board for pollution control measures and air-pollution-assessment studies. The amount collected from this source across NCR is still big, amounting to Rs 401.06 crore as in 2024, despite the reduction in diesel car registration in Delhi. This fund is being largely spent on research studies, technology trials, pellet plants, central control room, awareness activities etc.

**Graph 19: Age-wise, fuel-norm-wise and fuel-wise registration of buses in Delhi**



Source: VAHAN database

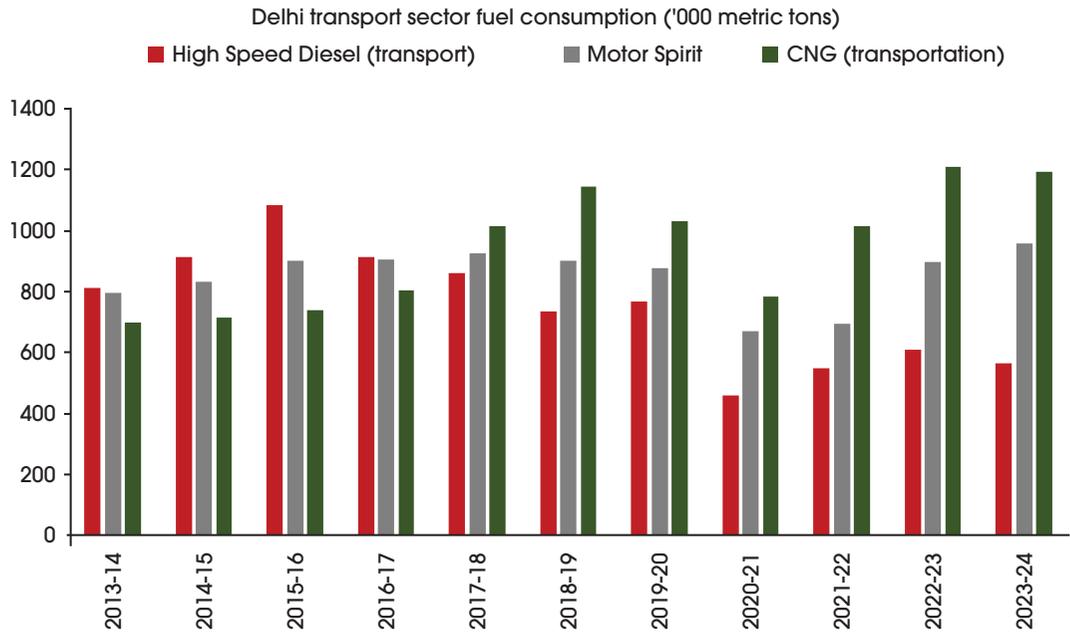
**How have anti-diesel measures impacted energy transition?**

**Drop in high-speed diesel consumption:** The impact is evident in the overall as well as transport sector diesel consumption. Between 2015-16 and 2023-24, Delhi witnessed a 59.3 per cent decrease in overall diesel consumption; whereas the CNG (transport) consumption increased by 61.5 per cent (see *Graph 20: Delhi fuel consumption ('000 metric tonnes)*).

According to a PPAC study conducted in 2013-14, around 72 per cent of Delhi’s total diesel was consumed by the transportation sector. However, due to strict measures for air pollution control in the industry sector, in 2019-20, around 92 per cent of the total diesel was consumed by the transportation sector.<sup>12</sup>

A comparison between fuel-wise energy consumed by the transportation sector excluding electricity, in 2015-16, the share of different conventional fuels in Delhi’s transport sector energy mix was 40 per cent diesel, 30 per cent petrol and 30 per cent CNG. However, in 2023-24 the share was 20 per cent diesel, 32 per cent petrol and 48 per cent CNG.

## Graph 20: Delhi fuel consumption ('000 metric tonnes)



Source: MoPNG, PPAC

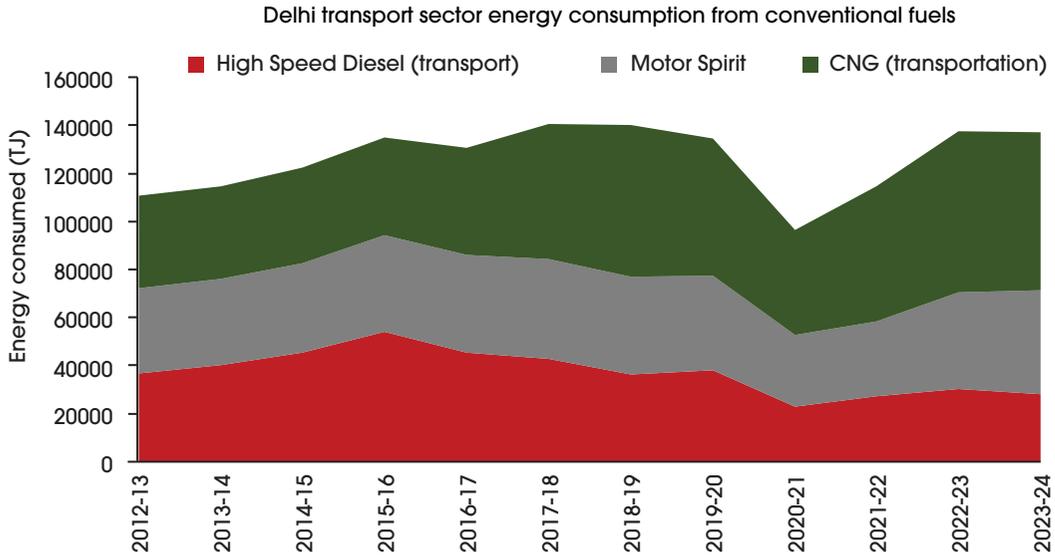
There was an increase of 1.4 per cent of total energy provided by conventional fuels for Delhi's transportation sector between these years (see *Graph 21: Energy consumption from conventional fuels in the Delhi transport sector (terajoules)*).

**Declining share of diesel four-wheelers in new sales:** As a result of series of measures initiated to discourage diesel vehicles, the share of registration of diesel four wheelers in the overall registration has reduced drastically from the time when anti-diesel measures were intensified (see *Graph 22: Sharp drop in diesel four-wheeler registration in Delhi*).

**Share of electricity in transport sector increasing:** The electricity consumed by the EV public charging stations (PCS) has continuously increased over the years. Notably, while the electricity consumption by the heavy duty PCS has increased owing to the increase in electric buses, the electricity consumed by other public charging station used for charging two-wheelers, three-wheelers and four-wheelers has decreased even though the number of in electric vehicles on road have increased. This might be because of increase in the adoption of residential charging stations (see *Graph 23: Power consumption in public EV charging stations in Delhi*).

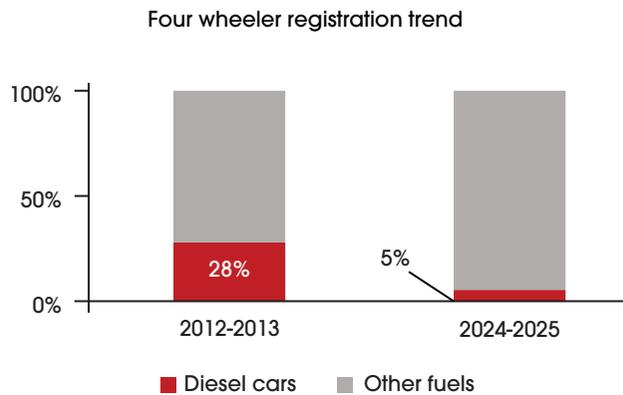
Clearly, the cumulative impact of the series of decisions taken to reduce dieselisation has catalysed significant energy transition in the transport sector.

**Graph 21: Energy consumption from conventional fuels in the Delhi transport sector (in terajoules)**



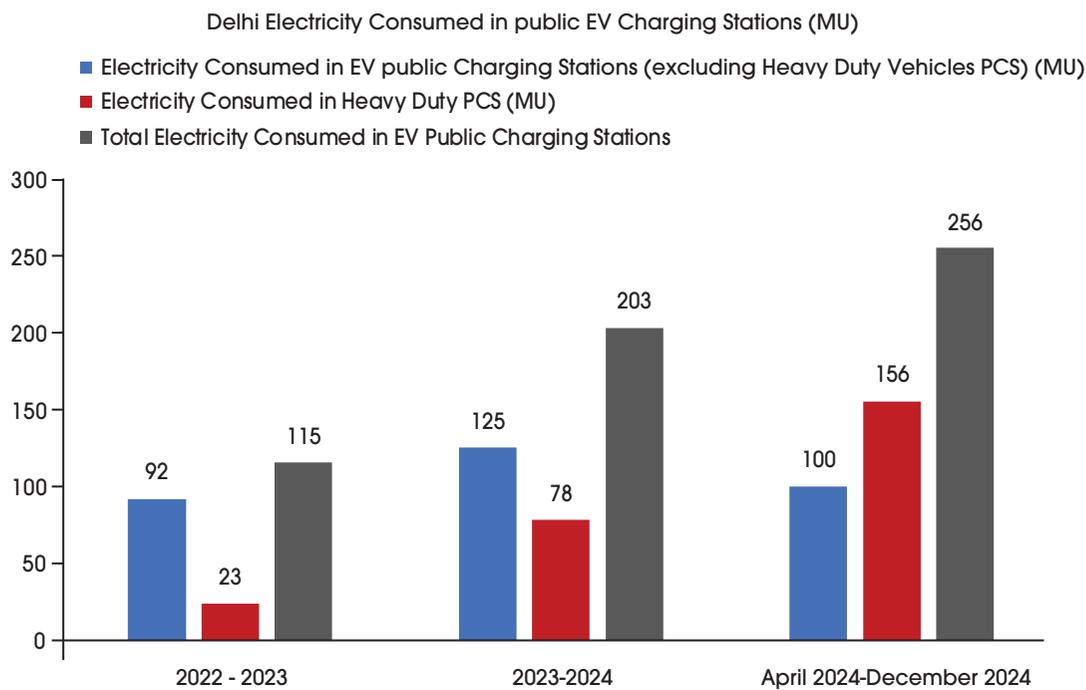
Source: CSE analysis

**Graph 22: Sharp drop in diesel four-wheeler registration in Delhi**



Source: Computed based on Vahan database

## Graph 23: Power consumption in public EV charging stations in Delhi



Source: CSE analysis

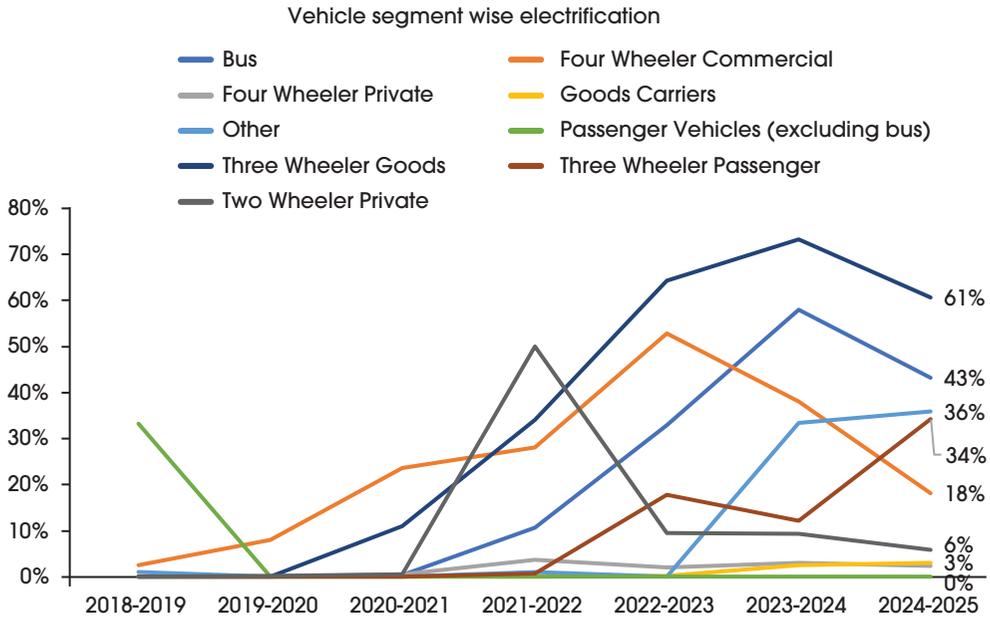
### ELECTRIFICATION FOR ZERO TAILPIPE EMISSIONS

Despite the technology leapfrog in the internal combustion engines with BS VI technology and substitution of diesel with CNG in public transport, vehicles have remained the top contributor to Delhi's pollution. One BS IV diesel vehicle may emit particulate matter equivalent to around 5.5 BS VI diesel vehicles. But the increase in sheer number of BS VI vehicles can undo the gains from improvement in one unit of vehicle. In one year, the total number of vehicles is increasing 1.3 times. Pollution challenge will remain tough if motorisation continues based on internal combustion engines. Delhi therefore requires significant transition to zero tailpipe emissions to cut emissions at source.

The electrification programme has started with the notification of electric vehicle policy of Delhi in 2020. This executive order had set a target of 25 per cent electrification of all new vehicle registrations by 2024. This policy also aimed to register a minimum 50 per cent of all new-stage carriage buses as e-buses, including both city fleet and fleet for last-mile connectivity. All delivery service providers were expected to convert 50 per cent of their fleet operating in Delhi to electric by 2023 and 100 per cent by 2025.

Against these targets, the actual penetration of electrification is close to about 12 per cent. This is dominated by the small-format vehicles of e-rickshaws, two-wheelers and three-wheelers. Electrification of four-wheelers is still very small. Electric bus numbers have begun to increase. Delhi's EV policies, incentives and charging infrastructure expansion

**Graph 24: State of electrification of vehicle fleet in Delhi**



Source: Vahan database

have contributed to this trend (see *Graph 24: State of electrification of vehicle fleet in Delhi*).

There is uneven growth across segments. E-rickshaws have consistently dominated the trend and has the highest adoption numbers. Growth peaked early in 2016–17, reaching 18,886 in 2023–24. Passenger auto-rickshaw electrification began late and started in 2020–21 but grew to 8,547 in 2023–24.

Two-wheelers show an exponential rise from 20 in 2014–15 to 38,135 in 2023–24. This is the fastest-growing segment, likely due to affordability and operational cost savings. There were 31 private electric cars in 2014–15 that has risen to 5,957 in 2023–24.

Even though the number of electric cabs have increased from zero to 2,919, it is still low.

The electric bus numbers have reached 1,907 and goods vehicles 468 in 2023–24. It is now necessary to further strengthen the electric vehicle policy to increase the EV adoption in the capital state.

There is considerable opportunity in the ongoing framing of the Delhi Electric Vehicle Policy 2.0 that will provide the roadmap until 2030. This targets two- and three-wheelers, public and shared transport and goods vehicles for an ambitious target. It is reported that by 2027, it aspires to achieve 95 per cent electrification of all new vehicles other than N2 and N3 vehicles. It aims to provide fiscal and non-fiscal incentives over and above that is available under the national government’s incentive programmes to bring

further price parity. It has further proposed to combine incentives with phased mandates for commercial and goods vehicles and delivery service schemes to be electric. It is also proposed that car ownership beyond a second car need to be electric. This will be further supported by scrappage incentives and financing schemes and exemption from road tax and registration fee. The state EV fund will be further strengthened with additional taxes/cess on internal combustion engines. The proposed new policy has also proposed substantial expansion of the EV charging infrastructure.

This policy with detailed roadmap, targets and milestones can be a game changer. It will also be very effective if along with the vehicle segment-wise target set, sales mandate for the original equipment manufacturers (OEMs) are also notified. This can support the transition by accelerating product innovation and diversification to win consumer confidence, and reduce cost pressure due to competition between OEMs.

In view of the new EV policy in the making, it is necessary to ensure that no action is pre-empted to undermine this ambitious programme. The demand incentive schemes should be linked only with battery operated electric vehicles with zero tailpipe emissions. The Supreme Court on April 9, 2025 has stated that vehicles to be acquired by the Governments and public sector organisations should be only electric vehicles. An official proposal is expected to be submitted on this. The target and mandate and government support for electric vehicles for zero emissions transition is necessary given the pollution crisis in the city. The public support programme should not be diluted with internal combustion engines. Already, remote sensing measurement of the real-world emissions from the internal combustion engines in Delhi has shown that on-road vehicles including the CNG vehicles are emitting much higher in the real world driving conditions.

## **ADVANCING ON-ROAD EMISSIONS MONITORING**

While introduction of BS VI norms has enabled a paradigm shift in the way we manage emissions from vehicles powered by internal combustion engines, this has also created pressure for more improved on-road emissions monitoring and management to ensure that the advanced-emissions-control systems remain durable and effective during the useful life-of-vehicles on road and real-world emissions remain under control.

The Supreme Court in its orders (dated January 17, 2017 and February 6, 2017) directed the EPCA to inspect Pollution under Control (PUC) centres located in the NCT of Delhi and also those in the districts of the NCR. EPCA appointed teams, including CSE, to conduct the audit. This had brought out the gaps in the system and the need for further improving it and also upgrading the system with remote sensing measurement for improved fleet screening and more effective identification of the worst polluters on the road.

This was further reiterated by the Supreme Court directive in July 2024 that while referring to the earlier directives of 2018 and 2019, as well as the recommendations from its former monitoring body EPCA in 2018-19, had directed the Ministry of Road Transport and Highways (MoRTH) to implement RSD programme and has sought priority implementation in Delhi and NCR. On May 10, 2018, it was stated that remote-sensing screening of emissions would be of considerable utility in Delhi.

In 2018, the ICAT had carried out pilot measurements with remote sensing devices. On July 29, 2019, based on the recommendation from EPCA, the Supreme Court issued notice to the Ministry of Road Transport and Highways (MoRTH) to frame the rules for implementation of remote sensing and directed the Department of Transport, NCT of Delhi to implement this.

Since then, the MoRTH has framed the Automotive Standard Rules 170 but is yet to notify them to enable implementation. This is holding back the implementation of the programme in cities. This is urgently required for efficient screening of large number of vehicles with advanced emissions control systems that cannot be monitored adequately under the PUC testing regime.

## **MOBILITY MANAGEMENT – A MAJOR GAP IN ACTION**

**Mobility crisis eroding emission gains from technology improvement:** Mobility management has been one of the most difficult challenges in Delhi. Even though from time to time the Supreme Court has intervened to address mobility management, its application has remained very limited in scope. Unlike technology transition, which has gathered some momentum in Delhi, mobility transition has been much slower. As a result, the emissions benefits from technology transition are at risk of being negated due to explosive motorisation, growing congestion, massive daily entry of vehicles from the surrounding NCR, growing travel distances and travel trip generation, and declining share of public transport ridership and active mobility.

As per the information available from the multiple sources, over a decade private vehicle modal share (motorised trips only) has increased from 38 per cent to 49 per cent. Modal share of bus transport has declined. Due to urban sprawl, the average trip length has also increased substantially. A CSE analysis has found that during congestion, traffic speeds can reduce by as much as 41 per cent during morning peaks and 56 per cent during evening peaks. This increases idle emissions. Even though several good practices and policies related to public transport systems and vehicle-restraint measures have begun to take root, the scale and scope of action is very limited.

## **PUBLIC BUS SERVICES: SLOW STEPS**

**Renewal of bus fleet and technology upgradation:** Over the last two decades Delhi has gone through successive stages of bus fleet renewal. In the first phase, following the Supreme Court interventions in 1998, the entire diesel bus fleet was replaced with CNG bus fleet. During the 2010 Commonwealth Games, another fleet renewal followed when the old style “bus body on a truck chassis” was replaced and augmented with specially designed urban buses for improved attractiveness and comfort to attract ridership.

Currently, the CNG buses are being phased out steadily to be replaced with electric buses. Delhi has taken the initiative to also fund procurement of electric buses by utilizing the state budget, and not rely only on Central funding. Delhi’s state EV policy in 2020 targeted 50 per cent of its bus fleet to be electric by 2024. In July 2022, Tata Motors bagged an order of 1,500 electric buses by DTC under a larger tender floated by Convergence Energy Services Limited as part of the E-Bus Grand Challenge. This expansion positioned Delhi

as the city with the highest number of electric buses in India. Later, in 2024, Delhi added another 320 buses, driving up the electric bus fleet to 1,970 buses, and marking up 27.2 per cent of its total bus fleet. By 2025, Delhi aims to convert 80 per cent of its bus fleet to electric.

**Not enough buses despite the increase:** Even though bus technology upgradation is underway in Delhi, it has taken a while to increase the bus numbers. The original Supreme Court order of 1998 on CNG had also asked for augmentation of bus numbers to 10,000 in Delhi by 2001.

Currently, Delhi Transport Corporation (DTC) – a State Transport Undertaking – and Delhi Integrated Multimodal Transit System (DIMTS), a public sector company, manage the Cluster Scheme on behalf of Transport Department of Delhi, and are responsible for intra-city daily stage carriage services in Delhi. Delhi’s bus fleet size by July 2024 was 7,683, including both DTC and DIMTS fleets. This still falls short of the Supreme Court target given in 1998.

That makes the number of buses per lakh population equal to 47 buses, which makes Delhi fall short of the Level of Service (LoS) category 2, as per the Ministry of Housing and Urban Affairs’s (MoHUA’s) Service Level Benchmarks (SLBs) for public transport in mega cities (cities with population greater than 4 million). According to the definition of the SLB document, LoS 2 for public transport means, *“The City has public transport system which may need considerable improvements in terms of supply of buses/coaches and coverage as many parts of the city are not served by it. The frequency of the services available may need improvements. The system provided is comfortable.”*

To achieve the status of LoS 1 in the bus system, which is considered to be a *“good public transport system”* as per the SLBs indicators, the fleet size needs to be increased to at least 60 buses per lakh population in Delhi. This translates to close to 10,000 buses in Delhi, not too far off from the Court’s directive 27 years ago.

In 2022, Delhi’s Transport Department had aimed for a fleet size of 9,930 buses, which shall include 6,990 electric buses, making the e-bus share 70 per cent in the mix. The target was set for end of March 2025. The last known e-bus procurement done by the department was for 320 e-buses in July 2024, taking the count to 1,970 electric buses in the mix. The electric share in the fleet was 25.6 per cent.

Considering that Delhi is aiming to achieve LoS 1 as a priority, while fulfilling the electrification target of 70 per cent in its fleet set by the government, Delhi needs an additional fleet of 4,926 electric buses (over the current 1,970), while phasing out 788 existing CNG buses in the favour of electric buses. This will drive up the fleet size to 9,851 buses, with 6,896 electric buses.

**Bus ridership is sub-optimal:** Even though bus numbers have begun to grow, ridership is falling consistently. In the last decade, the annual average growth rate of ridership declined by 2 per cent. The highest decline was during COVID-19 lockdown (60 per cent

decline), and compared to pre-pandemic levels, the ridership is 18 per cent. In the last year, between 2021–22 and 2022–23, the total bus ridership saw an increase of 62 per cent in Delhi. The mode share of buses in Delhi is 14 per cent (as of 2018), after including non-motorised trips in modal share calculations.

**Inadequate service level:** Even though work has begun to improve the service efficiency and passenger convenience through rationalization of routes parallel to metro lines, introduction of integration of smart cards for ease of ticketing across mass transit services, free bus rides for women passengers and construction and modernisation of new depots for better management of buses etc., this is not adequate to reverse the declining trend in modal share.

Traffic congestion during peak hours continue to reduce bus service level, by decreasing frequency, reducing reliable services, and increasing chances of bus bunching, which leads to low passenger load per bus. CSE has also analysed the available data from “Open Transit Data”, which shows that up to 50 per cent bus stops in the city have a long waiting time (higher than 15 minutes) while about 3.5 per cent have a waiting time that is unpredictable (standard deviation from planned waiting time can be more than 100 per cent).

## METRO RAIL SYSTEM – NEEDS INTEGRATION

Delhi now has a multi-modal system for mass commuting that include buses and the Metro rail system. Metro rail caters to more than 46 lakh passenger journeys every day (as of 2022–23). Metro has a 9.5 per cent modal share in the city (as of 2018), after including non-motorised trips in modal share calculations. Metro trips have the highest average trip length of 16.7 km followed by buses (14 km).

The National Capital Region (NCT) of Delhi is the only region in the country which currently has network design for its metro rail. The current operational network stands at 362.27 km (including 58.6 km of adjoining national capital region), across 10 operational corridors, giving it a coverage of 32 per cent of Delhi’s population (calculated as per population density of wards) within 800 m of its metro stations, and about 10 per cent within 400 m. After the completion of currently under-construction Phase IV of the project, the network will be expanded to 463 km, making it one of the longest metro networks in the world.

DMRC, a joint venture between the Government of India and the government of the National Capital region, has demonstrated adoption of innovating financing models such as the public-private partnership (PPP) model for station retail, and advertising to generate revenue as well as to keep fares subsidised. The project was financed by leveraging international funding from institutions such as the Japan International Cooperation Agency (JICA) to finance initial phases.

In measures already taken, DMRC has integrated the metro stations with feeder bus services, auto/e-rickshaws and cycles for the ease of last-mile connectivity of its commuters. Recently, they have also installed charging infrastructures and swapping stations at metro stations to support Delhi’s effort towards electric mobility transition.

The ridership data suggests that DMRC has performed quite well in terms of passenger per kilometre of operational route, which is comparable to the biggest metro systems at a global scale. Delhi's average ridership per day per kilometre is 12,771. The figure for the largest metro rail system in the world, in Shanghai, is 12,069. Compared to other countries with the largest metro rail networks, Delhi fares well – Beijing Metro: 15,575; London Underground: 8,034; Madrid Metro: 8,191 passengers per km.

DMRC's efforts towards green technology transition to obtain energy from sustainable sources makes them the first rail-based organisation in the world to claim carbon credits. Delhi metro receives 35 per cent of its total energy from renewable energy sources with a capacity of about 50 MWp. Apart from installing rooftop solar panels at metro stations and depots and procuring solar energy from an off-site solar plant.

DMRC launched a dedicated data portal providing open access to information on routes, schedules, ridership, and environmental metrics, contributing to greater transparency. The "Open Transit Data" portal, a joint effort by IIT Delhi and Delhi's Transport Department, makes bus and metro transit data feed available in public in the standard General Transit Feed Specification (GTFS) format.

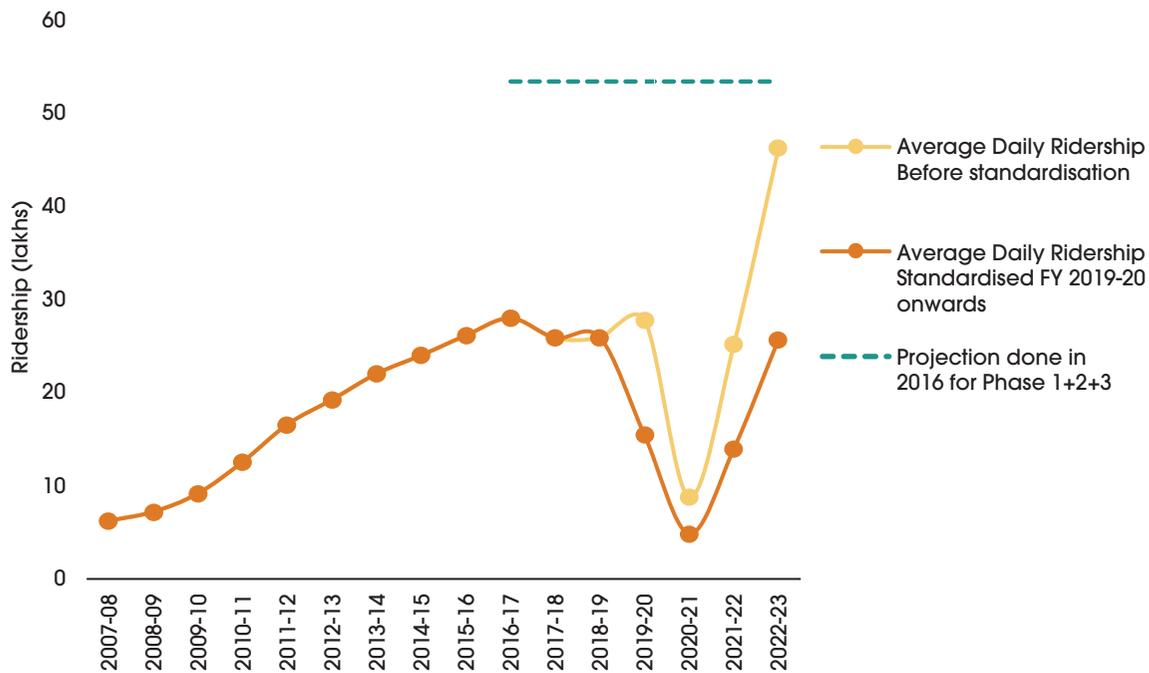
However, significant challenges remain in ensuring an accessible and efficient public transit system. In recent years, it was observed that while the operational network has seen an increase, the average ridership per km has not been proportional to the increase in network. Moreover, an assessment of the GTFS data (waiting times specifically) reveals that only 4.6 per cent stations of onward journey and 9.9 per cent stations of return journey presented an ideal scenario in which the wait times are consistently low on the stops.

Ridership augmentation can be achieved by improving accessibility to already built metro stations, increasing frequency and enhancing service levels at stations, physical multi-modal integration between transit stations/stops and last-mile connectivity, and planning dense development over long corridors to capture adequate land value and population.

**Metro ridership required to reach projected level:** DMRC in FY 2019–20 changed their method for calculating ridership for the metro system. Instead of the number of full trips (entire journey from origin to destination), the "passenger journeys" are considered, which translates journeys in terms of the number of corridors used by a passenger. This inflates ridership numbers by counting a single passenger multiple times if they use more than one corridor. It also makes year-on-year comparisons misleading, as earlier data based on full trips cannot be directly compared with the new method. It also distorts the perception of actual metro usage, making it harder to assess network efficiency, crowding patterns, and the true impact of metro expansion. Another drawback is that other travel modes cannot be directly compared to the DMRC ridership, making modal shift assessments difficult.

Passenger kilometres (PKM) is a better metric for measuring metro ridership because it provides a more accurate reflection of system usage and travel demand. Unlike passenger journeys, which count transfers as separate trips, PKM measures the total distance travelled by all passengers, offering a consistent and comparable indicator over time. This

**Graph 25: Metro ridership data standardised, 2007-23**



Source: CSE calculation

metric accounts for the actual utilization of the network, making it useful for evaluating service efficiency, capacity planning, and fare revenue assessment.

As per the latest information shared by DMRC, during FY 2023–24 (till October), the average PKM per day for the metro network was 540 lakhs. For the same period, the average passenger journeys made in metros per day was 62 lakhs. NIUA estimated the average trip length of metro trips to be 16.2 km in 2018 in Delhi.

Based on these figures, the average number of full trips made in the metro were 33.3 lakhs per day. This means that an average of 1.8 interchanges occurred during the period for DMRC to estimate 62 lakh passenger journeys per day. The passenger journey data can thus be used to demystify the metro ridership data in the Economic Survey of Delhi (see *Graph 25: Metro ridership data standardised, 2007-23*).

DMRC projected the ridership of its network in 2016 after completion of its first three phases to be 53.47 lakhs per day. However up until a year after 2017-18 the expectation had only been achieved by 47.45 per cent. In fact, this number still remains to be reached.

DMRC ridership needs to increase by 27.76 lakh trips per day (average) or 450 lakh passenger kilometres per day (average) to only meet the projections done in 2016.

## MULTIMODAL INTEGRATION

The only way to maximise ridership of all mass commuting modes – including buses, metro rail and para-transit – multi-modal integration (MMI) is required for seamless and cost-effective transfer from one mode to another mode. Delhi has adopted city-level MMI policy and regulations. These have been developed by the Unified Traffic and Transportation Infrastructure (Planning & Engineering) Centre (UTTIPEC) under the Delhi Development Authority.

This is needed to not only improve access to transit modes and enable seamless changing between modes, but also to reduce the cost of interchanges for affordable journey. In fact, CSE estimates show that total journey cost increases substantially for public transport compared to private transport due to hidden cost of time taken and waiting/interchange, especially for buses in Delhi. For personal vehicles, costs include fuel cost and time taken. The comparative median value of cost of using cars is Rs 35/km in contrast to Rs 40/km for buses, and Rs 47.5/km for metro in Delhi.

MMI is implemented in the following three critical ways:

- i) physical integration in which all drop off and pick-up facilities of all modes of transport are brought close through MMI design in which bus and para-transit stops get the highest priority and are brought closest to the metro stations in a well-designed manner (for instance, bus stops are within 50 metres). But private car parking get low priority and are placed after the public transport stops – a little away from the metro stations but within walkable distance.
- ii) Information integration is achieved with the help of digitization in which passenger information systems for all modes are shared for ease of access.
- iii) Institutional integration and fare integration of buses, Metro etc. is a way to reduce inter-change penalty by integrating the fare systems of all modes.

## APPLICATION OF MULTI-MODAL INTEGRATION IN DELHI

- **Physical integration:** Delhi Metro Rail Corporation (DMRC) has prepared detailed MMI plans and begun execution in 40 stations in consultation with the traffic police, Transport Department and the Public Works Department, 2019. UTTIPEC has approved multi-modal integration plans for 40 metro stations of Phase-3 metro lines. DMRC is developing metro stations as per the MMI design to physically integrate all modes – para transit, buses, pedestrian access and car parking – for seamless transfer and easy access. Some of these stations include Chhattarpur and RK Ashram Metro. In about eight metro stations, feeder bus services have been integrated.
- DMRC has been allotted 136 e-autos by the Transport Department for last-mile connectivity. Electric auto rickshaw services have been integrated in three metro stations and for this purpose battery-swapping facilities are being set up. E-auto services from metro stations is being introduced on a pilot basis in Dwarka.
- **Information integration:** Information systems on inter change of modes and connecting infrastructure has begun. DMRC is providing voice information for metro passengers about feeder services and information standees are placed. However,

this needs to be further developed and expanded for all modes. Technological advancements have been possible through the One Delhi App. This integrates real-time information through mobile apps and digital platforms for various transport modes. This is designed for real-time tracking, estimated arrival times, and route planning for integrated journeys.

- **Institutional integration:** All transport intuitions are made stakeholders for MMI and for any developmental activities required. This requires the approval from Lieutenant Governor of Delhi through UTTIPEC. Further, Transport Department and DMRC complement each other for these initiatives.
- **Fare integration:** Common Mobility Card (CMC) and TUMMOOC have been implemented to enable seamless travel across metro and buses. The process is also underway to National Common Mobility Card (NCMC).
- **Delhi-NCR regional integration:** Emphasis on regional integration with neighbouring cities like Gurgaon, Noida and Ghaziabad.
- **Development of the Regional Rapid Transit System (RRTS)** for faster connectivity between NCR cities. Feeder services should be provided between Sahibabad RRTS Station to Sarai Kale Khan multimodal transit complex. NCRRTC will provide space for halting of bus at station during operation, as per requirement. Sarai Kale Khan RRTS station will be a mega multi-modal transit hub of NCR, where all the three priority RRTS corridors will converge and integrate with the existing Delhi metro station, Nizamuddin Railway Station and ISBT.

Even though steps have been taken towards multi-modal integration, a lot more is needed to develop the requisite infrastructure and systems for city-wide implementation.

## **TRANSIT-ORIENTED DEVELOPMENT (TOD)**

Yet another critical aspect of urban transport infrastructure is adoption of transit-oriented development (TOD) policy and principles to prevent lock-in of pollution in the transport infrastructure. Delhi has adopted state level TOD policy and made it a part of the Master Plan 2040 as well. This aligns with the national TOD policy. All the new development and redevelopment are expected to follow this policy to bring people and jobs closer to mass transit through a planned densification process through integration of land use and transport systems in the city.

Through an urban regeneration process, targeted areas close to transit areas are redeveloped or regenerated to develop as compact, walkable neighbourhoods with mixed-use developments to bring residential, commercial and retail components together to reduce distances between residence, jobs and recreation as well as support augmented use of public transport, walking and cycling. These are designed to reduce private vehicle dependency by curtailing and capping parking spaces (as provided for in the Delhi Master Plan 2040 along with public transport intensification plan).

Even though the first draft TOD Policy for the city of Delhi was released in 2012 (DDA, 2012) as an addendum to the Master Plan Delhi-2021, it was notified with many revisions in 2015 (DDA, 2015) and has been further refined in 2019 and 2021.

Delhi's first TOD project at Karkaduma Metro Station did not see much light of success due to poor implementation. However, a lot of learnings from it helped to formulate an enabling framework. DDA has identified five metro stations for TOD-style development which includes Mayur Vihar Extension, Dwarka Sector 18, Sarojini Nagar, Dwarka Sector 21 and INA market area. However, it is too early to assess their adequacy and the level of success. But it is noteworthy that these approaches have begun to take shape.

TOD can also unlock the latent economic potential and land values in the city. It will facilitate the development/regeneration of select nodes/areas in the city through planned intensification of uses and activities, infusion of new infrastructure and improvements in the public realm. This will also allow the city to capitalise on the large-scale investments being made in the public transit infrastructure including Metro Rail, Regional Rapid Transit System (RRTS), etc., by facilitating the improvement of old housing stock in addition to creation of new housing stock and economic centres around strategically located transit nodes and opening up opportunities for value capture. This has powerful potential to reduce automobile dependence and attendant pollution and congestion.

These are important steps forward that needs massive upscaling to improve public transport accessibility, public space regeneration, upgradation of walking and cycling infrastructure, vehicle restraint measures in compact neighbourhoods. But this has not received adequate attention for upscaled implementation through a planned redevelopment process.

## **SLUGGISH PROGRESS IN PEDESTRIAN INFRASTRUCTURE**

Walking and cycling can be the dominant zero-emission mass mode within shorter-distance ranges. Moreover, augmented use of public transport requires extensive safe walking access. As per the Economic Survey of Delhi 2023–24, Delhi has a total road network of 18,594 km. The majority of it is under the Municipal Corporation of Delhi or MCD (68.3 per cent), followed by Delhi State Industrial and Infrastructure Development Corporation or DSIIDC (13 per cent) and Public Works Department (7.4 per cent), among others. The summary of road audit mentions that PWD and MCD roads did not undergo the study.

According to the Road Safety Audit done by IIT Delhi in 2024 as per the instructions of the Supreme Court Committee on Road Safety, only 56 per cent roads in Delhi have a footpath, and only 26 per cent out of the existing ones meet IRC guidelines of width and height of footpaths.

It is evident that as per the level of service of pedestrian infrastructure defined by the Ministry of Housing and Urban Affairs (MoHUA) Delhi is in service category 2 level. This means “the City has pedestrian facilities which may need some improvements in terms of improvements in intersections, footpaths, and street lighting as some parts of the city are not served by it. The footpath available needs improvements.”

**Initiatives to improve pedestrian infrastructure:** In 2021, Delhi government announced scheme to redevelop 540 km of road network with pedestrian facilities. The full scope of this plan has not been realised on the ground except a few stretches that

include Chirag Delhi to Sheikh Sarai in South Delhi, which is almost 800 metres long; some stretches of Outer Ring Road, Aurobindo Marg in South Delhi and in other parts of Delhi, have been redesigned with wide walkways and cycle lanes (see *Chirag Delhi–Sheikh Sarai stretch with redeveloped pedestrian facilities*).

The city authority has also taken several initiatives to improve the pedestrian infrastructure in the city. Some of the notable projects include pedestrianisation of Ajmal Khan Road from Karol Bagh Metro Station to Desh Bandhu Gupta Road, an almost 1 km stretch, and redevelopment of Shahjahanabad Area–Chandni Chowk area etc. In both the cases the busy commercial areas were redesigned with wide pedestrian walking ways, integrated utilities, public amenities and designated parking locations etc. (for transformation see *Before and after images of Chandni Chowk*).

Similar efforts were made to pedestrianise the busy 1-kilometre pedestrian stretch of the Ajmal Khan market in Karol Bagh in West Delhi. Car parking was removed from the area and the area was connected with remote parking area with e-rickshaw shuttles. Due to its close proximity to metro line it was possible to access this area by public transport and walk. The street was regenerated with pedestrian amenities, greenery and recreation spaces. However, lack of adequate support from the shopkeepers and administrative disdain this has started to degenerate (see *Box: Pedestrianisation: Undoing the gains*).

Lack of attention to pedestrian infrastructure and pedestrianisation to create hyperlocal low emissions zones is a big gap in the clean air action plan. The new action agenda has to implement a network of walking and cycling infrastructure and targeted pedestrianisation of key commercial areas to promote low-emission zones in the city, which can also incentivise use of public transport and clean vehicles in those targeted zones.

### Before and after images of Chandni Chowk



Source: Urban Design Lab

## Chirag Delhi-Sheikh Sarai stretch with redeveloped pedestrian facilities



Source: The Economic Times

### **PARKING MANAGEMENT AS A VEHICLE-RESTRAINT MEASURE**

Mobility crisis cannot be addressed if growing usage of personal vehicles that contribute to congestion and pollution cannot be tamed. Towards this end, parking policy and management as a demand management measure are considered the first-generation restraint measures. This matter was taken on board by the Supreme Court for the first time in 2006 when all municipal bodies were directed to provide parking plans as a demand management measure. EPCA had conveyed that parking for personal vehicles cannot be considered public good and it should be provided based on user pay principal. This was consistent with the National Urban Transport Policy 2006. However, it was too early for the municipalities to develop a restraint policy when their focus was on supply side management.

Subsequently, the Lt Governor committee of 2014 and Master Plan of Delhi 2021 took on board Parking Management Districts approach for optimal use of scarce public land and parking management strategies on the “user pays” principle while meeting the needs of all road users.

In 2019, Delhi government notified the Delhi Maintenance and Management of Parking Rules, 2017 along with guidelines for the Parking Management Area Plan under Section 212 of the Motor Vehicle Act 1988. This is the first-ever legislative backing for parking management as a vehicle-restraint measure in the country. This mandates all urban local bodies, including land-owning agencies, to implement local area-specific integrated parking management area plans (PMAPs). This requires ward-wise identification and demarcation of legal on-street and off-street parking, penalty on illegal parking,

## Pedestrianisation: Undoing the gains

Even after making investments and massive planning efforts to reclaim streets from cars and create pedestrian plaza and zero emissions streets, the initiatives are not sustained and made accountable. This is showing up in the much-acclaimed pedestrianisation of Ajmal Khan Road in West Delhi and the fissures that are beginning to appear in the pedestrian streets of Shahajanabad.

Ajmal Khan Road was Delhi’s first big test of pedestrianisation. Launched in May 2019 as a 1.7-km open-air mall closing Karol Bagh’s spine to private vehicles, it won awards and briefly showed cleaner air and quieter streets. Yet by 2025 the ban has largely collapsed – cars belonging to business now occupy half the pedestrian pathway, benches lie unused when SUVs surround them, and most bollards have been pushed aside. On Mondays – when formal stores shut and informal pathri stalls take over – the same space fills with walkers and stalls, proving that footfall returns the moment vehicles leave (see Comparison of an Ajmal Khan street on a regular day versus an off days when roadside stalls are open).

Traders who rely on curb-side parking blame the ban for revenue loss and have lobbied hard for its rollback, while the promised multi-storey car park is a scorching five to ten minutes’ walk away and still incomplete. Police presence is token; maintenance is negligible; and without shaded walkways or shuttle links the design fails when Delhi’s 45°C summer hits. In short, Ajmal Khan Road’s hardware arrived long before a workable regime for parking management, heat comfort or stakeholder compensation.

## Comparison of an Ajmal Khan street on a regular day versus an off day when roadside stalls are open



Shop-owner’s vehicles block half of the passenger pathway.



Roadside stalls are arranged to facilitate shopper’s movement.

prohibition on parking on footpaths, in green areas, near intersection, on emergency vehicle lane; variable parking pricing, sharing of parking facilities for optimised usage, integrated management of on-street and structured parking, proof of parking for transport vehicles among others.

Following this notification, the Supreme Court had directed implementation of three pilot schemes during 2019–20 as per the new rules in Lajpat Nagar III (South Delhi

Shahjahanabad's Red Fort–Fatehpuri corridor, popularly called the Chandni Chowk pedestrian zone, opened in September 2021 after the Public Works Department (PWD) spent roughly Rs 100 crore burying cables, laying granite promenades and installing boom barriers that should have kept cars out between 9 a.m. and 9 p.m. Initially the makeover won praise, but three years on the granite is cracked, litter piles up, and two-wheelers slip past unmanned barriers (see Status of implementation of makeover in Shahjahanabad).

The facility-management contract lapsed on September 7, 2024; since then PWD and the Municipal Corporation of Delhi have argued over who must sweep the street, while the Shahjahanabad Redevelopment Corporation (SRDC) pleads with Delhi Traffic Police for stricter control. Even the deployment of 75 home-guard volunteers in December 2024 has not stopped violations, prompting repeated High-Court admonitions.

## Status of implementation of makeover in Shahjahanabad



Even though four-wheeler and larger vehicles are scarce, two-wheelers are both parked and on-road.



Most of the original design and infrastructure is still intact.

Municipal Corporation); Kamla Nagar (North Delhi Municipal Corporation); and Krishna Nagar (East Delhi Municipal Corporation). Based on the successful implementation of these plans, the apex court had directed city-wide implementation in 2020.

In 2024, the Commission for Air Quality Management (CAQM) had further issued advisories to the need for urban local bodies to develop structured parking plans for implementation in Delhi and NCR. Further, the High Court of Delhi has also intervened

in March 2025 to seek implementation of these plans. As of now, 14 PMAPs are available for public review on the Municipal Corporation of Delhi's website. Despite this progress, challenges remain. The PMAPs are yet to be implemented.

**Parking measure as an emergency action:** During winter, when pollution levels peak due to atmospheric conditions, the Graded Response Action Plans (GRAP) – temporary measures to prevent further loading of pollution when high pollution levels are already trapped due to calm conditions – are invoked, and parking prices are hiked as a temporary measure. But such an action cannot be effective in the absence of implementation of a Parking Management Area Plan (PMAP). Abundant unregulated and free parking available can undercut such measures.

While Delhi has yet to further strengthen its implementation strategy, the parking rules and the pilot schemes provide important lessons for other cities to develop parking policy as a vehicle-restraint measure.

## REGULATION OF INTERMEDIATE PUBLIC TRANSIT SERVICES

Intermediate or informal public transport (IPT), or paratransit is a component of the transit system which provides mobility services to meet the demand gap between the private and the formal public transportation systems. In India, IPT largely refers to cabs, auto-rickshaws, and e-rickshaws.

In its 1998 order to convert all public transport in Delhi to CNG by 2001, the Supreme Court did not only include buses but also auto-rickshaws and taxis plying the city which were then running on diesel. Additionally, the number of auto-rickshaw permits specifically were frozen to the number of auto-rickshaws then plying in Delhi (which was 83,000, later dropping to 55,000 in 2011). The court order was issued to control pollution from auto-rickshaws, which at the time was estimated to be 80 per cent of all vehicular pollution in the state.

Later due to an appeal from the Transport Department, the cap on permits was extended to 100,000 in 2011. According to the department, the move was required to control incidences of overcharging and service denials since a fewer auto-rickshaw numbers and increased travel demand had led to a monopoly of few owners renting out vehicles.

As per the auto-rickshaw permit list published by the Transport Department, 74,151 permits have been taken up. However, sources have mentioned that 95,000 have been issued already. Regardless, in 2021, the Transport Department declared that 4,261 permits in the capital are up for grabs, out of which 1,406 will be reserved for women.

Interestingly, all of these ~4200 permits are reserved for electric autos and the department has stated that all the new or renewed permits should be issued for electric passenger three-wheelers only, and this will be like a lifetime permit as long as the vehicle is fit to ply on the roads of Delhi.

In the 2010s after the onset of cab-hailing services such as Uber and Ola (now augmented with more players such as Rapido, BluSmart, and so on), most taxis in the region were replaced by vehicles owned by these services. The draft motor vehicle aggregator scheme 2023 asks for phased targets of electrification from ride-hailing services for 100 per cent fleet electrification in four years. Companies and verticals such as EcoMobility, BluSmart, and Uber Green are deploying electric only fleet for passenger vehicles.

To fast-track transition to electric and newer technologies, the IPT segment will require strengthening in both fiscal and non-fiscal incentives, stronger industry participation for product development to support mandate for e-only registration, reliable charging ecosystem support, standardised charging rates and equipment, financing mechanisms, enabling a second-hand market for used vehicles, stringent oversight in the retrofit market for quality control and assurance and strong process of certification and standard setting, and creating awareness to build public support for electric passenger and good carrier services.

Even though the charging stations are quite numerous, only a few areas have dense charging facilities. Other areas need adequate and equitable distribution of charging infrastructure. To cater to the requirements of this segment, which is hugely price sensitive, requires affordable electricity and also security for the vehicles; informal parking-cum-charging places have emerged in different parts of the city. These are informal setups in open but enclosed areas where e-rickshaws and e-autos pay for parking and charging and can park and charge during the night and day as needed.

However, the city requires a strong inter para-transit (IPT) deployment scheme to integrate public transport and strengthen last-mile connectivity.

## WASTE AND CIRCULARITY

### Construction and demolition waste - staying ahead

Delhi has taken significant steps to remediate construction and demolition (C&D) waste and provides an important learning curve for other cities. A detailed case study has been presented on this case in the sectoral overview of this report. However, the key elements of progress are highlighted here.

There are two critical elements of C&D waste management, i.e., i) good practices in construction activities to minimise generation of dust, and ii) Management of C&D waste to process and recover resources of value for recycling and reuse. Both the strategies need to be strengthened to promote clean construction practices.

**Construction dust management:** Dust generation during construction and its impact on local air quality can be enormous. The key sources of dust during construction include sand, grit, conveyor systems, truck movement, soil excavation, site clearance, material handling and storage, and mobile plant – bulldozer, crane, crushers, piling, building demolition, and concrete batching, among others. Each of these stages require dust-control strategies. The construction dust can also be highly toxic.

Delhi's battle with construction dust dates back to 2014 when the EPCA noted an order by the NGT dated 10.04.2015 in O.A. No. 95 of 2014. These directions were circulated vide an order dated November 26, 2014 and December 4, 2014, which included the steps to control construction dust. Non-compliance could lead to immediate stoppage of construction Delhi and NCR.

A Supreme Court order dated 16.12.2015 subsequently came with a checklist of measures as given by the Central Pollution Control Board to be taken to mitigate dust pollution. This firmed up norms for dust control from construction and related activities. Violation of these norms would result in heavy penalties.

In November 2016, following an emergency level of pollution in Delhi, EPCA also developed an accountability mechanism to identify the agency and actions that have been taken to check pollution from construction activities.

The essential features of dust control included transport of material that can be easily wind borne and need to be covered by a sheet; raising the barricade along the perimeter; wind breakers of appropriate height (one-third of the height of the building and maximum of 10 metres to be provided); mounting of dust barrier sheet on scaffolding around the site; inclusion of dust mitigation practices in their Environmental Management plan; paving or black topping of roads leading to or at construction site; excavation of soil with adequate dust mitigation measures; loose soil, sand, construction and demolition waste or any other construction material to be covered; water sprinkling to be adopted; and cutting and grinding of building materials in open area are not allowed.

The GRAP measures have further included dust-control measures at construction sites and also stoppage of all construction activities when the air quality index hit emergency levels. These measures sought for i) action taken by development authorities, and municipal corporations for the construction projects with area between 20,000 sq. metres to 150,000 sq meters; ii) action taken by SPCBs for the construction projects with area greater than 150,000 sq. metres not following the environmental clearance guidelines; iii) SPCBs to bring list of all construction projects in NCR having area greater than 150,000 sq. metres.

DPCC launched an anti-dust drive in 2021. As part of this, all projects involving construction or demolition with a plot area of 500 square metres or more must register on DPCC's designated web portal. These project proponents must carry out a dust self-assessment/audit fortnightly and upload that report on the web portal. While all project must install PM<sub>2.5</sub> and PM<sub>10</sub> sensors at their site, these must be linked to a live dashboard on DPCC's portal to provide real-time air-quality data at and around those sites.

Subsequently in 2022 the CAQM policy sought monitoring of C&D sites and further refinement of the web portal for online monitoring of dust mitigation in C&D sites and registration of all projects for Construction and Demolition activities on the web portal in plot areas of >500sq. metres. It further defined dust-control measures and sought deployment of adequate numbers of anti-smog guns, water sprays, and wind fencing. It

has also mandated registration of large projects on a web portal, use of water suppression and avoiding dust-generating activities on days with high wind speed.

The construction industry is hugely impacted by the GRAP measures during winter when construction activities are stopped during severely polluted days.

## **C&D WASTE MANAGEMENT**

**Catalysed legal enabler for use of C&D recycling waste in construction:** The collection, processing and recycling of C&D started in Delhi in 2009–10 during the Commonwealth Games. Backed by surveys undertaken by MCD and IL&FS Environmental Infrastructure & Services Ltd. (IEISL) way back in 2004 and 2005, the first C&D recycling plant in India was established in Burari, Delhi, in 2009, with a processing capacity of 500 TPD. The 2010 Commonwealth Games became a significant catalyst for clearing the city's debris from the construction of infrastructure for the Commonwealth Games 2010.

During 2013–14, a roadblock was brought to light by a CSE investigation which found that IS: 383-1970, the Indian standard for concrete aggregates set by BIS, allowed only “naturally accessed material” for concrete production. EPCA took up this matter with BIS. Following this, BIS updated IS 383: *Coarse and Fine Aggregate for Concrete Specification*, officially acknowledging recycled C&D waste as a legitimate alternative to natural aggregates in concrete mixes. These developments helped to increase the demand for C&D waste recycled products within the market.

**Mandating uptake of recycled material in new construction:** Only processing of C&D waste to create value added goods without a strategy for their uptake cannot work. Therefore, the Department of Urban Development, GNCTD, made it mandatory for all municipal and local government bodies in Delhi, including the Public Works Department (PWD), Department of Irrigation and Flood Control, DSIIDC and Delhi Jal Board, to use recycled C&D waste products for construction and maintenance projects. This solved the problem faced by the plant for uptake of recycled products.

On January 14, 2020, the Delhi Pollution Control Committee (DPCC) issued directions under Section 5 of the Environment (Protection) Act, 1986 to various government departments and agencies, urging them to expedite and maximize the utilization of recycled materials from C&D waste processing facilities operating in Delhi. These steps aimed to ensure compliance with the targets set by the Ministry of Housing and Urban Affairs (MoHUA) for the use of recycled C&D materials. Subsequently, letters were issued by the Secretary (Environment) cum Chairman of DPCC to agencies such as NHAI, NBCC, CPWD, and DOA, emphasizing the need to increase the lifting and utilization of these recycled materials to achieve the mandated goals. Further directions followed on February 9, 2021, reinforcing these measures to drive progress.

**Expansion of C&D collection capacity:** One of the biggest challenges that recycling plants face nationally is inadequate feed stock due to poor waste collection and transportation. Delhi has made efforts to ensure extensive coverage through a widespread network of 132 collection points distributed across the city's three ULBs and 272 wards/

circles, providing easy access to waste-disposal facilities for residents, contractors and construction personnel.

The Municipal Corporation of Delhi (MCD), with 250 wards, has 106 designated collection centres with 61 more planned in the future. The New Delhi Municipal Council (NDMC), which oversees 14 circles, has 25 collection centres. The Delhi Cantonment Board (DCB) which has eight circles, has one designated collection centre. This ensures that nearly every two wards have a designated point for C&D waste, demonstrating a deliberate effort to ensure convenience and accessibility citywide. More collection points are being added regularly through the years. This has yielded positive results, with the MCD reporting a 38 per cent reduction in illegal dumping from October to November 2023. Delhi has utilized digital platforms to inform and engage its citizens. The city has used a mobile phone app and website to enable this. Both the platforms have the MCD helpline phone number that can be used to place C&D waste collection request.

**Expansion of C&D waste processing capacity:** Delhi has steadily expanded its waste-processing capacity by over 11 times from where it started initially – 500 TPD in 2009. There are five recycling plants in the city with a combined processing capacity of 5,150 TPD, which is the highest in the country.

However, the city’s decentralisation aspect remains partially unfulfilled as it still does not have a permanent C&D recycling plant to cater to the southern part of the city. In 2024, the municipality floated a tender for a recycling facility to be set up on a 7-acre plot of land in Tehkhand, Okhla. The plant will cater to the south and central zones of Delhi, cutting down the travel distances of debris further within the city.

C&D waste management also got an extra boost under the Swachh Survekshan 2021, which improved the ranking methodology for cities. The ranking points for C&D waste management was doubled to 100 points, creating greater incentives for the cities. It also moved away from the blanket and singular requirement of recycling plants. It set criteria for management infrastructure. Cities need to have C&D waste collection system, notify charges for C&D services, and segregate waste in five streams. It also set waste processing efficiency criteria. The ranking points are to be awarded based on percentage of collected waste that is processed and reused. Non-structural applications of C&D waste don’t require the specialized processing.

## **C&D WASTE MANAGEMENT: UNFINISHED AGENDA**

Despite such massive expansion of C&D infrastructure unsegregated waste continues to remain a challenge in the city. Waste reaching C&D recycling plants is often not segregated and require extra inputs to process such as wet processing which is cost and resource intensive.

**Quantify C&D waste:** The city requires comprehensive assessment and quantification of C&D waste generation, utilization and disposal to plan adequate infrastructure and system for management. It needs to implement network of collection points and GPS enabled

transportation system linked to recycling facilities. Integrating the informal sector may help to improve efficiency of the system and make the process more cost effective.

**Incentivise segregation and uptake of recycled material:** In the new agenda for the C&D waste management this needs to be taken forward to incentivise utilisation by increasing the target for use of recycled products. All government constructions may be mandated to use at least 20 per cent of recycled C&D waste products. All renovation projects involving demolition, even in private sector, may be mandated to use at least 20 per cent of recycled C&D waste products.

**Address the cost of recycled product:** At the city level, the tipping fee for delivery of C&D waste to the recycling plant, terms and conditions of civic body with the concessionaire may be designed to keep the price of C&D waste recycled products about 20 per cent lower than the corresponding conventional products. Moreover, at the Central government level, the GST on recycled products need to reduce. Currently, GST on C&D recycled products is 18 per cent as opposed to 5 per cent on virgin materials. This increases cost and impedes effective utilisation of recycled products. The tax burden on the value-added products of the recyclers need to be reduced.

**Incentivise the construction industry:** The bulk waste generators need to manage their own waste on-site through reuse and decentralised recycling. There is also a tremendous need to increase public awareness and build capacity on the waste stream and its management. This also needs preventive measures to reduce C&D waste generation: The management plan of the construction needs to adopt proactive prevention of waste through on-site construction management. The construction managers need to advance waste utilization plan on-site.

**Regulate demolition of structures as well:** Many cities including do not record demolition and therefore demolition permits are not usually issued to govern the process. Quick demolition without resource recovery to save time can be wasteful and polluting. This requires resource recovery standards and guidelines for demolition.

## **MUNICIPAL SOLID WASTE AND OPEN BURNING - SLOW PROGRESS**

Management of waste streams and addressing open burning of municipal solid waste have remained one of the critical gap areas in Delhi. Even though the Central government programme Swachh Bharat Mission 2.0 (SBM 2.0) is the primary driver of change, the real-world change on ground falls short of the target. The SBM 2.0 has set a target for a “garbage-free” India that include strategies remediation of legacy waste and establishment of infrastructure for municipal solid waste treatment, processing, recovery, and recycling. The mission aims to divert 80 per cent of waste from landfills by 2026. This requires massive efforts to collect 100 per cent waste from all households and processing to prevent their dumping. If open dumping in public spaces and also in landfills and dumpsites can be prevented the problem of waste burning can also be eliminated.

Against this backdrop, the Delhi government plans to target landfill sites with plans for eco-parks and enhanced waste-to-energy utilisation. This includes timely removal of the legacy waste from the existing landfill sites. It is estimated that about 11,342 TPD of MSW is generated daily and 7,542 tonnes are processed, i.e., about 66.5 per cent. The rest is dumped in landfills. The performance of different municipal bodies vary – the New Delhi Municipal Council (NDMC) has achieved 100 per cent segregation and Delhi Cantonment has also achieved about 90 per cent segregation. But the Municipal Corporation of Delhi (MCD) with the largest number of households within its jurisdiction falls woefully short at 56 per cent. There are still large areas of informal settlements that are not covered by the formal municipal services. As of 2024, about 41 per cent of the legacy waste has been remediated. Even though 50 per cent of MSW is biodegradable, the processing capacity is only 23 per cent.

The key strategy adopted for remediation of legacy waste in Delhi is incineration of waste to generate electricity. About four waste-to-energy plants have been set up. The critical challenge is that of mixed waste as feedstock with low calorific value that result in incomplete combustion and contribute to toxic emissions. Instead Delhi with such an extensive CNG network could have opted for bio CNG plants to feed the gas pipelines. That would have been a much cleaner strategy and that would have also earned enormous revenue.

Clearly, the infrastructure development or waste management and processing remains inadequate. The next generation action therefore needs to incentivise segregation of waste, eliminate tipping fee for mixed waste and linked it only with segregated waste, enforce user charges that are currently extremely meagre, and strengthen the compliance strategy for the bulk-waste generators in the city. Use of mixed feedstock in waste-to-energy plants need to be eliminated while opting for other processing methods to generate cleaner products like bio CNG.

## **USE OF SOLID FUELS IN HOUSEHOLDS - COMPLEX CHALLENGE**

The dynamic forecasting of contribution of pollution sources in Delhi by IITM shows a substantial share of residential biomass burning. This is one of the most complex dilemmas of Delhi as energy poverty continues in the capital city.

Even though officially the LPG connections have expanded under Central government schemes, with near 100 per cent coverage, the annual LPG refills that are needed for sustained use are not fulfilled. The available information shows that there is shortfall in refill targets. Despite the subsidy, poor households cannot often afford LPG and fall back on mixed fuel use. Moreover, the informal sector as well as construction industry, which attract large numbers of migrants, have limited access to LPG connection. This will require more inventive fiscal strategy at the local level even though this is a national challenge requiring inventive solutions to enable affordable and sustained access to clean fuel for all, especially poor and very poor households. However, restrictions on firewood and coal in eateries under the approved fuel list have reduced solid fuel usage in the city.

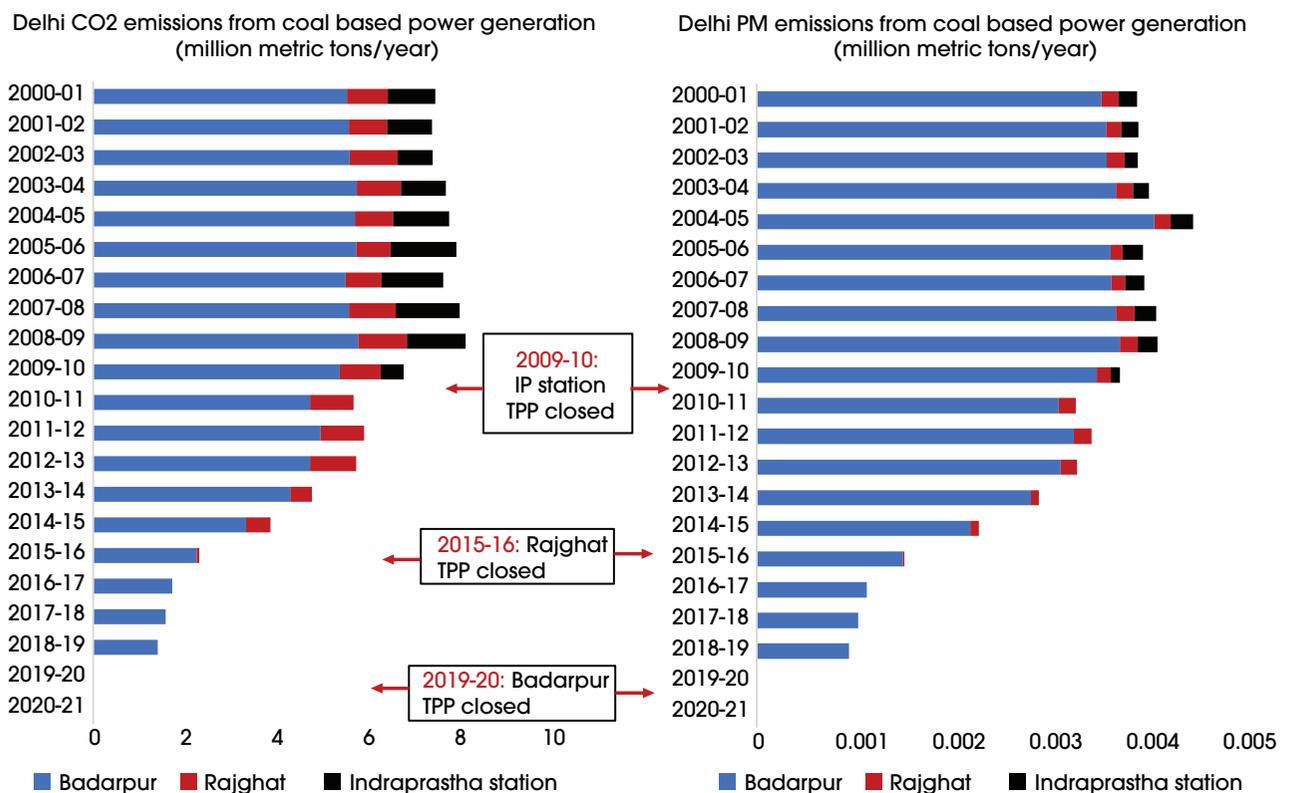
## DELHI'S WIN - EMISSIONS CO-BENEFITS FROM TECHNOLOGY AND FUEL TRANSITION

While Delhi's air quality management is an ongoing agenda, it is important to take note of the air quality benefits from the long-term action. The multi-sector interventions have enabled co-control of toxic local air pollution and also greenhouse gas emissions, providing both public health and climate change mitigation benefits.

There has been substantial reduction in the PM and CO<sub>2</sub> load from industry and transport in the capital city due to interventions that have enabled energy transition in both industry and transport sectors. As noted earlier, these measures have led to banning of coal in industry and power sectors and reduction of diesel consumption in the transport sector. These have enabled co-control of both local air pollution and warming gases, providing substantial co-benefits.

The minimisation of coal consumption in Delhi due to closure of the coal-based thermal power plants and ban on industrial coal, have reduced both particulate load and CO<sub>2</sub> load. With gradual and phased closure of coal power plants, it is possible to track the progress in emissions reduction in the city (see *Graph 26: CO<sub>2</sub> and PM emissions from coal-based thermal power plants in Delhi*) It is important to note that the complete closure

**Graph 26: CO<sub>2</sub> and PM emissions from coal-based thermal power plants in Delhi**

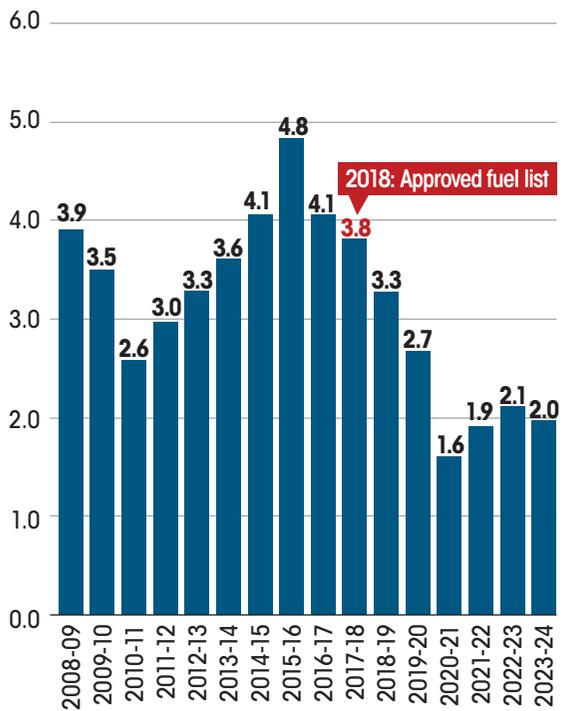


Note: This assumes thermal power plants had air pollution control devices with at least 90 per cent efficiency.

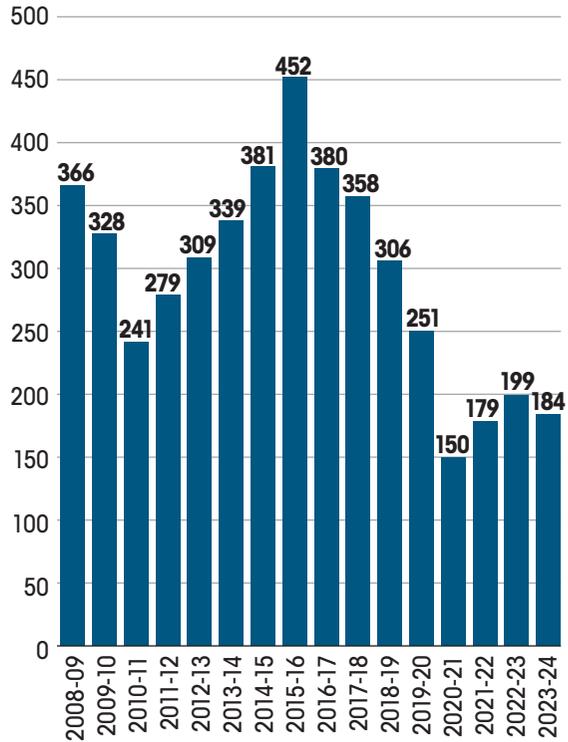
Source: CSE analysis based on CEA data

### Graph 27: CO<sub>2</sub> and PM emissions from diesel consumption in Delhi

CO<sub>2</sub> emissions from Delhi's Diesel consumption (million tonnes)



SPM emissions from Delhi Diesel consumption (tonnes)



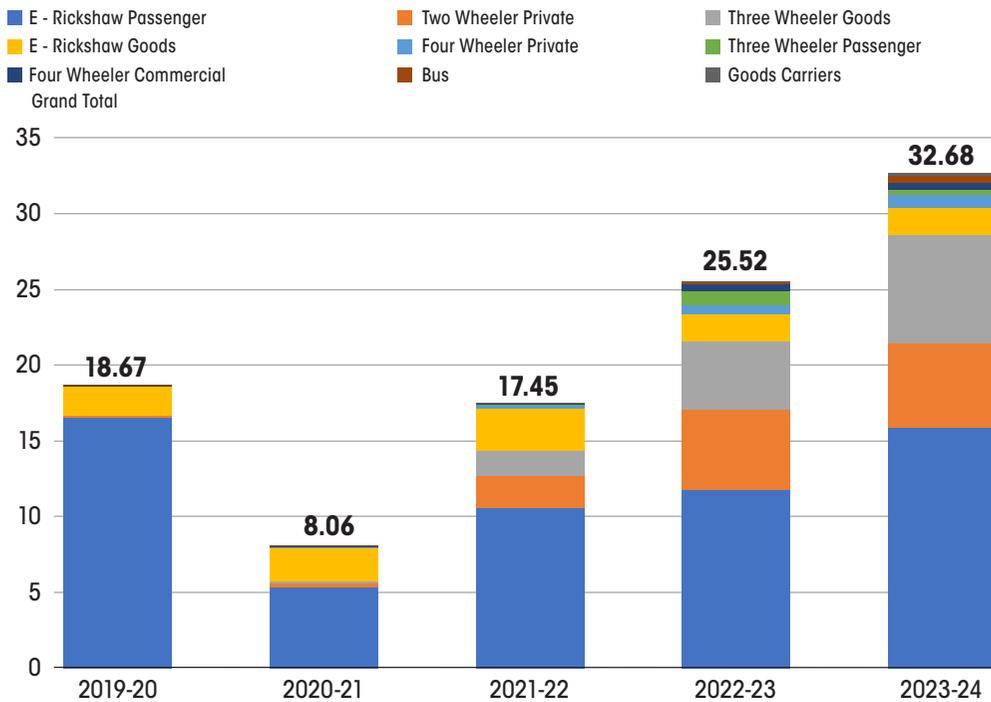
Source: CSE analysis based on PPAC data

of any given TPP is a gradual process wherein the most inefficient generating units are decommissioned first; which is evident how the emissions for all the three TPPs of Delhi decreased gradually.

Along with the decommissioning of coal-based power plants, coal was phased out of Delhi’s industry sector too. In 2007–08, the relocation of metallurgical cokeres itself removed 1.5 million tonnes of CO<sub>2</sub> and 1,710 tonnes of PM annually. As discussed earlier, as per the data of the Central Electricity Authority (CEA), Delhi has reported near zero coal consumption since 2015–16, with only a few tonnes consumed in 2020–23. Coal has witnessed a significant decrease after the implementation of approved fuel list in 2018. Moreover, Delhi also saw a gradual decrease in diesel consumption after various policy measures disincentivised diesel consumption. The impact of these actions was mirrored in the corresponding decrease in the load of CO<sub>2</sub> and particulate pollution from diesel combustion (see *Graph 27: CO<sub>2</sub> and PM emissions from diesel consumption in Delhi*).

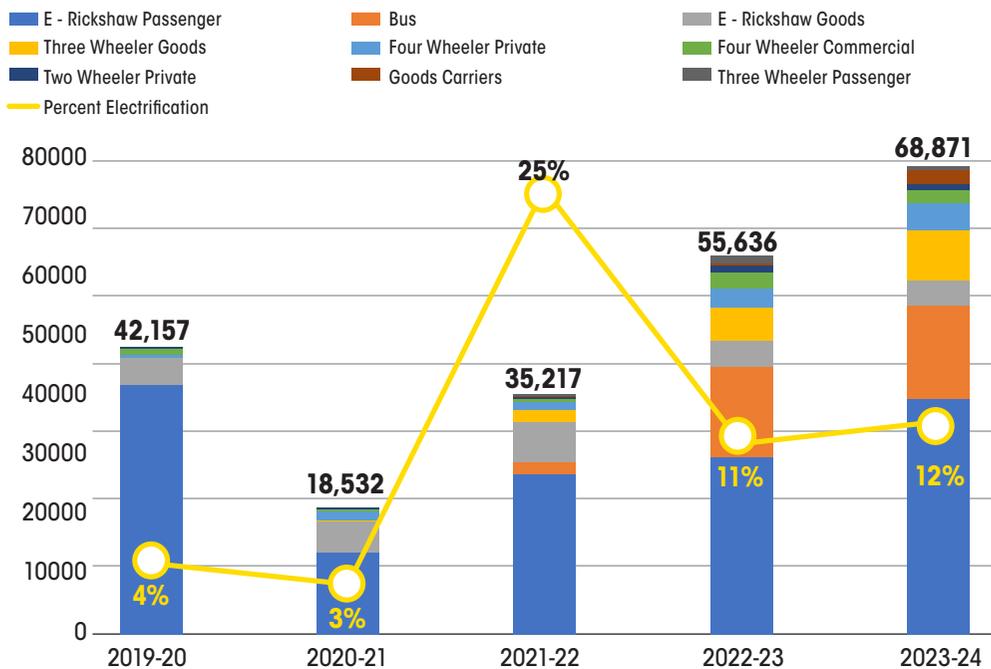
The impact of the technology and fuel transition in Delhi’s transport sector is evident through the PM and CO<sub>2</sub> avoided over the years. In 2023–24 alone, Delhi’s fleet avoided 32.68 metric tonnes of tailpipe PM and 68,871 metric tonnes of CO<sub>2</sub> due to electrification. It is important to note that Delhi’s ICE fleet has already transitioned to BS VI and hence the PM and NO<sub>x</sub> emissions from the new fleet has decreased significantly as compared to the corresponding BS IV and BS III fleet (see *Graph 28: PM avoided due to Delhi’s transition to ZEV* and *Graph 29: CO<sub>2</sub> avoided due to Delhi’s transition to ZEV*).

**Graph 28: PM avoided due to Delhi's transition to ZEV**



Source: CSE analysis

**Graph 28: PM avoided due to Delhi's transition to ZEV**



Source: CSE analysis

## DELHI'S DILEMMA AND THE NEW AGENDA FOR ACTION

Delhi's multi-sector clean air action so far has been the most diverse, structural and systemic in nature in several cases, and relatively more comprehensive compared to most other cities in the country. Its legacy action has specifically targeted energy transition in the transport and industry sector that has been taken forward. This is showing up in the energy consumption trends in these sectors with potential emission reduction benefits.

While this has helped to bend the long-term pollution curve, the clean air target is still way off. Delhi still requires another 62 per cent reduction to meet the national ambient air quality standards for PM<sub>2.5</sub>.

This presents a strong lesson for other cities regarding the scale and speed of change needed. The clean air action is still an unfinished agenda in Delhi.

The new agenda has to build scale and speed for the following action:

### Address the gaps to address transport emission

- **The electric vehicle policy 2.0 under preparation needs to deliver on its proposed target of 95 per cent fleet electrification by 2030 for zero emissions transition:** Adopt vehicle segment-wise targets, mandate annual zero emissions vehicle sales, adopt state-level incentive programmes, strengthen charging infrastructure, adopt tax measures to disincentivise internal combustion engines, adopt enabling financing strategies, and implement battery recycling system. This must not be diluted by linking state incentives and priority measures with the intermediate internal combustion technologies and fuels. The state incentives and priority need to be linked with fully battery operated electric vehicles.
- **Advance on-road emissions monitoring by introducing remote sensing monitoring for effective screening and identification of worst emitters.** Connect vehicle inspection with the automated testing centres for identification of end-of-life vehicles.
- **Strengthen the electric bus programme and significantly improve service level of bus service city-wide:** Make DTC and DIMTS liable for targeted improvement in bus ridership that is monitorable and verifiable. Only monitoring number of kilometres per bus per day will not help. Advance bus infrastructure and ITS system to upgrade passenger information system ensure reliable services especially during peak hours, and improve safe access.
- **Upscale multi-modal integration for city-wide implementation:** Integrate metro and bus service with advanced last-mile connectivity (feeders and para-transit) for seamless journeys. Ensure physical integration of all metro stations, information integration for improved passenger information and service for all modes, and fare integration to reduce interchange penalty and journey costs and make public transport affordable for all.

- **Mandatory implementation of ward-wise parking management areas plans to manage and reduce demand for parking and promote low emission zones:** Implement ward-wise PMAPs to identify and demarcate legal parking areas, penalise illegal parking, prohibit parking on footpaths, green areas, on emergency vehicle lanes, near intersections etc. Implement variable parking and eliminate free parking city-wide. Implement proof of parking policy linked to PMAPs. Promote shared usage of parking facilities to optimise use. Simultaneously, implement low emissions zones in targeted areas to encourage use of clean and zero-emission vehicles and intensify public transport services. Mandate sustained upkeep and maintenance of the pedestrian zones and infrastructure and not let the systems degenerate. Hold implementing agencies accountable.
- **Implement transit-oriented development policy in all redevelopment and new development areas:** Redevelop and regenerate influence zones around the key metro stations and transit lines to get more people to live closer to the transit lines, regenerate the area to make it more walkable and cyclable with improved infrastructure, make metro stations and commercial nodes more accessible, change the urban and road design to make it people friendly and more transit oriented in compact neighbourhoods.
- **Develop financial plan for implementation** of the requisite public transport infrastructure to upgrade service level to make the systems more financially sustainable.

### **Addressing gaps in industrial pollution control**

- Strengthen piped natural gas network adequately to ensure 100 per cent coverage of all industrial units. Promote electrification of industrial process as applicable.
- Adopt a natural gas pricing strategy to keep the cost of natural gas affordable on a longer term basis.
- Bring industrial units in peripheral and non-conforming areas within monitoring system and mandate display of consent to operate certificate from Delhi Pollution Control Committee: This can help to enable implementation of clean fuels and emissions control approaches all across.
- Inventorise all industrial units across all land-uses.
- Implement industrial non-hazardous waste management plan to prevent open dumping and burning of industrial waste.
- Strengthen smart monitoring of industries

## Waste management and circularity - upscale action

### ***Municipal solid waste***

- Enforce the mandate to meet the target of 80 per cent diversion of MSW from landfills and dumpsites by expanding capacity of waste processing for material recovery
- Mandate 100 per cent collection of segregated MSW from all households including informal areas. Integrate informal waste collectors with the formal system through cooperative models or any other innovative model.
- Expand processing capacity of wet and dry waste.
- Stringent implementation of the obligation of the bulk waste generators for collection, segregation, transport and in-situ processing of waste.
- Tipping fee should be linked with segregated waste collection and not collection of mixed waste.
- Expand collection of user fee to mobilise resources for waste infrastructure development.
- Quantify and characterise real-time waste generation in each ward and make **the** data trackable online.
- Prioritise circular economy with compressed biogas generation from municipal **solid** waste to inject the CNG pipeline instead of waste to energy plants. Ensure use of 100 per cent segregated waste as feedstock in the existing plants with stringent emission control system.

### ***Construction and demolition waste - further strengthen the system***

- **Maximise capacity utilisation of all C&D processing plants.** This requires stronger collection system, segregation, GPS enabled tracking of C&D waste transport, and stringent enforcement for bulk waste generators to transport waste to the plants or designated collection modes.
- **Mandate at least 20 per cent of the material in new construction to be recycled material in both government and private construction.** Issue certificates as proof of usage of recycled material.
- **Rationalise collection points to reduce distances for waste collection and transportation.**
- **Mandate waste management plans for approval of building projects.**
- **Incentivise industry to segregate and reuse waste.**
- **Issue demolition permits.**

- **Quantify and characterise C&D waste.**
- **Stringent regulations will be imposed on construction sites to enforce strict compliance with pollution control measures.**

### **Eliminate use of solid fuels in households**

- **Implement financing systems to upscale and ensure sustained use of affordable LPG in households:** Government policies have helped to upscale use of clean household energy like LPG in the city. But its use is not consistent in a large number of households as evident in the lower rate of annual refills. The night shelters and rental housing for the migrants can be equipped with LPG connected kitchens.
- **Implement financing systems to upscale and ensure sustained use of affordable LPG in households:** Government policies have helped to upscale use of clean household energy like LPG in the city. But its use is not consistent in a large number of households as evident in the lower rate of annual refills.

### **Strengthen regional airshed-level air-quality management**

- While Delhi needs to upscale its multi-sector strategy to address the remaining gap areas, this needs to be co-joined with larger regional-level implementation of priority strategies in the NCR region and beyond to reduce the influence of transboundary movement of pollution on local air quality.

