# Fleet Modernization: solution to achieve better air quality

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**AT A GLANCE**

- India's transport demand has grown from a total of 5.3 million in 1981 to 230 million in 2016, with two wheelers and cars having 73% and 14% shares, respectively. Commercial vehicles though constitute only about 5% of total fleet, contribute to nearly 80% of total PM emissions.
- Phase wise implementation of fleet modernization (transforming pre BS-IV commercial vehicles to BS-VI) would lead to 40-80% reduction in PM and NOx emissions from the sector by 2025.
- The total number of avoided mortality from attributable to $PM_{2.5}$ reduction from fleet modernization between 2020 and 2040 is estimated to be more than 500,000.
- The net present value of the total economic cost to consumer because of fleet modernization is estimated to be INR 13,000 billion and the total economic benefit is estimated to be INR 14,200. Thus the cost-benefit ratio of fleet modernization is estimated to be 1.1:1.
- If the government provides 50% excise duty exemption on purchase of new vehicle, the total cost of the vehicle to the consumer will decline by 8-10% than the current price.

## 1. Introduction

Air pollution has become a crisis in India. A recent WHO study has fourteen Indian cities featuring in the top fifteen most polluted cities in the world (WHO, 2018)[1]. Breach of ambient air-quality standards in about 80% of Indian cities presents a grim picture across the country (CPCB, 2019)[2]. Over the last several years, $PM_{10}$ concentrations in Delhi have remained well above the prescribed national standards[2] (Fig.1).

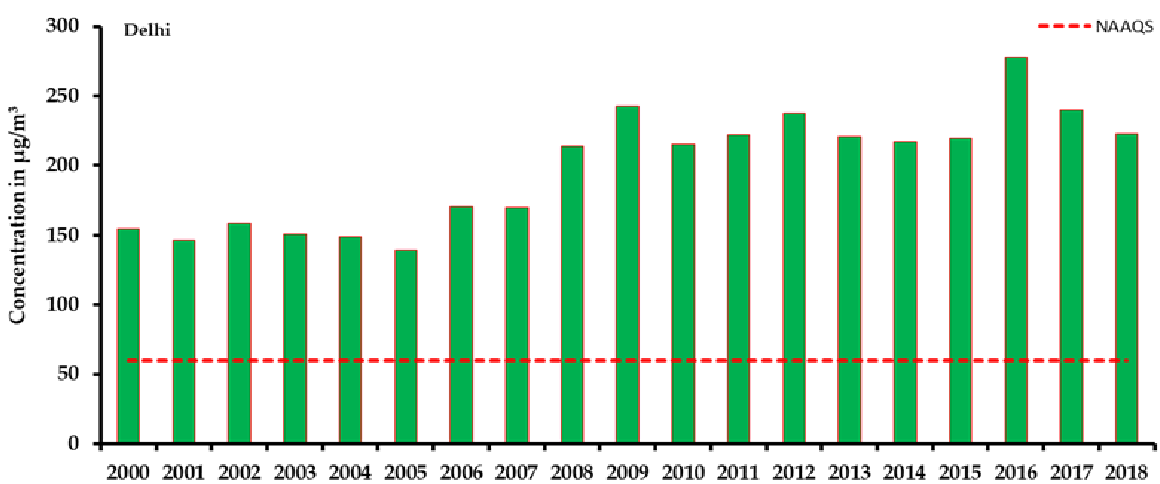


Figure 1: $PM_{10}$ Concentrations in Delhi over the years. Source: CPCB

Exposure to high pollutant levels is linked with cardiovascular and respiratory disease, and even cancers (WHO, 2018)[3]. Among various pollutants, $PM_{2.5}$ has been found to have one of the strongest associations with mortality and morbidity (Cohen et al. 2005, Dockery & Pope 1994 and HEI 2010)[4]. Since these particles are extremely small sizes they tend to get into human organs thereby affecting them over time. As per recent estimates by the WHO, in both cities and rural areas, exposure to ambient $PM_{2.5}$ concentrations were estimated to cause 4.2 million premature deaths worldwide per year (WHO, 2018)[3]. In 2017, long-term exposure to ambient $PM_{2.5}$ contributed to a loss of 21.3 million disability-adjusted life years (DALYs) in India (HEI, 2019)[5]. In Delhi the number of deaths attributable to air pollution was estimated to be 12,322 in 2016 (ICMR 2018)[6]. The neighbouring states like Haryana and Uttar Pradesh also have a high incident rate of deaths caused by air pollution. It has been estimated that the number of deaths due to outdoor air pollution in Uttar Pradesh was around 161,178 and 19,788 in Haryana in 2016[6].

Vehicular emissions are one of the major contributors of air pollution in India. Vehicles are known to emit high quantities of PM and NOx emissions. Registered vehicles in India have grown from a total of 5.3 million in 1981 to 230 million in 2016 (Fig.2), with two wheelers and cars having 73% and 14% shares, respectively. 31% of vehicles are registered in million plus cities only (MoRTH, 2016)[7].

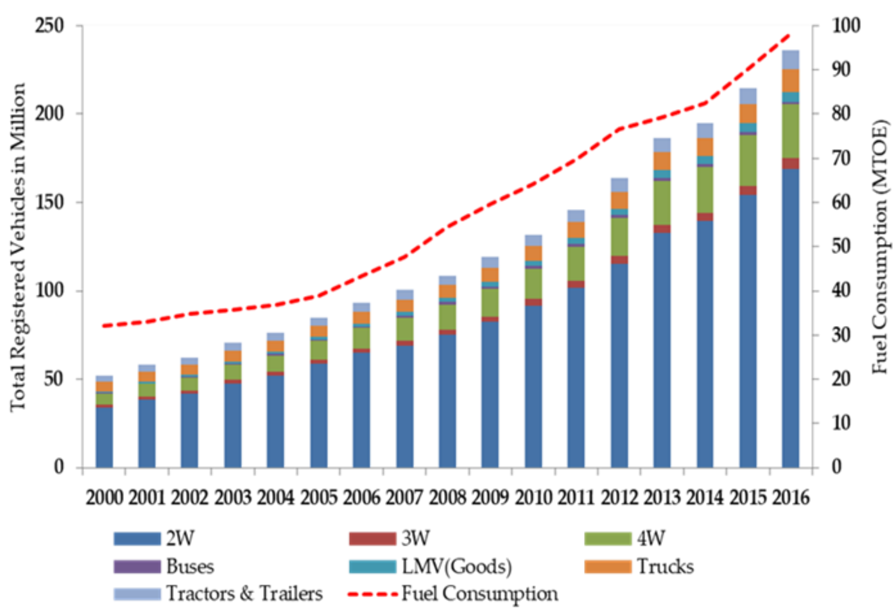


Figure 2: Total Registered Vehicles in India over the years
Source: MoPNG

Other than primary pollutants, gaseous pollutants (NOx, VOCs) released from transport sector are precursors for the secondary pollutants such as ground level ozone, which is also known to cause several respiratory diseases (Liu et al., 2018)[8]. In 2011, transport sector contributed to about 38% of total oxides of nitrogen ($NO_x$), 5% of particulate matter less than 10 µm ($PM_{10}$) and 7% of carbon monoxide (CO) emissions at the national scale in India (Sharma et al., 2016)[9]. These emissions are concentrated at the urban centers, where their contribution to the prevailing air pollutant levels is found to be much higher. For example, a source apportionment study conducted by TERI shows that, among all the sources in Delhi, transport emerged as one of the significant source with 23% of contribution to $PM_{2.5}$ concentrations (TERI, 2018)[10]. An average sectoral contribution in $PM_{2.5}$ concentrations in Delhi is shown in Figure 3.

As per TERI's assessment at national scale in 2016, commercial vehicles (Buses, trucks and light commercial vehicles) though constitute only about 5% of total fleet, contribute to nearly 80% of total PM emissions. Of these, the older commercial vehicles, typically manufactured before 2000, constitute less than 1% of the total fleet but contribute to 23% of the total PM emissions as these pollute 10-12 times more than a modern vehicle. Since India is dealing with air pollution crisis, there is a strong need for a policy targeting scrapping of old commercial vehicles and replacing them with the newer, greener fleet, which can be really useful in reducing vehicular emissions in the country.

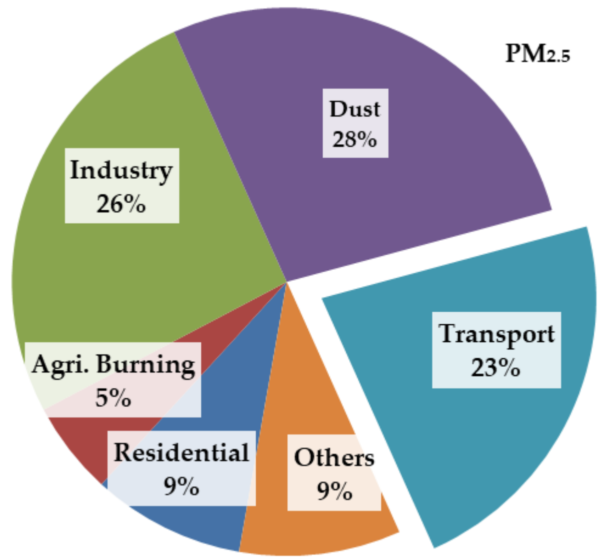


Figure 3: Average sectoral contribution in $PM_{2.5}$ concentrations in Delhi Source: TERI, 2018

This policy brief aims to analyze the issue in terms of challenges with regards to phasing out of old vehicles and plausible solutions. The brief assesses the contribution of transport sector towards emission and pollutant concentrations at a national scale, and also the cost-effectiveness of incorporating fleet modernization in India. This brief argues for need of the vehicular fleet modernization scheme in India.

## 2. Existing policies to control tail pipe emission from transport sector

In order to control air pollutant emissions from the transport sector, the Auto Fuel Policy, was introduced in 2002 (MoPNG, 2002)[11], which laid out the roadmap for the introduction of advanced vehicular emissions and fuel quality norms in India (BS-I to BS-IV) by the year 2010. In 2016, Government of India had announced leap frogging from BS-IV to BS-VI vehicle emissions for the whole country in the year 2020. The major difference between the existing BS-IV and forthcoming BS-VI norms is the presence of sulphur in the fuel. While the BS-IV fuels contain 50 parts per million (ppm) sulphur, the BS-VI grade fuel only has 10 ppm sulphur content[12]. Once BSVI emission norm is implemented, in case of cars, a reduction of 82% in PM emissions and 68% in NOx emission is expected to be seen (Vashist et al., 2017)[13].

Ministry of Road Transport and Highways (MoRTH) commissioned a study in March, 2016 to design the Voluntary Vehicle Fleet Modernization Programme for phasing out of older commercial vehicles with newer fuel efficient and environment friendly vehicles. The program is still to be launched and implemented at the national level (MoRTH, 2018)[14]. The program aimed at pushing 28 million decade-old polluting vehicles off the road and incentivizing people to retire their old vehicles that were bought before March 2005 or are below BS IV standards. This means vehicles such as taxis, three-wheelers, trucks and buses that were registered before 2000 cannot ply on road from April 1, 2020 and subsequently any commercial vehicle reaching the 20 year age limit will be automatically de-registered.

The proposed program offers a fair value for the scrap and excise duty at 50% of the normal rate on the purchase of new vehicle. The program recommends complete excise exemption for state transport buses to encourage public transport to shift to newer and higher capacity buses, which will also help decongest roads. Given that commercial vehicles change hands two to three times during their lifecycle, ways to issue tradable certificates, which would incentivize the last owner to scrap the truck, and subsidize the purchase of the primary buyer would need to be part in place. The number of vehicles to be scrapped (type and age of vehicles it is required for), type of incentive it may offer for its effective implementation (excise duty exemption), infrastructure creation (recycling and shredding centers) and investments had also to be determined.

## 3. Impacts of Fleet Modernization scheme

In order to estimate the impact of fleet modernization in short, intermediate and long-term, a Business as Usual (BAU) scenario has been developed for the period 2016-2040, which takes into account the growth in energy consumption in the transport sector along with implementation of BS VI norms as planned. The energy consumption for different categories of vehicles is projected using TERI MARKAL model. Emission factor database of ARAI has been used for the emission assessment.

BAU scenario assumes fleet-turnover to BS-VI vehicles without any fleet modernization scheme. Based on the growth in energy consumption, the BAU scenario has been developed and emission loads for different pollutants like $PM_{2.5}$ and NOx have been estimated and are shown in Figure 4. From 2016 to 2040, the total $PM_{2.5}$, and NOx emissions from the transport sector are projected to decrease by 27% and 45% respectively. The decrease in emissions can be primarily attributed to introduction of BS-VI emission norms from April 2020 onwards.

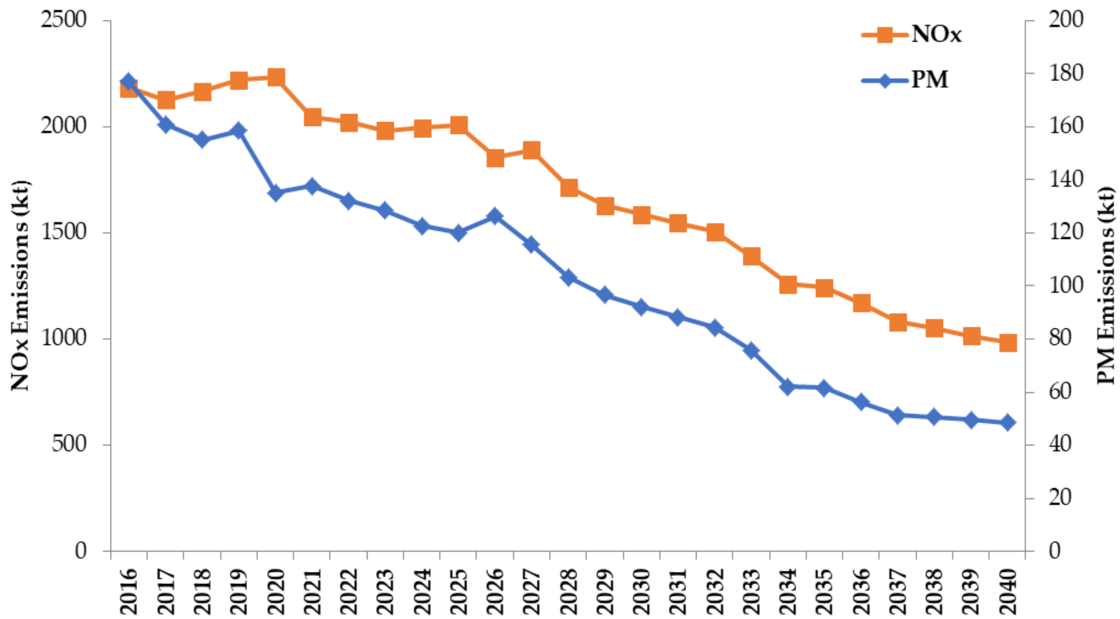


Figure 4: Emission profile in BAU Scenario

An alternative scenario ALT (FM) has been developed on the basis of a proposed fleet modernization programme based on incentives so as to get the benefits from BS-VI at an accelerated pace. The description of alternative scenario is provided in Table 1.

Table 1: Phases wise implementation of fleet modernization scheme in different years

| Phase | Implementing Year | Strategy | Description |
|---|---|---|---|
| I | 2020 | All BS-I + All BS-II commercial vehicles transformed to BS-VI | Vehicles of age 11 years or older to be replaced with BS-VI equivalent |
| II | 2021 | All BS-II + BS-III commercial vehicles that are registered between (2010-2013) transformed to BS-VI | Vehicles of age 8 years or older to be replaced with BS-VI equivalent |
| III | 2022 | All BS-II + All BS-III commercial vehicles transformed to BS-VI | Vehicles of age 6 years or older to be replaced with BS-VI equivalent |
| IV | 2025 | All BS-IV commercial vehicles transformed to BS-VI | Vehicles of age 6 years or older to be replaced with BS-VI equivalent |

The alternative scenario has been assessed to derive overall emission reductions in the transport sector if fleet modernization comes into practice in 2020. Through an example Figure 5 explains the methodology for assessing emission reduction potential of implementing phase wise fleet modernization in India.

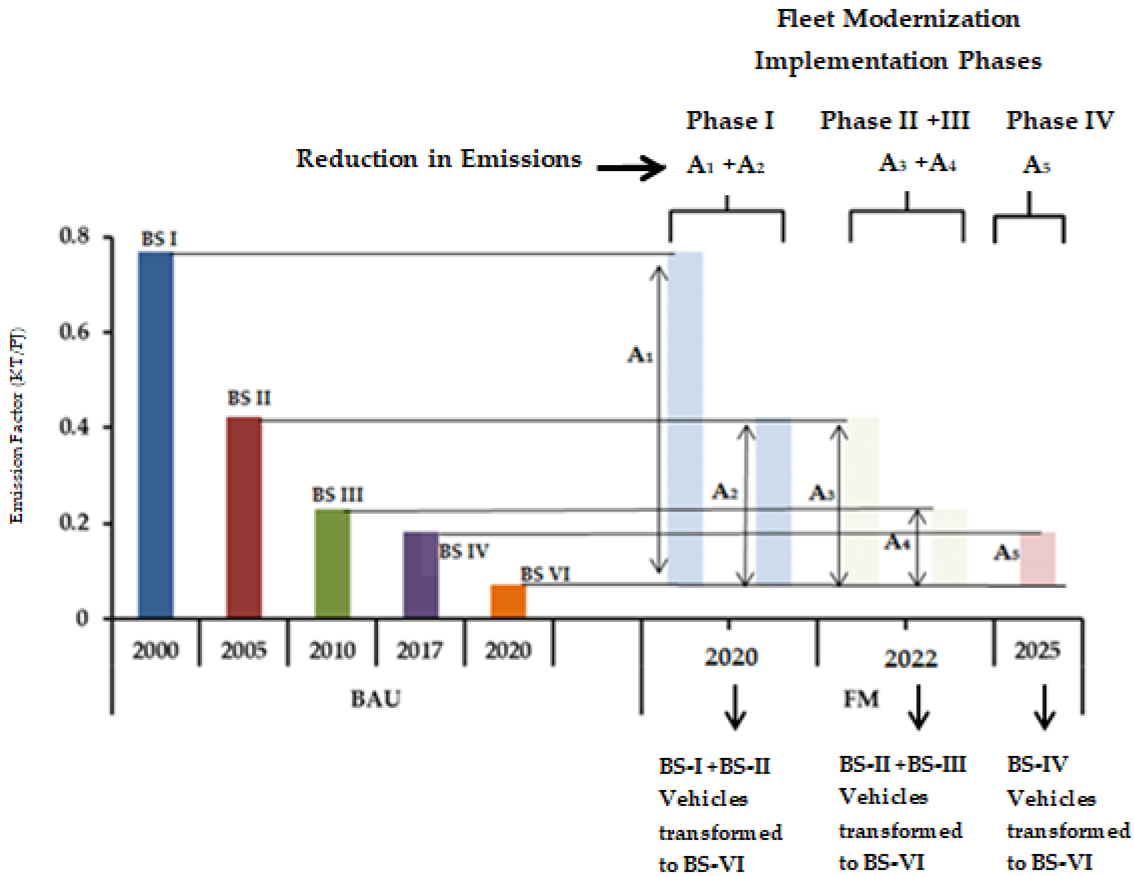


Figure 5: Methodology for assessing emission reductions in alternative (FM) scenario

### a. Reduced air pollutant emissions

In $PM_{2.5}$ emissions, fleet modernization can lead to 40% reduction in 2020, 58% in 2021, 69% in 2022 and 79% in 2025 in India, with the above specified interventions applied in each year (Table 2). After the year 2025, the emissions will increase as the number of vehicle on the roads increases and will be equal to emissions in the BAU scenario in 2040. In this way, the cumulative reduction of $PM_{2.5}$ emissions due to the fleet modernization scheme during 2020-2040 will be 1167 kt.

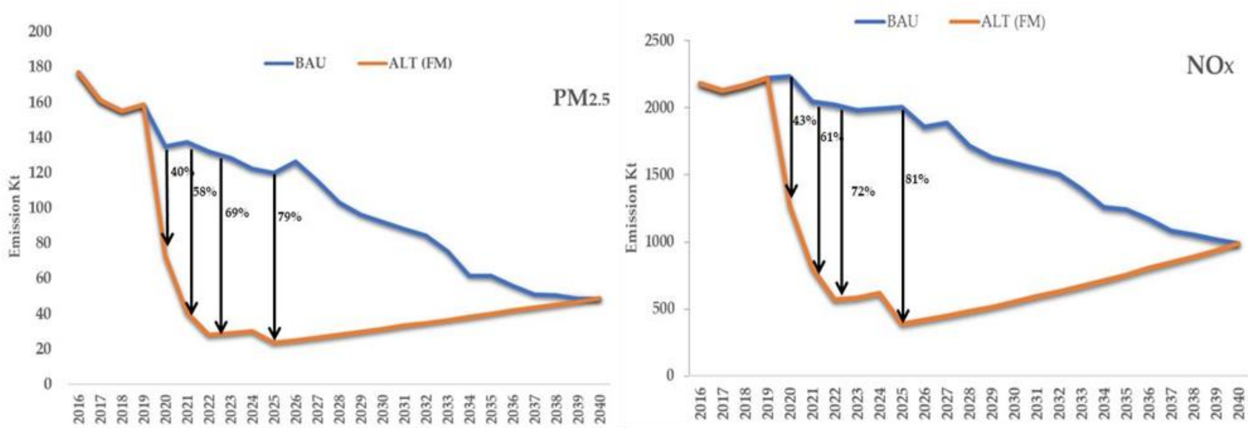


Figure 6: Total $PM_{2.5}$ and NOx emissions in India in BAU and ALT scenario

In $NO_X$ emissions, Fleet modernization (replacing older vehicles with BS-VI) can lead to 43% reduction in 2020, 61% in 2021, 72% in 2022 and 81% in 2025, in India, with the above specified interventions applied in each year. In this way, the cumulative reduction of NOx emissions due to the fleet modernization scheme with respect to the BAU during 2016-2040 will be 18788 kt.

Table 2: Emission reduction potential of fleet modernization scheme in different years

| Phase | Implementing Year | Strategy | Reduction in Emissions | |
|---|---|---|---|---|
| | | | $PM_{2.5}$ | $NO_x$ |
| I | 2020 | All BS-I + All BS-II commercial vehicles transformed to BS-VI | 40% | 43% |
| II | 2021 | All BS-II + BS-III commercial vehicles that are registered between (2010-2013) transformed to BS-VI | 58% | 61% |
| III | 2022 | All BS-II + All BS-III commercial vehicles transformed to BS-VI | 69% | 72% |
| IV | 2025 | All BS-IV commercial vehicles transformed to BS-VI | 79% | 81% |
| Total cumulative reduction during 2020-40 | | | 1167 kt | 18788 kt |

Higher reductions have been observed in NOx emissions than in $PM_{2.5}$, the reason being more reduction in NOx emission factors than PM between BS III/BS IV and BS VI vehicles (Figure 7).

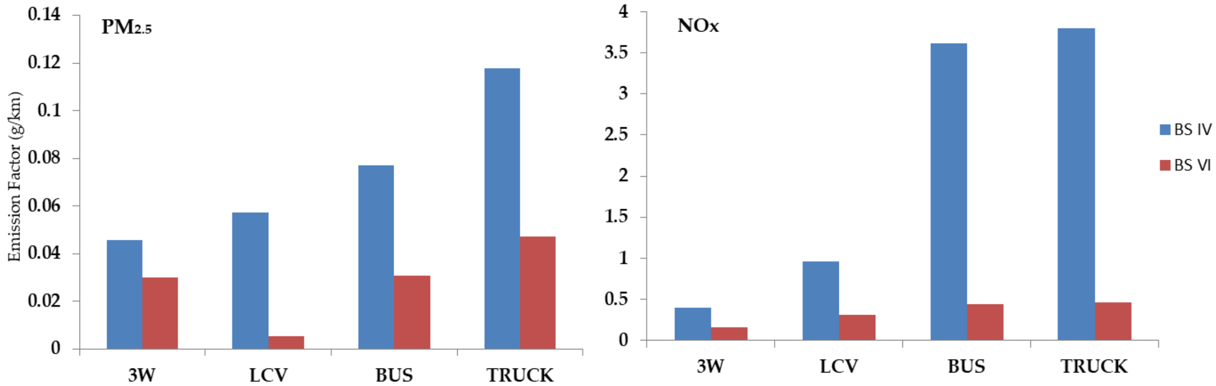

Figure 7: Difference in BS IV and BS VI emission factors.

In case of $PM_{2.5}$, the difference between BS-IV and BS-VI emission factors for 3W's is insignificant; therefore, replacement of BS-IV powered 3W's with motorized electric vehicles, can also be thought as an option for modernizing the fleet. 50% incentive on the GST is being suggested, once the 3W is replaced with the electric one. While the Supreme Court has already banned the extended fitness of a vehicle beyond its 15-year stipulated life in metros like Delhi, the big challenge lies as to how vehicle owners go about disposing off their vehicles, which have completed their time on the road, in a legal way. Currently, scrapping of vehicles is handled by unorganized sector in India and is highly unscientific, leading to pollution. There is a need to establish regionally licensed vehicle dismantling units all over India to handle the scrapping of vehicles in scientific manner. Moreover, this would boost sales of automobiles leading to higher production capacity utilization and provide revenue to government in terms of 50% of excise duty as a tax as additional sales would take place due to the incentive of fleet modernization which could otherwise have not taken place.

**b. Reduced impact on human health and economy**

Ambient air pollution is widely known to have severe negative impacts on human health. Many other studies have established a strong correlation between air pollutants and human health impacts (Kan, 2007; Pope, 2002; Schwartz, 1996; Dockery, 1993)[4]. The Indian Council of Medical Research (ICMR) considers air pollution as the second leading health risk factor in India after child and maternal malnutrition. In the past years, a number of additional studies (IIASA, 2015; TERI, 2018; Crooper et al., 2018)[15] estimated the health effects associated with ambient air pollution in India.

The study here has assessed the impacts of ambient air pollution on human health because of fleet modernization in the country. It quantified both the health and economic benefits arising from exposure to atmospheric particulate matter in the $PM_{2.5}$ because of fleet modernization in all the states. Figure 8 explains the overall approach for estimating the health impact of exposure to ambient particulate matter. The approach is broadly divided in two components:

the disease burden estimation (or avoided mortality) and the quantification of the health impact or estimating the health benefit.

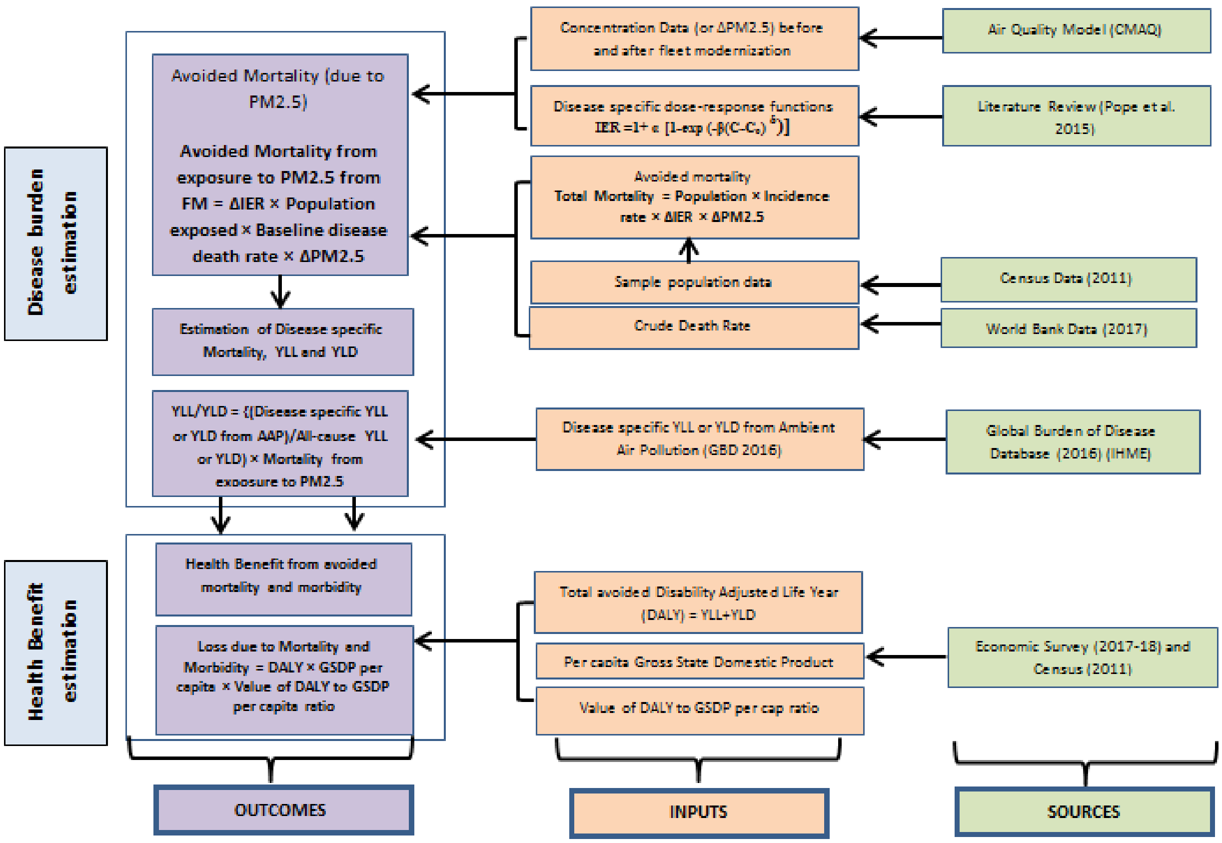


Figure 8: Overall methodology for estimation of the health impact and economic impact of fleet modernization

The air quality modeling was carried out using the Community Multi-Scale Air Quality model (CMAQ). The output of the air quality modeling exercise was in the form of pollutant concentration at each grid in the study domain. These grid level concentrations were population weighted and aggregated at the state level. The study then quantified the specific impacts of fleet modernization, by estimating the decremented risk arising because of fleet modernization. The associated avoided deaths and savings in the form of economic benefits due to improvements in air quality were analyzed based on the change in $PM_{2.5}$ concentrations. Based on the exposure of the population, health impacts were quantified in terms of disease-specific mortality caused from the decremented $PM_{2.5}$ because of fleet modernization. Concerning disease-specific mortality, the study estimates the health impacts of four diseases, cardiopulmonary diseases (COPD), lung cancer (LC), ischemic heart disease (IHD) and lower respiratory infections (LRI) attributable to ambient particulate matter. The health impact was captured through the integrated exposure risk function (IER) developed by (Burnett et al., 2014)[16]. Following the GBD 2016 data, the derivative of IERs are employed to estimate the decremented relative risk attributable to $PM_{2.5}$ exposure for the four diseases specified (Cropper et al. 2015)[17]. The IERs have been employed here to estimate relative risks attributable to $PM_{2.5}$ exposure for four endpoints, lower respiratory infection (age below 5), chronic pulmonary disease (age above 30), lung cancer (age above 40) and ischemic heart disease (age above 25). The coefficients pertaining to each disease have been estimated for India using the data for $PM_{2.5}$ concentration and the related risk for 4042 data points provided by Apte et al. (2015)[18].

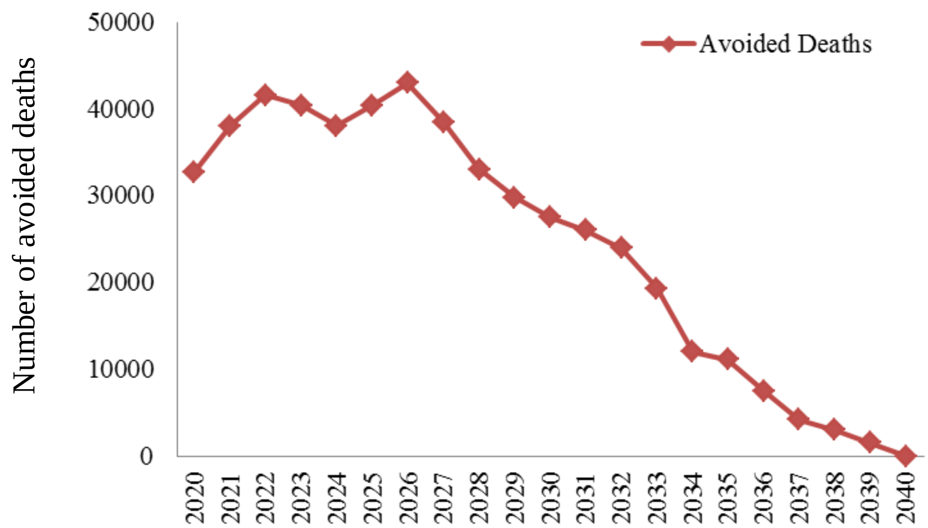


Figure 9: Avoided deaths from fleet modernization in India between 2020 and 2040

The PM2.5 levels from the transport sector significantly declines due to fleet modernization and subsequent increase in health benefits. The total avoided deaths in India due to fleet modernization are estimated to increase from almost 32,600 to 43,000 between 2020 and 2026 and thereafter the mortality decreases. The cumulative deaths avoided due to fleet modernization between 2020 and 2040 are more than 500,000.

In order to arrive at the economic benefits associated with fleet modernization, years lived with disability (YLDs) and years of life lost (YLLs) were estimated. The cumulative health benefits arising from avoided mortality and morbidity attributable to the reduction in PM2.5 from fleet modernization is INR 7010 billion. Economic benefits increase from INR 314 billion in 2020 to reaches a peak of INR 567 billion in 2026 and subsequently falls beyond till 2040. The net present value of health benefits (at 10% discount rates) is INR 3800 billion. Thus fleet modernization can lead to significant positive health impacts for India in the next two decades.

**c. Other Benefits**

There are other benefits perceived over and above the health benefits. Selected benefits are briefly described below.

- **Scrap value:** Vehicle retirement will fetch revenue through scrapping at designated vehicle dismantling and recycling centers depending on the vehicle type and make, etc. The discounted present value of revenue that can be generated through vehicle scrapping has been estimated at INR 2900 billion (using 10% discount rate).
- **Fuel Efficiency Benefits:** The transition to BS VI fleet is reported to increase average fuel efficiency by 1%. Hence the discounted net present value of the economic benefits calculated is more than INR 6000 billion (using 10% discount rate).
- **Government revenue:** Further, providing 50% rebate on excise duty, government can still have net positive cash flows. The net present value of the positive cash flow for the exchequer is estimated at INR 1500 billion.

**d. Economic Cost**

Fleet modernization will lead to an upfront cash outflow from the consumer and the opportunity cost. The net present value of opportunity cost to consumer from accelerating fleet modernization is estimated at INR 13,000 billion.

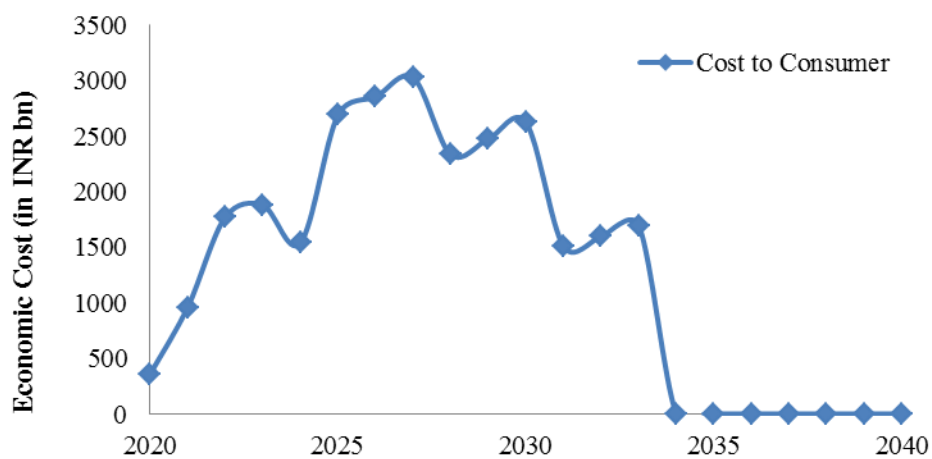


Figure 10: Net Cost to consumer due to fleet modernization in India between 2020 and 2040

**e. Benefit to Cost Analysis**

The total cost of fleet modernization is estimated to be INR 13,000 billion; however the cumulative economic benefit accruing from health impact, scrap, fuel efficiency and government revenue is INR 14,200 billion. Therefore the cost-benefit ratio of this policy is 1.1:1. Thus the faster implementation of this policy would lead to more overall benefit than the cost.

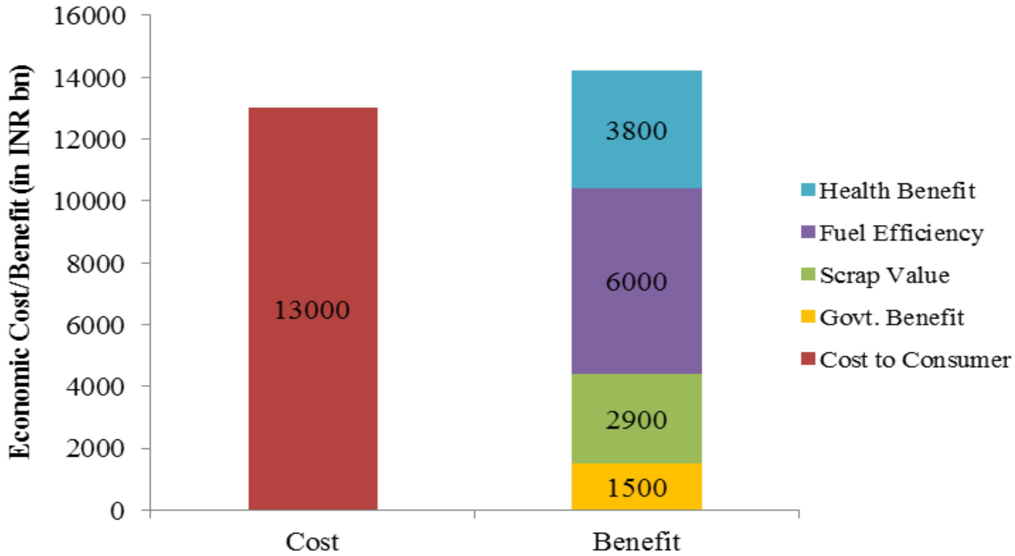


Figure 11: Total cost and benefit due to fleet modernization in India between 2020 and 2040

## 4. Key actions required for implementation of fleet modernization scheme

The fleet modernization program can significantly benefit the air quality and reduce the associated health and economic burden, especially in the cities of India. One of major challenge faced by the government in implementation of fleet modernization is setting up of authorized scrapping centers and ensuring that the scrapped vehicles are not restored. There is a need to establish licensed vehicle dismantling units on self-sustainable business model. These dismantling units can provide a scraping certificate to the vehicle owner, on the basis of which, the owner can claim the incentives. Also this study states that if the government provides 50% excise duty exemption on purchase of new vehicle, the total cost of the vehicle to the consumer will decline by 8-10% than the current price. As discussed in the Section 3, first the scheme can be rolled on for pre-BS-III commercial vehicles and thereafter for other vehicles. In the present circumstances, it is recommended that government should go ahead with fleet modernization program at the earliest possible to maximize the air quality and economic gains.

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