DISCUSSION PAPER

National Transport
Decarbonization Council

EMISSION REDUCTION AND EFFICIENCY IMPROVEMENT

teri
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About National Transport Decarbonization Council

The Intergovernmental Panel on Climate Change (IPCC) reports a serious need to implement transport decarbonization policies in India. The responsibilities to draft and implement the decarbonization policy fall under the various ministries of the central government. An effective decarbonization policy requires collaboration between various central ministries, civil societies, activists, industry, technology providers, and research organizations. The need of the National Transport Decarbonization Council (NTDC) is to bring all the stakeholders to a single platform.

Role of the Council

To develop a common understanding of transport decarbonization measures and build consensus among policymakers at various levels. Under the guidance of the council, three theme-based workshops on key issues in the transport sector were organized to discuss the pivot issues and challenges in achieving decarbonization and formulating various strategies. The deliverables also include the preparation of a discussion paper on each of the themes.

The themes identified for the study are:

1. Vehicle Scrappage Policy
2. Emission Reduction and Efficiency Improvement

   Part A: CO_2 emission reduction through fuel efficiency improvement

   Part B: Future road map for tightening emission standards
3. Biodiesel as Fuel

This discussion paper is on the second theme – Emission Reduction and Efficiency Improvement.

To know more about NTDC: https://www.teriin.org/project/national-transport-decarbonization-council

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List of Abbreviations

AIS	Automotive Industry Standards
AISC	Automotive Industry Standards Committee
AMP	Automotive Mission Plan
ARAI	Automotive Research Association of India
BEE	Bureau of Energy Efficiency
BEV	Battery Electric Vehicle
BSES	Bharat Stage Emission Standards
CAFÉ	Corporate Average Fuel Economy
CBG	Compressed Biofuel Gas
CNG	Compressed Natural Gas
CO	Carbon Monoxide
COP	Conference of Parties
CPCB	Central Pollution Control Board
CSFC	Constant Speed Fuel Consumption
DPF	Diesel Particulate Filter
ECE R49	Economic Commission for Europe Regulation 49
EPA	Environmental Protection Agency
ESC	European Stationary Cycle
ETC	European Transient Cycle
EU	European Union
EVs	Electric Vehicles
FAME	Faster Adoption and Manufacturing of (Hybrid and) Electric Vehicles
GDI	Gasoline Direct Injection
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GoI	Government of India
GVW	Gross Vehicle Weight
HDV	Heavy Duty Vehicle
HEV	Hybrid Electric Vehicle
ICAT	International Centre for Automotive Technology
ICE	Internal Combustion Engine
IPCC	Intergovernmental Panel on Climate Change
ISC	In-service Conformity Test
ITS	Intelligent Transport Systems
JC05	Japanese Emission Test Cycle

LDV	Light Duty Vehicle
LPG	Liquified Petroleum Gas
MIDC	Modified Indian Driving Cycle
MMT	Million Metric Tonne
MNRE	Ministry of New and Renewable Energy
MoEFCC	Ministry of Environment, Forest and Climate Change
MoHUA	Ministry of Housing and Urban Affairs
MoP	Ministry of Power
MoPNG	Ministry of Petroleum and Natural Gas
MoRTH	Ministry of Road Transport and Highways
MOSPI	Ministry of Statistics and Programme Implementation
MT	Million Tonnes
MTOE	Million Tonnes of Oil Equivalent
NAPCC	National Action Plan on Climate Change
NDC	National Determined Contribution
NEDC	New European Driving Cycle
NITI Aayog	National Institute of Transforming India Aayog
NMEEE	National Mission for Enhanced Energy Efficiency
No_x	Nitrogen Oxides
OBD	On-Board Diagnostic
OEM	Original Equipment Manufacturer
PEMS	Portable Emissions Measurement Systems
PHEV	Plug-in Hybrid Electric Vehicle
PM	Particulate Matter
PN	Particle Number
PPAC	Petroleum Planning and Analysis Cell
SATAT	Sustainable Alternative Towards Affordable Transportation
SIAM	Society of Indian Automobile Manufacturers
UDC	Urban Driving Cycle
VECTO	Vehicle Energy Consumption Calculation Tool
WHSC	World Harmonized Steady State Cycle
WHTC	World Harmonized Transient Cycle
WLTC	Worldwide Harmonized Light Duty Vehicle Test Cycle
WLTP	Worldwide Harmonized Light Duty Vehicle Test Procedure
WNTE	World Harmonized Not to Exceed Cycle

Glossary

CSFC	**Constant Speed Fuel Consumption** is a method for assessing the fuel consumption of a vehicle. The same can also be done at different speeds as per requirement.
DC	**Driving Cycles** are evolved based on statistical data of vehicle movement to facilitate simulation of these driving conditions on a Chassis dynamometer for testing in a lab under controlled conditions
ESC & ETC	The **European Stationary Cycle** together with the **European Transient Cycle** are the tests for emission measurement from heavy-duty diesel engines
ECE R49	The R49 is a 13-mode steady-state diesel engine test cycle. This has been used for type approval emission testing of heavy-duty highway engines
GDI	**Gasoline Direct Injection** is a fuel delivery system in gasoline internal combustion engines where fuel is injected into the combustion chamber.
ISC	**In-Service Conformity** testing means testing of a vehicle from the market fleet to verify that the tailpipe and evaporative emissions
JC05	JC05 is chassis dynamometer test cycle for light vehicles (< 3500 kg GVW). Cycle represents driving in congested city traffic, including idling periods and frequently alternating acceleration and deceleration
NEDC	**New European Driving Cycle** is a driving cycle designed to assess the emission levels of car engines and fuel economy in passenger car.
OBD	**On-Board Diagnostics** refers to a vehicle's self-diagnostic and reporting capability.
PEMS	A **Portable Emissions Measurement System** is a vehicle emissions testing device that is small and light enough to be carried inside or moved with a motor vehicle that is being driven for testing, rather than on the stationary rollers of a dynamometer.
VECTO	**Vehicle Energy Consumption Calculation Tool** is a Heavy-Duty Vehicle (HDV) energy consumption simulation software developed by the European Commission for regulatory purposes. VECTO software platform consists of VECTO software, and a series of other software tools developed for the needs of the HDV certification procedure. Those include VECTO-Engine, VECTO-AirDrag and VECTO-hash and sign tools which are used at various points during the certification process.
WHSC	The **World Harmonized Stationary Cycle** test is a steady-state engine dynamometer schedule defined by the proposed global technical regulation (GTR). The GTR is covering a world-wide harmonized heavy-duty certification (WHDC) procedure for engine exhaust emissions.
WHTC	The **World Harmonized Transient Cycle** is a transient engine dynamometer schedule defined by the proposed global technical regulation (GTR). The GTR is covering a world-wide harmonized heavy-duty certification (WHDC) procedure for engine exhaust emissions.
WLTC	The **Worldwide Harmonized Light Vehicles Test Cycles** are chassis dynamometer tests for the determination of emissions and fuel consumption from light-duty vehicles.
WNTE	**World Harmonized Not to Exceed Cycle** is the emission limits and testing requirements as an additional instrument to make sure that heavy-duty engine emissions are controlled over a wide range of speed and load combinations commonly experienced in use.

1. Introduction

India in the past two decades has shown tremendous economic growth. With an increasing population and one of the fastest-growing major economies in the world, in the upcoming years, India will play a big role in the global energy markets. It is responsible for more than 10% of the increase in the global energy markets since 2000.[1] Although there are vast differences between geographical regions and socioeconomic groups, the energy demand in India has risen over 60% since 2000 (IEA, 2021).

India is the world's third-largest energy consumer in 2021 (Enerdata, 2021). From 2007 to 2017, final energy consumption in India increased by 50%, with growth across all sectors (IEA, 2021). Total final consumption (TFC) in India is dominated by industrial sector followed by building, transport and others as shown in the figure 1 (IEA, 2022).

India's transport energy demand is growing significantly. The energy consumption in transport sector has increased more than two folds in last ten years and more than three folds since 2000 (IEA, 2021). It has been estimated that annually 200 million tonnes of oil equivalent (MTOE) of energy supply is required by 2030 to achieve the energy consumption of the sector if the growth trend remains the same.[2] It has been observed due to pandemic the energy consumption of transport sector has been declined from 17% in 2019 (IEA, 2021) to 15% in 2022 of its total energy consumption (IEA, 2022). India's consumption rate has been slow in past two year due to COVID 19.

Among the world's biggest consumers of oil, India has tripled its demand for road freight since 2000 (IEA, 2021). It is important to note that India's import dependence on crude oil is 85.5% in the financial year (FY) 2021-22 (Petroleum Planning and Analysis Cell, May 2021).

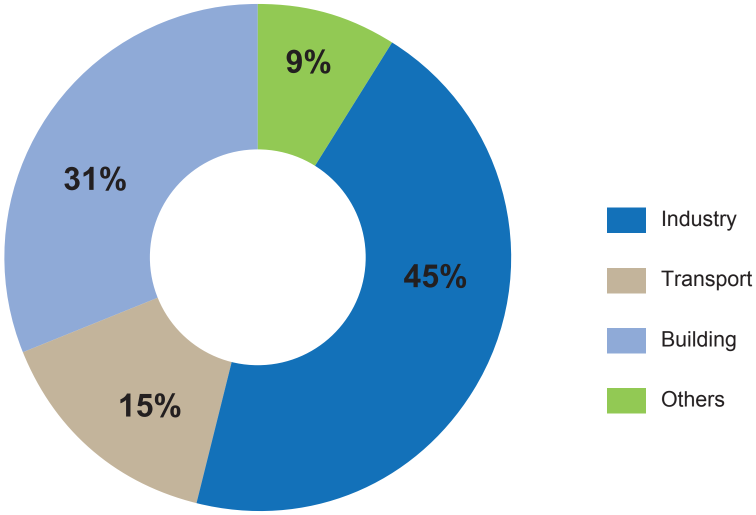

Figure 1: Sector-wise energy consumption in India, 2022

Source: World Energy Outlook 2022, IEA

1 Details available at https://powermin.gov.in/en/content/overview2#:~:text=India%20has%20been%20responsible%20for,the%20beginning%20of%20the%20century

2 Details available at https://beeindia.gov.in/content/e-mobility

India is the world's fourth largest global carbon emitter after China, the United States (US) and the European Union (EU).[3] 13.5 % of India's energy related CO_2 emissions are accounted for by the transport sector (Climate Action Tracker, December, 2020) which contributed around 300 $MtCO_2$ annually (including maritime transport) (International Transport Forum, 2021). Figure 2 shows that the highest share of CO_2 emissions from road transport generates from trucks followed by passenger cars and two-three wheelers (IEA, 2021). India's heavy-freight trucks have a relatively high level of fuel consumption per tonne kilometre compared with other countries. There has been an increasing concern globally about reducing CO_2 emission and India has committed to reducing its emissions.

Other than emissions Indian transport sector is also responsible for the local pollutants with significant negative impact on the human health. Due to high exposure to air pollution such as particulate matter (PM) and nitrogen oxides (NO_x) (both are products of fossil fuel combustion) severe health issues have been observed (Guttikunda et al. 2015). Almost 40% of NO_x emission from energy come from the transport sector followed by 31% from power sector and 20% from industrial sector. Vehicles, particularly heavy-duty vehicles (HDVs), are responsible for most of the NO_x emissions in the transport sector (IEA, 2020).

Through this discussion paper, the initiative has been taken to understand the existing policies and norms on tailpipe emissions and fuel efficiency norms. Also, the valuable feedback of the council members constituted under the National Transport Decarbonization Council (NTDC), has been incorporated in the discussion paper. This paper focuses on strengthening the existing policies by identifying the current gaps and tightening the norms with the recommendations provided by the council and the sectoral experts.

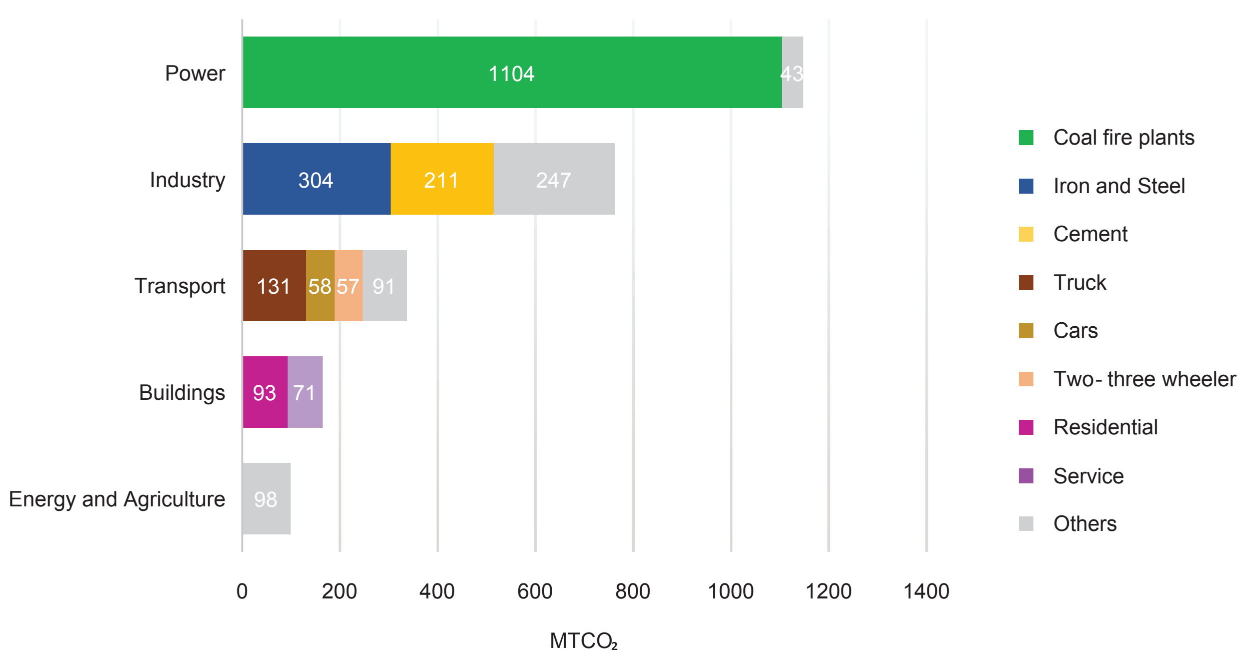

Figure 2: Sector-wise CO_2 emissions in India, 2019

Source: India Energy Outlook IEA, 2021

3 Details available at https://www.outlookindia.com/international/report-at-cop27-india-records-highest-emission-increase-among-top-global-contributors-news-236452

2. Background

India's rapid economic growth increases transportation activities and simultaneously dependency on fossil fuels. Due to the growing dependence on imported energy for the transportation sector several concerns on energy security arises. Considering the progress of the automobile sector, the vehicle population is also growing at a rate of over 5% per annum. It has been estimated that the dependency on fossil fuels for the year 2030 will increase to 486 MTOE (Ministry of Power, 2019). Considering India's ambition to become a $5 trillion economy by 2025 and growth of the automobile industry, the fuel efficiency improvement will optimize the fuel/crude requirement (Petroleum Planning and Analysis Cell, 2020-2021).

Keeping in mind the above concerns there is a need to ensure that the increasing mobility requirements arising from economic growth are met through sustainable options such as electrification. In additional to the gradual shift to these options, conventional vehicle will have to meet improved performance standards for fuel efficiency and reduction in emissions.

2.1 Vehicle market segments in India

India's automotive industry is the fourth largest market globally and contributes 7% of the country's GDP (Autobei Consulting Group, 2019). The annual production of automobiles in FY 22 was 22.93 million vehicles which comprises commercial vehicles, passenger cars, three and two-wheelers (SIAM, 2022).

In 2022, there are over 304.8 million registered vehicles in India[4] and the total vehicle sales has reached 17.51 million, with two-wheelers and passenger cars dominating the domestic auto market. The two-wheeler segment contributed the highest sales share of 76.9 % followed by passenger cars at 17.5%. Although a dip in domestic vehicle sales since 2019 has been observed due to the COVID-19 pandemic, in FY 23 substantial growth is expected in the Indian auto industry, post-recovery from the pandemic (IBEF, 2022).

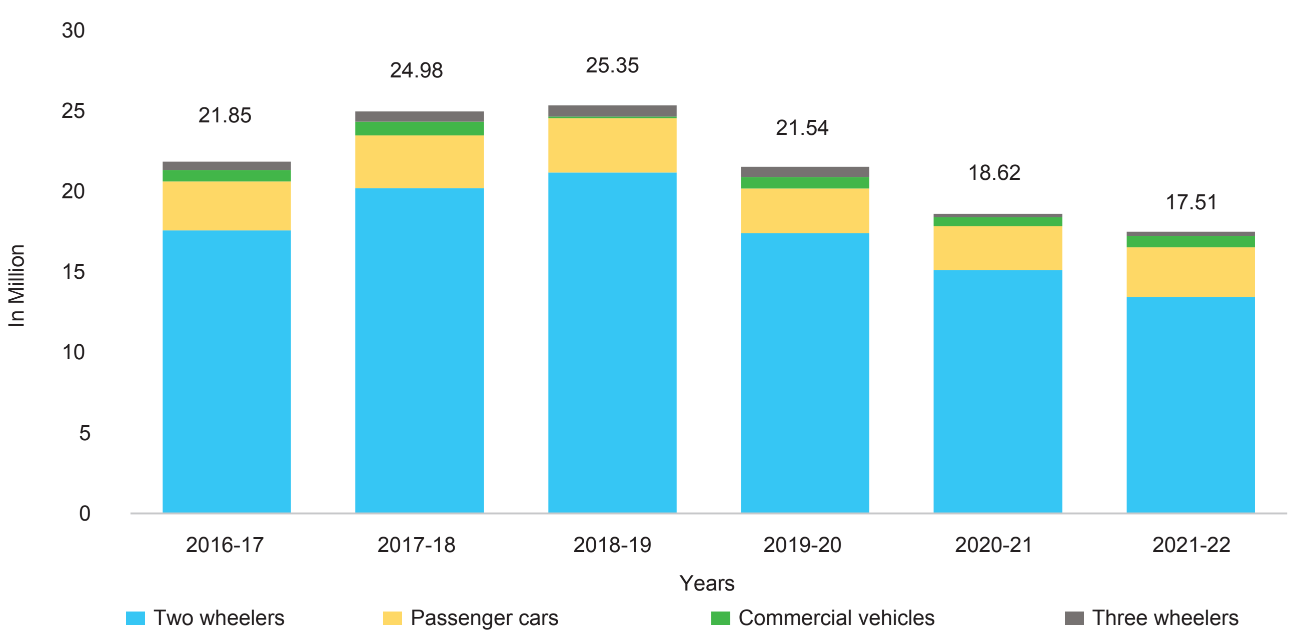

Figure 3: Domestic vehicle sale over the year

Source: Society of Indian Automobile Manufacturers, 2022

4 Details available at https://vahan.parivahan.gov.in/vahan4dashboard/

2.2 Overview of fuel consumption trends

Road transport is mainly powered by diesel and petrol. The total petroleum products consumption in India stood at 194.3 Million Metric Tonne (MMT) in 2020-21 (Petroleum Planning Analysis Cell, 2020-21). The total diesel consumption has increased from 60.07 MMT in 2010-11 (Petroleum Planning Analysis Cell , 2013) to 72.72 MMT in 2020-21 while the consumption of MS/petrol consumption also shows a substantial increase from 14.19 MMT 2010-11 to 27.95 MMT in 2020-21.[5]

It can be seen from the recent PPAC report[6] that the diesel retail segment accounts for 68% of the petrol-diesel basket, while the transport segment accounts for 87% and the non-transport segment contributes for 13%. There are significant changes in the consumption patterns of the transport sector. Due to extensive economic activities diesel consumption by trucks (HDVs and LDVs) increased from 33% in 2011-12 to 64% in 2020-21 (Petroleum Planning and Analysis Cell, 2020-2021).

Petrol consumption showed a decrease in the share of two-wheelers from 61% in FY 12 to 59% in FY 22, while in the cars/utility vehicles segment, an increase to 40% in FY 22 from 36% in FY 12 has been observed (Petroleum Planning and Analysis Cell, 2020-2021).

2.2.1 Trends in consumption pattern of petroleum

In 2019, due to increased demand for motorized transport, the consumption of petroleum products was around 211 million tonnes (MT) causing a significant expenditure on oil import. Considering a growing demand for fossil fuel and the rapidly rising motor vehicle fleet in India, the government has set a goal for a 10% reduction in imports by 2022 (Bureau of Energy Efficiency, 2019-20).

2.2.2 Trends in consumption pattern of diesel

Prior to 2014, the Government of India (GoI) was the regulatory body for diesel fuel pricing and compared to gasoline, diesel prices were on the lower side. Though the purchase cost of diesel vehicles was higher than gasoline vehicles, lower diesel prices along with higher fuel efficiency made the total cost of ownership for diesel vehicles lower and more affordable. The price gap between diesel and gasoline fuels gradually decreased after the deregulation of diesel fuel in 2014. This led to diesel vehicles becoming more expensive due to regulatory compliance, thereby reducing the demand.

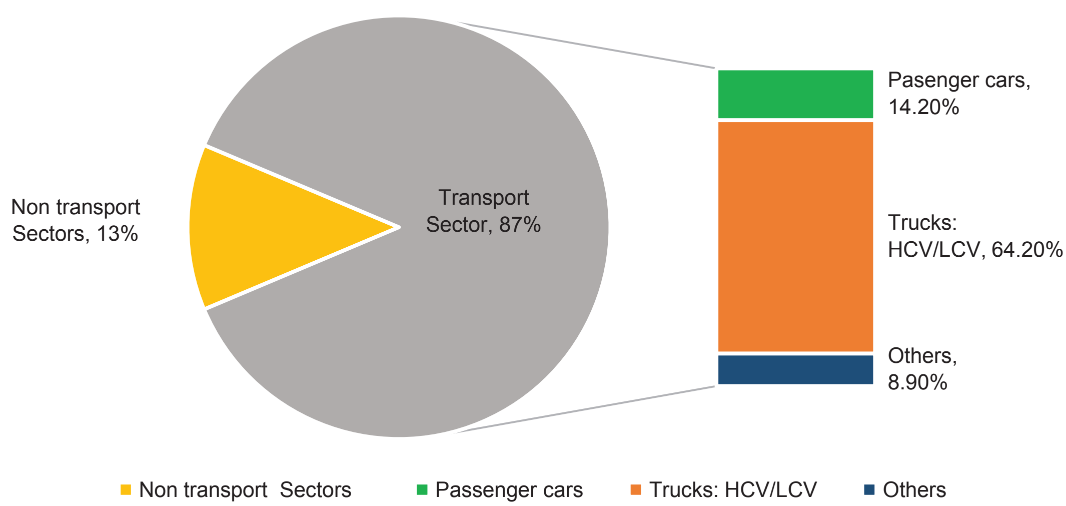

Figure 4: End-use share of diesel, 2020-21

Source: All India study on sectoral demand for petrol and diesel, 2020-2021

5 Details available at https://mopng.gov.in/en/petroleum-statistics/indian-png-statistics

6 Details available at https://www.ppac.gov.in/WriteReadData/Reports/202203291206002029009ExecutiveSummarySectoralConsumptionStudy.pdf

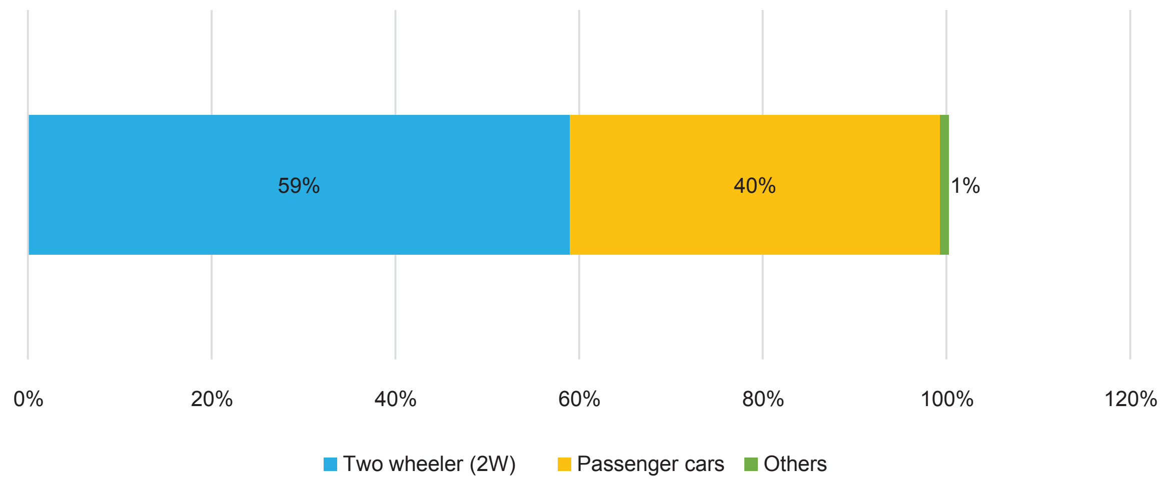

Figure 5: End-use share of petrol, 2020-21

Source: All India study on sectoral demand for petrol and diesel, 2020-2021

The deregulation of diesel fuel had an impact on the market share of diesel vehicles, especially in the smaller car segment, which continues to decline.

2.3 Growth potential of the Indian automotive industry

The Automotive Mission Plan (AMP) 2016-26 is a collaborative effort by the GoI and the Indian automotive industry to develop the roadmap for its growth of the industry. According to the AMP by 2026, the automobile industry has potential to contribute about 12% of the total GDP (Ministry of Heavy Industry, 2016).

In the AMP, econometric model that factors the parameters such as historical trends, expected growth rates of the economy, various macroeconomic and other variables are used to calculate the future demand for different vehicle categories. The future growth demand for automobiles in 2026 is based on the base case scenario which comprises of an average annual GDP growth rate of 5.8% for all vehicle segments other then passenger cars. The passenger cars projections have been considered from the global light vehicle sales summary, November 2022 by S and P Global. Table 1 represents the category-wise automotive forecasted demand in million units till 2026.

It has been observed by future growth projections that the automobile industry is expected to grow. Hence, the consumption of fossil fuels and emissions will also tend to increase unless some interventions are made. Implementation of BS-VI emission norms in 2020 has significantly improved the PM emissions as per TERI-ARAI study.

Table 1: Category-wise automotive forecasted demand in million units

	Category-wise demand (million units)		
Category	**FY 2015**	**FY 2021**	**FY 2026**
Passenger Cars	3.2	3.07	4.93
Commercial Vehicles	0.7	0.72	2
Two- Wheelers	18.5	13.46	50.6
Three- Wheelers	0.95	0.26	2.8
Total	**23.35**	**17.51**	**60.33**

Source: Final Draft Automotive Plan, 2016-26 and global light vehicle sales summary, November 2022 by S and P Global

3. Policy Landscape

3.1 Key institutional framework

India has well-developed policy and institutional framework for energy efficiency as well as tail pipe emissions. The National Institution for Transforming India (NITI) Aayog supports the government in assessing and formulating policy regulatory and national plans. With the support of the Ministry of Statistics and Programme Implementation (MoSPI), NITI Aayog conducts surveys to improve data collection and dissemination across the central and state governments. Line ministries like the Ministry of Power (MoP), Ministry of New and Renewable Energy (MNRE), Ministry of Petroleum and Natural Gas (MoPNG), Ministry of Environment, Forest and Climate Change (MoECC), Ministry of Heavy Industries (MHI), Ministry of Road Transport and Highways (MoRTH), Department of Science and Technology (DST) and Ministry of Housing and Urban Affairs (MoHUA) also plays a vital role in the development and implementation of energy efficiency policies and emission standards.

In the late 1980s and 1990s as per the Supreme Court judgments, India initiated the first steps towards mitigating the public health impacts of vehicle and fuel emissions. The preliminary steps comprised of eradicating lead in petrol, switching to compressed natural gas (CNG) for autorickshaws and buses in Delhi (and, subsequently in other cities), and establishing emission standards known as Bharat Stage Emission Standards (BSES) for new vehicles based on Euro standards from European Union (EU).

3.1.1 Institutional framework for tailpipe emission standards

MoRTH enforces compliance with India's vehicle emission standards under the Motor Vehicle Act, of 1989, through which the government regulates vehicle emission standards limit value (generally, an emission limit is the maximum amount of pollutants that can be discharged into the atmosphere from a vehicle). The new vehicle emissions standards were first proposed by the standing committee from MoEFCC, MoPNG, Society of Indian Automobile Manufacturers (SIAM) and state testing agencies such as the Automotive Research Association of India (ARAI) and later by International Centre for Automotive Technology (ICAT).

3.1.2 Institutional framework for efficiency standards

The Bureau of Energy Efficiency (BEE), under MoP formulates the efficiency standards and regulates energy efficiency policies and programs under the Energy Conservation Act, 2001. Recent amendments to this act bring about a renewed focus on sustainability, as well as support India's journey towards a net-zero economy by 2070. Several other penalties were also increased for violations of the Act, including those relating to efficiency and consumption. The Act provides the foundation for India's energy efficiency policy background. It is reinforced through the National Mission on Energy Efficiency (NMEE), one of the eight missions under the National Action Plan on Climate Change (NAPCC), 2008. Currently, MoRTH, MoP, and BEE take the lead on the disaggregating energy consumption by subsector and end-use.

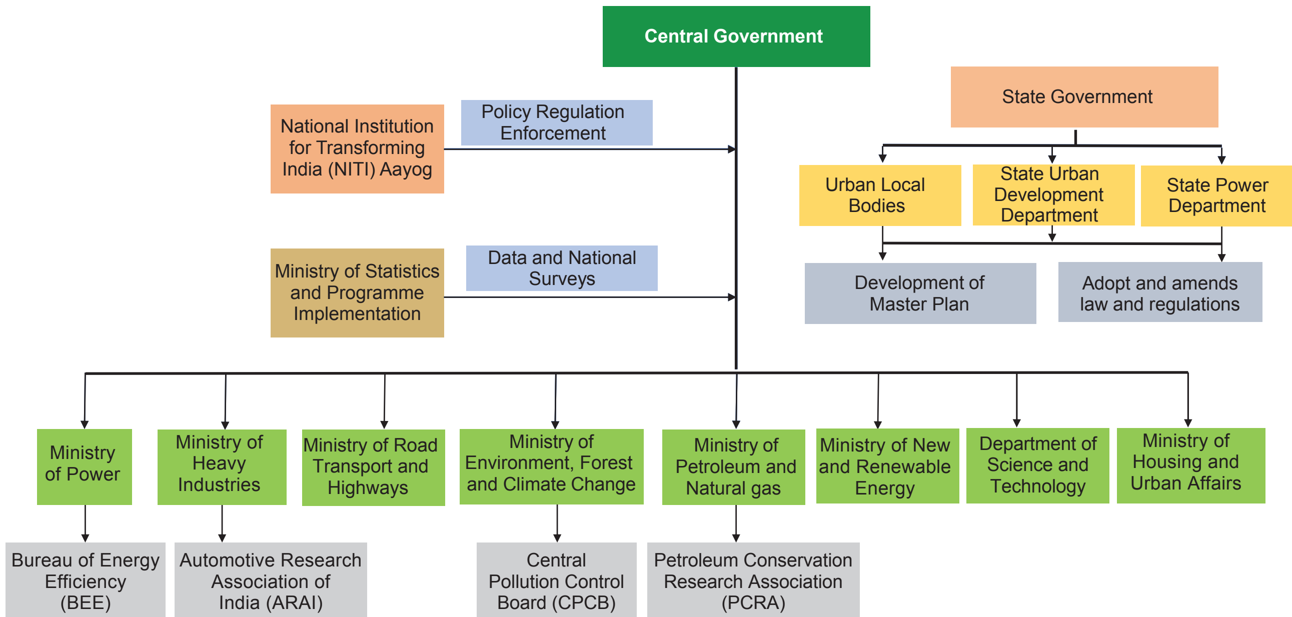

Figure 6: Key government stakeholders

Source: India Energy Policy Review 2020, IEA

3.2 Perspective on policies till date

Table 2 represents the various policies, plans, missions, programs, and schemes that have been implemented to encourage energy savings in all major end markets.

Table 2: Objectives, description and status of selected Acts, Policies and Plans

Act/Policy/Plan/ Mission/ Programme	Sectors	Objective	Description	Status
Energy Conservation (EC) Act, 2001	All	Energy security, energy efficiency	Legal framework for efficient use of energy and its conservation	Notified
Auto Fuel Policy, 2003	Transport	Vehicle-fuel efficiency	Vehicle emission norms, fuel quality standard and standard of CNG /LPG kits	Not notified
Integrated Energy Policy, 2006	All	Clean energy, energy efficiency	Procurement of energy services through a technically efficient, economically viable and environmentally sustainable approach	Not notified
National Action Plan on Climate Change (NAPCC), 2008	All	Clean and green environment	Aims to reduce stress of climate change	Not notified
National Mission on Enhanced Energy Efficiency (NMEEE)	Industry	Energy efficiency	Reduces specific energy consumption (SEC) by energy efficient technology and fuel switching, increasing thermal efficiency of power plants	Notified

Act/Policy/Plan/ Mission/ Programme	Sectors	Objective	Description	Status
National Sustainable Habitat Mission (NSHM)	Transport	Energy efficiency	Promoting urban public transport	Not notified
National Electric Mobility Mission Plan (NEMMP) I (FAME scheme)	Transport	Energy security	Promotion of hybrid and electric mobility in India	Notified
Auto Fuel Policy, 2014	Transport	Vehicle fuel efficiency	Recommends standardising the quality of fuel in India	Not notified
Green Urban Mobility Scheme 2017	Transport	Clean air	Reducing air pollution caused by the transportation	Not notified
National Policy on Biofuels, 2018	Transport	Reduction in emission, energy security	Promoting alternative fuels and substituting petrol-based fuels	Notified
Sustainable Transport Policy/ initiative: Bharat Stage Emission Standards	Transport and automotive industry	Reduction in emission, energy security	Regulates output pollutants and fuel economy	Notified
Fuel efficiency norms: CAFÉ				Notified

Source: Report 'Enhancing Energy Efficiency in India: Assessment of sectoral potentials, 2017

PART A: CO_2 emission reduction through fuel efficiency improvement

4. Fuel Efficiency in India

Fuel efficiency of the vehicles indicates mileage or work done by vehicle and carbon emissions generated per litre of fuel consumed in the process. CO_2 emissions are related to the carbon content of the fuel and the quantity of fuel consumed (Chattopadhyaya, India's Fuel Economy Benchmarks, 2021). There are different ways of indicating fuel efficiency such as kilometers per litre to gauge the mileage of a vehicle. A few countries regulate fuel efficiency standards as litres per 100 kilometers. Fuel efficiency is generally used to compare the performance of different models in terms of ratio of units of fuel consumed and distance travelled. Another approach to efficiency indication is as grams of CO_2 emissions per kilometer (CO_2 g/km).

In 2006-07, passenger vehicles emitted an average of 153g/km of CO_2 equivalent to 15.5 kmpl of fuel efficiency. It has been analyzed by ICCT study[7] that CO_2 emissions of passenger cars have decreased 1.4% a year on an average between FY 2009-10 and FY 2019-20 and the new passenger cars in India emit an average of 121.3 grams of CO_2 per kilometer in FY 2020-21 (Deo A., 2021). Average on road fuel consumption highlighted that the policies and counter measures, if fully implemented, would lead to a significant improvement in the average on road fuel efficiency.

4.1 Overview of the existing fuel efficiency policies in India

The government is making several efforts to reduce the oil import dependency, which further enhanced the requirement for policies and measures that could moderate the rising demand for fossil fuels. With increase in vehicular population and growing demand for fossil fuels, the BEE developed the fuel efficiency norms for vehicles. MoRTH is the nodal agency responsible for monitoring and reporting a summary of annual fuel consumption by automobile manufacturers at the end of each fiscal year.

4.1.1 Fuel efficiency norms for different vehicle segments

4.1.1.1 Passenger cars

CAFÉ norms were first notified by the MoP in 2017 under Energy Conservation Act, 2001 to mitigate fuel consumption by lowering CO_2 emissions aiming to reduce oil dependency and air pollution. These norms are relevant for petrol, diesel, liquefied petroleum gas (LPG), and compressed natural gas (CNG), hybrid and electric passenger vehicles. It relates the gasoline equivalent corporate average fuel consumption (in liters/100 km) to the corporate average kerb weight of all the cars sold by any original equipment manufacturer (OEM) in a fiscal

7 Details available at https://theicct.org/wp-content/uploads/2021/12/India-PV-FC-workingpaper-FINAL.pdf

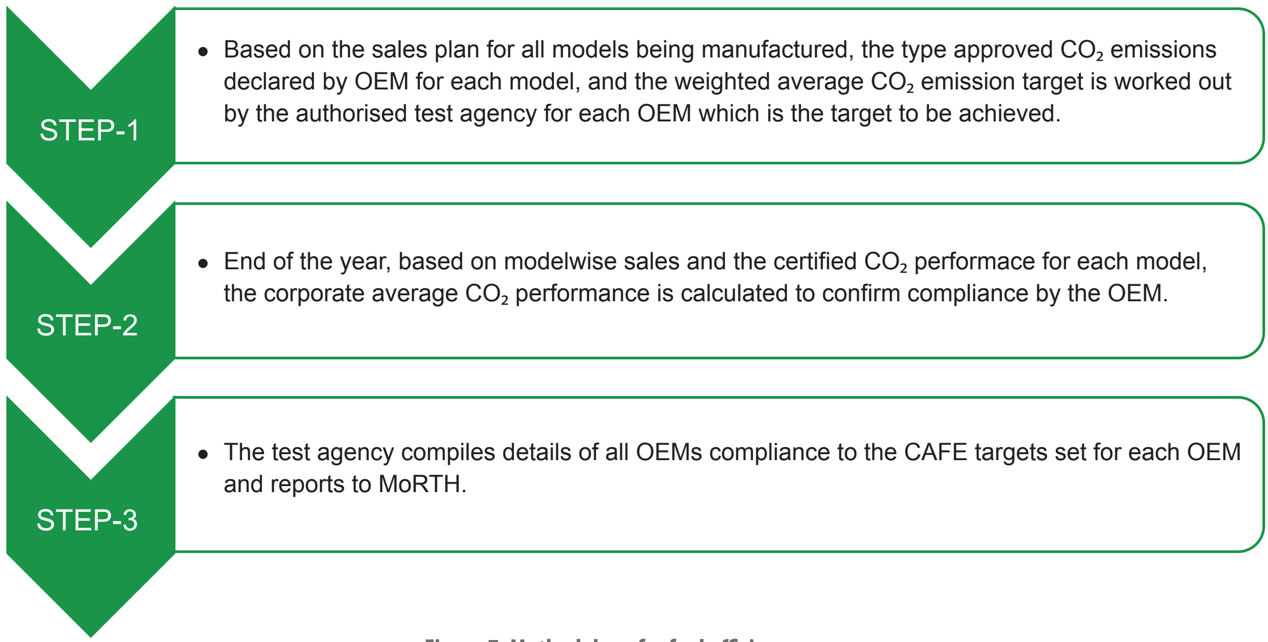

Figure 7: Methodology for fuel efficiency norms

Source: Impact of energy efficiency measures, BEE 2018-19

Table 3: CAFÉ norms for passenger cars

	CAFÉ norms stage-I	CAFÉ norms stage-II
Effective year	2017-18 onwards	2022 -23 onwards
Average kerb weight (kg)	1,037	1,082
Average fuel consumption (liters/ 100 kms)	< 5.49	<4.77
CO_2 emissions (grams of CO_2/km)	<130	<113

Source: BEE official website

year. These standards were introduced in two phases – the first fuel consumption standards CAFÉ norms stage-I was introduced effective 2017-18 and the CAFÉ norms stage -II standards came into force in 2022-23 (ARAI, 2020).

The corporate average fuel consumption is estimated by averaging the standard fuel consumption of all vehicles sold each year. This fuel consumption is measured under standard conditions in national accredited labs. There is a limit set on the total emission of CO_2 emitted, as the amount of CO_2 a car emits has direct correlation with the amount of fuel it consumes.

4.1.1.2 Super credits

CAFÉ norms allow manufacturers of passenger cars to earn extra credit points based on specific model performance for fuel efficiency and specific features which would help get better fuel efficiency. These extra credit points are referred as super credits. The CAFÉ norms allow super credits for battery electric vehicles (BEV), plug-in hybrid electric vehicles (PHEV) and hybrid electric vehicles (HEV). The norms also allow super credits for technological features like tyre pressure indicator, six speed transmission, start stop system, regenerative braking, etc.

In case of the features, CO_2 emissions are taken as 98% of the test value for calculations. Table 4 represents the credit for adopting for different categories of vehicles.

Table 4: Derogation factors for super credits for different categories of vehicles

Vehicle Type	Volume derogation factor for super-credits
BEV	3
PHEV	2.5
HEV	2

Source: Amendment no 6, MoRTH/CMVR/TAP-115/116

4.1.1.3 Light Duty Vehicles (LDVs)

The fuel efficiency standards for light and medium commercial vehicles of category passenger carriage vehicles (M2 and M3) and commercial goods carriage vehicle (N2) with GVW between 3.5 to 12 tonnes are yet to be formulated. MoRTH specified the CSFC to measure the vehicle performance similar to HDVs. However currently Modified Indian Driving Cycle (MIDC) testing method are used for LDVs and passenger cars.

4.1.1.4 Heavy Duty Vehicles (HDVs)

The BEE has developed the current fuel efficiency standards for heavy-duty vehicles (HDVs), exceeding twelve tonnes in gross vehicle weight (GVW). The main objective is reduction in fuel consumption and greenhouse gas (GHG) emissions from trucks and buses. The standards are represented as equations based on gross vehicle weight and axle configuration.

To measure the fuel efficiency performance, vehicles are tested on constant speed fuel consumption (CSFC) driving cycle. The fuel consumption in the CSFC driving cycle is evaluated over a set speed without any transient behaviour. According to this regulation, the CSFC test is run at two speeds, one at 40 km/h, and the other at 60 km/h, and 50 km/h for buses (ICCT, 2017). These norms, originally developed in 2017, are to be enforced by MoRTH with effect from the FY 2023-24.

Passenger Car (M1)
GVW<3.5 ton

Passenger Car (M1)
GVW<3.5 tonnes

- CAFE norms stage-I (2017-18) 5.5L/100 km (129.8 gm CO_2/km) @1037 kg
- CAFE norms stage-II (2022-23) 4.78L/100 km (113 gm CO_2/km) @1082 kg

Light & Medium Commercial Vehicle
(M2, M3, N2)
GVW 3.5 - 12 ton

Light and Medium Commercial Vehicle (M2, M3, N2) with GVW 3.5 - 12 tonnes

- M2 and M3 passenger carriage vehicle
- N2 commercial goods carriage vehicle
- MIDC testing cycle is used for LDVs however fuel efficiency norms are yet to be finalized.

Heavy Commercial Diesel Vehicle
GVW >12 ton

Heavy Commercial Diesel Vehicle GVW >12 tonnes

- Evaluation of fuel economy using constant speed fuel consumption test
- Fuel consumption determined at 40 & 60 kmph with fully laden condition and for bus at 50 kmph

Figure 8: Fuel efficiency norms for various vehicle segments

Source: BEE official website

4.1.1.5 Two-wheelers

Currently there are no fuel efficiency standards for two-wheelers. According to studies[8] the two-wheelers are fuel efficient compared to the four-wheelers. The transitions from 2-stroke to 4-stroke engines has also improved the fuel economy among two-wheelers (Roychowdhury, 2007). Fuel efficiency of the vehicle is the top consideration for purchase for a typical Indian customer. The two-wheelers with carbureted engines were always tuned to run on lean mixture to get the best fuel efficiency.

Two-wheelers are important constituent of India's road transport, they account for 77% of the total automobile production (SIAM, 2022) and 59% of the total petrol sale (Petroleum Planning and Analysis Cell, 2020-2021). In 2020, tailpipe CO_2 emissions from the two-wheelers segment have been estimated at nearly 38 megatonnes (Deo S. A., 2021). A variety of technologies for reducing CO_2 emissions from new two-wheelers are available. Moreover, setting fuel efficiency targets for the new two-wheelers fleet would be an effective way to encourage the adoption of modern internal combustion engine (ICE) technologies to reduce the gasoline consumption and hence import of crude. More stringent fuel efficiency requirements would also accelerate the electrification of the two-wheelers.

Fuel efficiency norms in India have been implemented only for passenger cars. For real-world performance, test parameters are just as relevant as the norm value. At present, the MIDC is used to test passenger cars and LDVs in India. However, it is necessary to replace the existing driving cycle and adopt the worldwide harmonized light duty vehicle testing cycle (WLTC) to measure fuel consumption and other pollutants. WLTC are chassis dynamometer test and are more dynamic, covers a broader spectrum of engine working states also is more realistic in simulating typical real-world driving conditions. There are no fuel efficiency standards for other vehicle segments such as HDVs and LDVs and two-wheelers. Also, there is absence of representative test duty cycle for HDVs. Considering the existing standards and testing cycle for different vehicle segments, necessitates an urgent attention to these issues and improve the efficiency performance of the vehicles through more stringent limits.

4.2 Comparative analysis of fuel efficiency norms

4.2.1 Passenger cars

India has declared target to become carbon neutral by 2070. This is a conscious decision taken by the government based on the common but differentiated responsibilities (CBDR) principle of international environment law. All actions for decarbonization must be in line with this carbon neutrality goals.

Developed countries like Europe and United States are targeting 2050 as target year for this carbon neutrality. When compare the CO_2 emissions targets for automobiles in different countries, with 50 years lead time for carbon neutral target in 2070, India has achieved better CO_2 performance compared to what the developed countries achieved at the same lead time from their target year. The Figure 9 below gives this comparative situation of different countries of carbon neutral goals.

8 Details available at https://www.downtoearth.org.in/coverage/fuel-inefficient-india-heading-towards-energy-crisis-5496

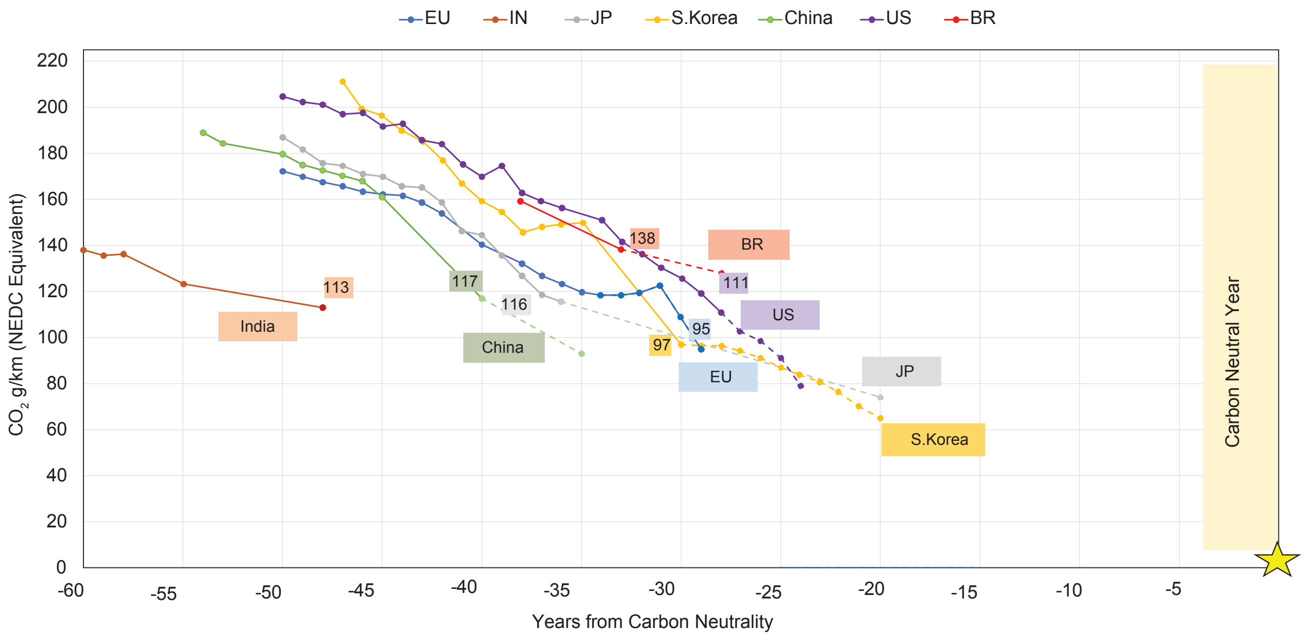

Figure 9: Comparative summary of different countries of carbon neutral goals

Source: ICCT, 2014 and official website climate action tracker

4.2.2 Heavy Duty Vehicles (HDVs)

The regulations for HDVs are based on achieving the minimum requirement during the CSFC testing in India, the CSFC testing has been used for vehicle certification. The regulatory cycle in India is different from the regulatory cycles adopted by other countries for HDVs standards. Japan, the United States, Canada, and China all four countries have HDVs fuel-efficiency standards in place and are evaluate vehicles over cycles that include some portion of urban, stop-and-go driving. The CSFC test in India is conducted at the gross vehicle weight of the test vehicle and the vehicle weights with the test protocols are defined by Indian Standard (ICCT, 2017).

To better align India with trends in other markets, several stakeholders have recommended implementing simulation-based standards similar to the vehicle energy consumption calculation tool (VECTO). The European Commission has developed a simulation tool called VECTO to measure the HDVs fuel consumption and emissions (Sathiamoorthy, 2019). A technical committee has been formed by the GoI to guide the development of a VECTO-based certification process.[9]

4.3 New technology used in improving fuel efficiency

To achieve CAFÉ-II targets the Indian automobile industry, introduced some new technologies to reduce the fuel consumption for passenger vehicles. In addition to the improvements in powertrain for better efficiency, the manufacturers also introduced technologies like start stop device, regenerative braking system, tyre pressure monitoring system and six speed transmissions. Adopting these technologies provide super credits to the manufacturers. Additionally, different manufacturers have embraced different strategies for introducing electric vehicle and/or hybrid vehicles for compliance with CAFÉ-II norms.

9 Details available at https://beeindia.gov.in/content/fuel-efficiency/

The Indian government is committed to improving vehicle fuel economy for HDVs. Also, technologies for improving the efficiency of HDVs differ from those for light-duty vehicles. To meet the proposed standards, manufacturers have invested substantial resources in technology in the transition from BS-IV to BS-VI such as diesel particulate filter (DPF). A fuel savings analysis by ICCT is being conducted for HDVs in the timeframe from 2025 to 2030, using current and future technology packages for trucks and buses GVW between 3.5 and 12 tonnes. It has been analyzed that fuel efficiency could be improved with new engine and transmission technologies, including hybrid electric drivetrains that recover braking energy, as well as tyres, aerodynamics, and weight reduction for reducing fuel consumption for truck and buses (Ben Sharpe, 2018).

4.3.1 Use of Intelligent Transport Systems and other techniques to improve fuel efficiency

The transportation industry contributes significantly to global greenhouse gas emissions. There has been a strong effort to switch fossil fuels to alternative fuels and devise driving strategies to improve traffic flow, reduce traffic congestion, and reduce climate change impacts.

An intelligent transportation system (ITS) is one of the most effective ways to simplify or minimize traffic challenges. ITS improves traffic efficiency, reduces congestion, controls environmental degradation, conserves energy, reduces travel time, improves passenger safety, and improves travel comfort (Jain, 2019). Technology and techniques used in ITS can assist in reducing fuel consumption by improving driving behaviour and minimizing traffic congestion. The ITS techniques and technologies can significantly reduce energy consumption by modifying driving behaviour and implementing traffic control signal, electronic toll collection and platooning (Mostofa Kamal Nasir, 2014).

4.3.2 Driving behaviour aspect to improve fuel efficiency in India

To meet European emission standards, India is continuously upgrading its fuel quality and vehicle technology. Moreover these efforts did not make much improvement in the air quality due to the continuous vehicular growth and existing road infrastructure in the country. However, road quality, traffic management, and driver behaviour have played a limited role in reducing emissions and improving fuel efficiency on Indian roads. A study was carried out which involved a gasoline-powered passenger car fitted with a global positioning system, in-car emission measurement system, and fuel flow meter and as the results it was observed that driving behaviour and training are key factors in improving fuel economy. It was also analyzed that vehicle emissions were lower under steady speeds and higher under acceleration mode and stop-and-go conditions (Sunil Pathak, 2011).

4.4 Fuel efficiency norms: International experience

Table 5: Fuel efficiency norms for passenger cars: International experience

	China	USA	European Union	Japan	India
Fuel Efficiency Norms	Corporate Average Fuel Consumption (CAFC)	Safer Affordable Fuel-Efficient Vehicles Rule (SAFE)	Corporate Average CO_2 Emissions Standards	Corporate Average Fuel Economy Standards	Corporate Average Fuel Economy norms
Existing Fuel Efficiency Standards	Set target in 2020: 5L/ 100kms	3.75L/65kms, or 202 g CO_2/1.6km in the model year 2026.	95 g CO_2/km for passenger light-duty vehicles and 147 g CO_2/ km for light commercial vehicles (2022-24)	Japanese government issued 2020 standards that would set the fuel economy target at 20.3 km/L	Existing standards 2022-2023 (M1) 4.78L/100 km (113 g CO_2/km) @ 1082 Kg

	China	USA	European Union	Japan	India
Future Target of Fuel Efficiency Standards	Future target: 4.0L/ 100kms for 2025 and 3.2L/100km for 2030. Standard estimate reduction in fuel consumption: 6.5% in 2025 and 5.5% 2030	Reducing annual improvement in fuel economy standards from 4.7% to 1.5% for model years 2021 through 2026	Expected 2030 60 g CO_2/kms for PVs	Set Target: average fleet gasoline-equivalent fuel economy of 25.4 km/ liter by 2030 32.4% improvement over fleet average of fiscal year 2016	Being evolved
Driving Cycles	Chinese version of the New European Driving Cycle (NEDC)	Federal Test Procedure (FTP) heavy-duty transient cycle.	Worldwide Harmonized Light-Duty Vehicle Test Cycle (WLTC)	Worldwide Harmonized Light-Duty Vehicle Test Cycle (WLTC) instead of its own JC08 test cycle	Modified Indian Driving Cycle (MIDC)

Source: Global Fuel Economy Initiative 2021, IEA

Table 6: Fuel efficiency norms for HDVs: International experience

Country/ Regions	Standards	Measures	Structure	Target Fleet	Test Procedure	Implementation
US	Joint fuel consumption standards and GHG emission limits	g/CO_2/ ton-mi, gal/1000 ton-mi	Vehicle Class based on weights and application	New	Vehicle Simulation using Greenhouse gas Emission Model (GEM) based on various test cycles- Federal Test Procedure, Steady State Supplemental Emissions test, Highway Federal Economy Test, etc	Mandatory
EU	Fleet average CO_2 emission limits	gCO_2/t-km	Based on axle and GVW	New	Simulation using Vehicle Energy Consumption Calculation Tool (VECTO) based on WHTC and WHSC cycles	Mandatory
Japan	Fuel Consumption	Km/l	Based on Category and GVW	New	Simulation-based on engine dynamometer test on JEO5 cycle and an interurban transient test (speed: 80 km/h, load factor: 50%)	Mandatory
China	Fuel Consumption	l/100-km	Based on GVW	New	Chassis dynamometer using the World Transient Vehicle Cycle (WTVC)	Mandatory
India	Fuel Consumption	l/100-km	Based on axle and GVW	New	Constant Speed Fuel Consumption Test (CSFC)	Yet to be implemented

Source: Transport policy.net

4.5 Next stage fuel efficiency norms

It is understood that only focusing on tailpipe emissions may mislead us. Also, important to consider the overall life cycle emissions of the vehicles to fulfill India's Conference of Parties (COP) targets. Overall GHG emissions of the vehicle depends on the way the fuel was produced. It is important to evaluate the real GHG emissions of various fuel options. Considering India's specific situation and availability of vast biological resources there is a need to integrate carbon neutral ethanol and carbon negative (Bio-CNG) biofuels in upcoming CAFÉ considerations.

Part B: Future road map for tightening emission standards

5. Bharat Stage Emission Standards (BSES)

Deteriorating quality of air has always been an issue of concern worldwide, especially with growing vehicular emissions. The exhaust emissions from vehicles are very harmful and TERI's study on source apportionment indicates that transport vehicles contribute about 25-30% of the air pollution. Proper measures must be set in place to curb vehicular pollution. BSES were instituted to regulate and control the emissions from the motor vehicles. These standards are usually set by the Central Pollution Control Board (CPCB) under MoEFCC and are generally derived from regulations implemented in European countries. India started adopting emission standards based on EU from BS-I (Euro I) in 2000. BSES are updated regularly to make vehicles more environmentally friendly and greener.

In India, the emission regulations were first mandated in 1988, and the BS-I equivalent of Euro I was implemented pan India in 2000. In the case of Delhi NCR, Mumbai, Chennai, and Kolkata (the other four metros), BS-I was advanced to June 1999 through a directive from the Supreme Court. There have been several revisions in the last two decades as shown in Figure 10.

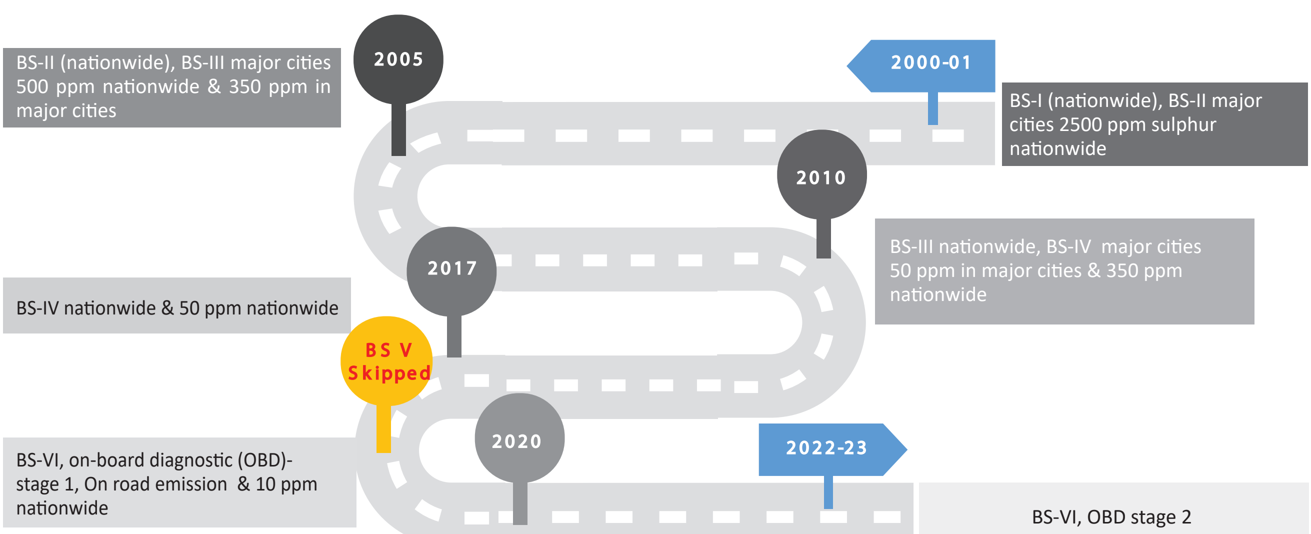

Figure 10: Timelines of Bharat Stage Emission Standards (BSES)

Source: ARAI, 2022

5.1 National Auto Fuel Policy

The National Auto Fuel Policy, 2003 laid out a road map for introducing cleaner fuels and vehicles in the country aimed to address issues of vehicle emissions and vehicular technology by applying fuel quality standards. The standing committee under the MoPNG was constituted to review and update the policy. The Auto Fuel Vision and Policy 2025 with more stringent fuel and emission standards was published in 2014. The standing committee framed the road map for the implementation of BS-IV, equivalent of Euro IV emission standards up to the year 2017. It also made the recommendations for BS-V and BS-VI emission standards to be implement up to the year 2024 (Ministry of Petroleum and Natural Gas, 2014).

Though the committee proposed both BS-V and BS-VI to be adopted nationwide by 2020 and 2024 but MoRTH decided to skip BS-V and leapfrog to BS-VI norms to be implemented in April 2020.

BS-VI emission standards have aligned Indian motor emission regulations with the EU regulations for light-duty passenger cars, commercial vehicles, heavy-duty trucks, and buses. In case of two-wheelers the emission norms implemented in 2020 in India are yet to be implemented in Europe.

The standing committee also suggested for an interim review to keep a track on the various recommendations indicated in the Auto Fuel Vision and Policy 2025. There is an urgent priority to formulate an expert committee to review the status of the existing policy as well as to finalize the next stage emission standards and efficiency norms for future timelines.

5.2 Existing emission regulations in India

With BS-VI standards the particulate matter (PM) emissions are tightened. Moreover, the limit for particle number (PN) has been introduced for light and heavy-duty vehicles fitted with gasoline direct injection (GDI) and compression ignition (diesel engines). Under BS-VI emission regulations there are several other parameters which are planned to be implemented in phased manner in the upcoming years. BS-VI introduced real driving emission (RDE) and in-service conformity test (ISC) requirements for LDVs and HDVs. RDE and ISC testing are planned to implement from 2023. Indian vehicle for the first time would be tested under testing cycles and compliance to more stringent real-world driving cycle emission measurements using portable emissions measurement systems (PEMS). It will help to bridge the existing gap between emissions occurring during the time of certification by type approval and conformity of production with real-world conditions. (Singh, 2022)

Also, the BS-VI standards call for enhanced on-board diagnostic (OBD) requirements for all vehicle classes, with first-ever OBD specifications for two and three-wheelers.

While this is major progress, there is an opportunity to further tighten norms also decide the time schedule for the next phase of BS norms as BS-VII

5.3 Comparative summary of existing emission standards with other countries

Different test cycles vary between countries resulting in different emission standards. Currently, the US emission standards are fuel neutral and there is no separate weight classification for LDVs. In Europe, Japan and India both petrol and diesel vehicles are classified according to their emission limits and weights.

Table 7: Comparison summary of emission standards: International experience

Category	Pollutants	USA		Japan	Europe		India	
	(g/km)	USA Tier 3	California		Euro 6		BS-VI	
PCs	CO	0-2.610	0.621-2.61	0.63(1.15)	0.5 (1.0)		0.5 (1.0)	
	HC	–	–	–	– (0.10)		– (0.1)	
	NOx	–	–	0.15,0.05	0.08 (0.06)		0.08 (0.06)	
	HC+NOX	_	_		0.17		0.17	
	NMHC	–	–	0.024 (0.1)	–		–	
	PM	0-0.0002	0.006	0.005,0.005	0.005		0.0045	
	PN	_	_	_	6 X 10^{11}		6 X 10^{11}	
	(g/km)							
LDVs	CO	0-2.610	0.621- 2.610	0.63, 1.15-4.02	0.5-0.74 (1.0-2.27)		0.5-0.74, (1.0-2.27)	
	HC	–	–	–	– (0.1-0.16)		– (0.1-0.16)	
	NOx	–	–	0.15-0.24, 0.05-0.07	0.08-0.125 (0.06-0.082)		0.08-0.125, (0.06-0.082)	
	HC+NOx	–	–	–	0.17-0.215 (_)		0.17-0.215 (_)	
	NHMC	–	–	0.024, 0.1-0.15	– (0.068-0.108)		– (0.068-0.108)	
	PM	0-0.002	0.006	0.005-0.007, 0.005-0.007	0.005 (0.005)		0.0045 (0.0045)	
	PN	_	_	_	6 X 10^{11}		6 X 10^{11}	
	g/kWh				WHSC	WHTC	WHSC	WHTC
HDVs	CO	0- 4.536	1.988- 4.536	2.22,(16)	1.5	4	1.5	4
	HC	_	_	_	0.13		0.13	
	NOx	_	_	0.4, (0.7)	0.4	0.46	0.4	0.46
	NMHC	_	_	0.17,(0.23)	_	0.16	_	0.16
	CH4	_	_	_	_	0.5	_	0.5
	PM	0-0.006	0.0037- 0.0075	0.01, 0.01	0.01	0.01	0.01	0.01
	PN	_	_	_	8 X 10^{11}	6 X 10^{11}	8 X 10^{11}	6 X 10^{11}

Source: Metrology Society of India, 2022 and transport policy.net

In the USA, LDVs and HDVs are currently required to comply with Tier 3 emission standards similar to California's LEV III standards by using Federal Test Procedure (FTP) heavy duty transient cycle for emission testing. Japan has its own emission limits. In Japan, the testing cycle has been changed from JEo5 model to worldwide harmonized testing cycle (WHTC) and the European Union currently uses Euro VI emission standards for different vehicle segments. In Indian emissions standards, the magnitude of emissions varies according to the pollutant**.** As part of BS-VI, there is also a limit on ammonia emissions, which should not exceed 10 parts per million for both compression ignition and spark ignition engines.

5.4 Test fuels

The quality of fuel is an essential component for improving tailpipe emissions from vehicles. As per Euro V/VI diesel fuel specifications, sulphur limits have been reduced, among other specifications, as sulphur has detrimental effects on diesel emission control systems, that lead to increased emissions of nitrogen oxides and particulate matter (Bharadwaj Sathiamoorthy, 2021).

BS-VI fuels specifications apply a 10-ppm sulphur limit to both test fuel and commercially available diesel and gasoline. MoPNG implemented a nationwide supply of BS-VI specification fuel in conjunction with the implementation of BS-VI emission standard in April 2020.

5.5 Future road map of emission standards

With the implementation of RDE in April 2023, all the gaps between BS-VI as implemented in 2020 and Euro VI provisions would be covered. Further Europe have implemented WLTP to bridge the gap between real world fuel consumption and emissions. WLTP testing mode have more transient operation to have real world operations. India also must adopt WLTP testing process.

With full compliance to BS-VI (all clauses of Euro VI), there is a need to debate whether India should still adopt Euro VII as next stage emission regulation or research and evolve a standard addressing critical issues for air quality in India. This requires a study of the various pollutants and their contributing factors to Indian air quality to formulate the norms to be adopted. For example, in India main pollutant causing higher air quality index (AQI) is particulate matter. India can focus on such parameters with scientific study so that better air quality can be achieved rather than implementing what Europe has announced as Euro VII which is based on European critical situation which may be different from India.

It is proposed that an India-specific emissions study should be done and based on those future emissions norms focusing India-specific situations to be evolved as norms in the form of BS-VII.

6. Transition of tailpipe emissions and fuel efficiency to vehicle electrification

India announced its long-term low emissions and development strategies (LT-LEDs) as an approach to its low-carbon development at COP 27, the transport sector will also play a significant role. India's rising urbanization, rapid economic growth and travel demand have led to the urgency of prioritizing of the country's energy security. India being the fifth largest global passenger car market in the world[10] which requires the country to work harder on the technological innovation in reducing the vehicular emissions. It is therefore crucial to understand which powertrain and fuel technologies are most capable of reducing the carbon footprint of passenger cars and two-wheelers in India, including emissions from tailpipes, fuel, electricity production, as well as vehicle manufacturing.

It is a well-known fact confirmed by the Environmental Protection Agency (EPA) of the United States the energy consumption in the manufacturing of electric vehicles (EVs) is more in comparison to gasoline vehicles manufacturing due to the additional energy consumed in battery manufacturing. However, when considered over long-term use or the vehicle's lifetime, total GHG emissions of EVs are much lower considering the elements of manufacturing, charging, and driving in comparison to gasoline vehicles. Furthermore, the on-going research on the recycling of EVs batteries will further aid in the reduction of energy consumption associated with their manufacturing along with more reduction in the carbon footprint due to less manufacturing materials required.

Electrification of vehicles, first and foremost, eliminates the tailpipe emissions from the vehicles which is the primary source of pollution from the transport sector and badly impacts the local air quality, The GoI encourages the adoption of EVs under the FAME scheme. This scheme generates the demand incentives for EVs and covers the implementation of charging technologies and stations in urban centers. If these aims are realized by 2030, will result in an estimated saving of up to 474 MTOE and 846 million tonnes of net CO_2 emissions (NITI Ayog and RMI, 2019). With these incentives and government's intent has been a steady rise in the uptake of electric two-wheelers, passenger cars, and buses. However, a similar policy push is required for electrification of trucks as they are responsible for largest share of diesel consumption and carbon emissions.

Emission control along with fuel efficiency improvement are two important factors to meet the net zero targets. There is an urgent need to tighten emissions and improve fuel efficiency by targeting towards the zero emission vehicles. Having more stringent targets for both the standards (emissions and fuel efficiency) in future timeframe will encourage manufacturers to adopt green vehicles.

10 Details available at https://www.mobilityoutlook.com/news/india-remains-5th-largest-global-car-market-in-2020//

7. Key recommendations

Fuel efficiency and tailpipe regulations are critical measures for India to meet its National Determined Contribution (NDC) commitments. The regulations are also important to reduce oil dependency and further to strengthen energy security. It is important to note that India's oil dependency and crude oil imports are showing a substantial increase. It is also estimated that India's oil dependency on fossil fuels has increased from 196.5 MMT in FY 2020-21 to 212.2 MMT in FY 2021-22 (Petroleum Planning Analysis Cell, March 2022). These statistics indicate that it is high time for policymakers to regulate the existing policies and standards. Based on the stakeholders (from different domains) consultations and the literature review following are recommendations to improve the existing standards and regulations:

Emissions and CAFÉ regulation to be implemented in same timeframe

Currently, corporate fuel economy norms and vehicle emission standards are implemented separately. To optimize the development timelines and costs, MoRTH should decide simultaneous implementation of both standards, keeping in mind importance of both and not delaying one for the other. This would help OEMs and component manufacturers in better planning and optimizing activities.

Tightening of existing norms and regulations

In HDVs segment, fuel economy standards are currently lagging the leading markets. As the other markets are tightening the fuel economy standards considering the climate impacts. India should follow suit to achieve economic and environmental benefits while making the heavy duty vehicle industry globally competitive.

Alternative fuel options

India is the fourth largest emitter of methane which has an impact that is 28 times more adverse, than that of CO_2 in global warming.[11] If methane gas is captured and cleaned, it can become substitute for natural gas as a fuel for automobiles and can be a game changer for India's energy security. This can be achieved if dairy waste can be consumed as feedstock for generating biogas and after purification can substitute natural gas. Provision for including contribution of such fuel vehicles should be well integrated in CAFÉ regulation. MoPNG started a Sustainable Alternative Towards Affordable Transport or "SATAT" to encourage entrepreneurs to set up compressed biogas (CBG) plants in India. This initiative needs an aggressive push for pan India implementation and has the potential to change the rural economy for better.

Technological interventions

Transport sector is the third largest CO_2 emitter with road transport contributing more than 90% of CO_2 emissions and hence, there is an urgent need for technological interventions for greening the transport to restore the equilibrium. The Indian automobile industry is the fastest growing automobile industry in the world and there is a significant amount of focus on carbon neutral fuels. Though EVs have zero emission on roadside, there are apprehensions on the life cycle analysis of the EVs in comparison with conventional ICE. In line with the National Solar Mission the government should encourage the auto industry to adopt solar energy for charging EVs resulting in total elimination of fossil fuels for EVs (having a very positive impact on air quality). There is a need to give priority to immediately available carbon neutral like ethanol/ Bio-CNG and keep on improving carbon footprint of electricity which can improve GHG emissions of EVs beyond ethanol and Bio-CNG for future.

11 Details available at https://www.indiaspend.com/explainers/chasing-methane-why-curbing-methane-emissions-is-crucial-to-fighting-climate-change-828127

Innovative Testing Procedure

Worldwide harmonized light vehicle test procedures (WLTP) for LDVs has been adopted by most of the countries for determining the levels of pollutants from ICE and hybrid cars. The Indian automobile industry should immediately implement the WLTP to include a wide range of on-road driving conditions. Although the Automotive Industry Standards Committee (AISC) committee has agreed to implement WLTP from 2027 onwards.

Most of the countries are shifting towards developing testing procedures and cycles that can be translated well to real driving conditions. India should also modify the CSFC fuel economy testing procedure for HDVs to a simulation-based approach similar to VECTO. This will save testing cost, time and combined with real world drive cycle will result in more realistic fuel consumption data. The implementation of Indian version of VECTO should be inclusive in future fuel efficiency standards.

Long-term road map for improvement

There is an urgent need a long-term road map/ action plan for emission reduction and fuel efficiency improvements. This would help in improving air quality and strengthening energy security for transformation to zero emission vehicles. Until that there is a need to clearly spell out priority of alternative fuels and powertrains that can improve CO_2 emissions. A clear policy goal of increased stringency will provide the automobile industry and consumers a confidence to shift to zero emission vehicles.

Implementation and enforcement mechanism

Currently, the GoI has different tax slabs for passenger vehicles depending upon parameters such as type of vehicle (EVs/hybrid/ICE), engine size, fuel type, and length of the vehicle, etc. For a cleaner and greener environment, the GoI should consider differential tax structure for new passenger vehicles depending upon CO_2 emissions. With respect to the older passenger vehicles on road emission test should be mandatory and a high penalty should be applied if there is noncompliance, or such older vehicles can be recommended for scrappage.

Delayed implementation of norms leads to huge loss to the nation in terms of emissions and oil imports. Hence, periodic update of standards with timely implementation is critical to move towards decarbonization.

8. Conclusion

There is a serious concern for energy security and deteriorating air quality as the transport sector is growing rapidly. An exponential increase in fuel consumption is expected at a time when the country is tackling with energy insecurity and the aftereffects of climate change. Hence, arises the needs to raise the objective for decarbonization. With the adoption of BS-VI emission standards in 2020, India has taken big steps to reduce toxic vehicular emissions however, similar measures have not been applied to fuel efficiency norms. Thus, the standards need to be much stricter in the future to drive manufacturers to adopt zero-emission vehicles.

There is a difference between CAFÉ norms which are sales-weighted corporate average standards and the Bharat Stage Emissions Standards, which require each model to comply with the norms based on lab testing. BSES are much more stringent as compared to CAFE norms; in BS-VI on road testing parameters (yet to be implemented) and stringent compliance to real-world driving cycles have been introduced.

There is an urgent need to set the stringent targets for future timeframes of 2027 (WLTP and CAFÉ-III) and 2034 (CAFÉ-IV), which should be synchronized with India's specific situation of carbon neutrality targets and local emission challenge of India.

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Annexure A

The equation of the average fuel consumption standard (in litre/100km) given in the said notification issued by Ministry of Power as

a x (W-b) + c, where

a= Constant Multiplier

Average Fuel Consumption Standard = Average fuel consumption standard of manufacturer in petrol equivalent litre per 100 kilometer

b= Fixed constant

c= Fixed constant

W= weighted average of unladen mass in kilogram (Kg) of all new said motor vehicle, manufactured or imported for sale by the manufacturer.

The constant multiplier and the fixed constants shall be determined from Table below depending upon the year of manufacturing or import of said motor vehicle in India

For fiscal year 2017-18 to 2021- 22

a	0.0024
b	1037
c	5.4922
Average Fuel Consumption Standard for Manufacturer	0.0024x(W-1037) +5.4992

For fiscal year 2022-23 onwards

a	0.002
b	1082
c	4.7694
Average Fuel Consumption Standard for Manufacturer	0.002x (W-1082) +4.7694

Where weighted average is the unladen mass (W) for a manufacturer is calculated as per the following formula

W= Σ NiWi/ ΣNi

Ni= number of said motor manufactured or imported for sale in India of a model I in respective fiscal year

Wi= unladen mass in kilogram of model I in the respective fiscal year

Annexure B

List of Council Members

1. Mr. Sudhendu J. Sinha, NITI Aayog
2. Mr. Abhay Bakre, Bureau of Energy Efficiency (BEE)
3. Ms. Anumita Roy Chowdhury, Executive Director, Centre for Science and Environment (CSE)
4. Mr. Amit Bhatt, International Council on Clean Transportation (ICCT)
5. Mr. Ambuj Sharma, Ex-Secretary, DHI
6. Prof. Ashish Verma, Indian Institute of Science (IISc) Bangalore
7. Dr. A R Sihag, The Energy and Resources Institute (TERI)
8. Ms. Akshima Ghate, Rocky Mountain Institute (RMI)
9. Mr. Pawan Mulukutla, Clean Mobility & Energy Tech, World Resources Institute (WRI) India
10. Dr. Himani Jain, Council on Energy, Environment and Water (CEEW)
11. Mr. K. K Gandhi, Auto and Fuel Expert

Annexure C

List of Experts Members for Emission Reduction and Efficiency Reduction Workshop

Date September 1, 2022, | Time: 14.00 – 16.00 IST

1. Mr. P.K Banerjee, Executive Director, Society of Indian Automobile Manufacturers (SIAM)
2. Dr. Reji Mathai, Director, Automotive Research Association of India (ARAI)
3. Dr. Pankaj Sharma, Add. Director, Petroleum Planning and Analysis Cell (PPAC)
4. Mr. Anoop Bhat, Executive Vice President, Maruti Suzuki India Limited
5. Dr. S.K Sharma, Director (Gas) Federation of Indian Petroleum Industry (FIPI)
6. Ms. Anumita Roy Chowdhury, Executive Director, Centre for Science and Environment (CSE)
7. Mr. Ambuj Sharma, Ex-Secretary, DHI
8. Prof. Ashish Verma, Indian Institute of Science (IISc)Bangalore
9. Dr. Pierpaolo Cazolla, Independent Consultant
10. Mr. Aditya Ramji, University of California, Davis
11. Mr. Aviral Yadav, International Council on Clean Transport (ICCT)
12. Ms. Chetna Nagpal, Rocky Mountain Institute (RMI)
13. Ms. Avantika Garg Tayal, Asst. Director, Petroleum Planning and Analysis Cell (PPAC)
14. Mr. Nitant Kumar, The Climate group
15. Mr. Sudeept Maiti, Program Head – Transport, WRI
16. Mr. Ajay Kumar, General Manager, Maruti Suzuki India Limited
17. Mr. Vijay Kansal, Add. Director, Petroleum Planning and Analysis Cell (PPAC)