Programme Objective Series

PROBES/ 136 /2010

STATUS OF THE VEHICULAR POLLUTION CONTROL PROGRAMME IN INDIA

(March, 2010)

CENTRAL POLLUTION CONTROL BOARD
(Ministry of Environment & Forests, Govt. of India)
East Arjun Nagar, Delhi – 110 032

FOREWORD

The growing cities, sharp increasing traffic, trajectory growth, rapid economic development and industrialization, and higher levels of energy consumption has resulted an increase of pollution load in the urban environment. It is also accepted that automobiles have emerged as a critical source of urban air pollution specially in the developing world. Realizing the gravity of the problem, steps are being taken to introduce better technologies, better fuel quality, shift to environment friendly fuels, and mass transit system for the control of environmental pollution in urban areas.

The Central and State Governments in India have been developing strategies for mitigation measures to improve the urban air quality and make the cities cleaner and greener. Over the past decade or so, the Government of India has notified statutes aimed at regulating and monitoring vehicular emissions across the country.

Present document presents the Status of Vehicular Pollution Control Programmes and their impact on the urban air quality.

Contribution of Sh. J.S. Kamyotra Member Secretary is thankfully acknowledged. Thanks are duly extended to Dr. R.S. Mahwar Additional Director for his extensive inputs. Shri R.C. Saxena Sr. Env. Engineer, Shri G. Thirumurthy Env. Engineer and Ms. Meetu Puri JSA for their respective contributions in the report.

Hopefully the document will prove useful as a reference for all the concerned interested in the improvement of urban air quality in general and control of vehicular emissions in particular.

(Prof. S. P. Gautam)
Chairman

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ABBREVIATIONS

AAQ	Ambient Air Quality
AAQS	Ambient Air Quality Standards
AKI	Anti Knock Index
API	American Petroleum Institute
APM	Administrative Pricing Mechanism
AQM	Air Quality Model
ARAI	Automobile Research Association of India, Pune
ATF	Aviation Turbine Fuel
BARC	Bhabha Atomic Research Centre, Mumbai
BIS	Bureau of Indian Standards
BRT	Bus Rapid Transport
BS	Bharat Stage
CAC	Command and Control
CAGR	Compound Annual Growth Rate
CARB	California Air Resource Board
CESE	Centre for Environmental Science & Engineering, Mumbai
CFPP	Cold Filter Plugging Point
CI	Cetane Index
CI	Compression Ignition
CVMR	Central Motor Vehicle Rules
CN	Cetane Number
CNG	Compressed Natural Gas
CO	Carbon Monoxide
COP	Conformity of Production
CPCB	Central Pollution Control Board
CRRI	Central Road Research Institute, New Delhi
CVs	Commercial Vehicles
DF	Deterioration Factor
DHDS	Diesel Hydro De-Sulphurisation

DME	Di –Methyl Either
DOC	Diesel Oxidation Catalyst
DTC	Delhi Transport Corporation
DPCC	Delhi Pollution Control Commitee
ECE	Economic Commission for Europe
EPCA	Environmental Protection & Control Authority (for NCT/NCR)
Evs	Electric Vehicles
EGR	Exhaust Gas Recirculation
EMFAC	Emission Factor
GDP	Gross Domestic Product
GVW	Gross Vehicle Weight
HC	Hydro Carbon
HC + Nox	Hydro Carbon plus Nitrogen Oxides
HCVs	Heavy Commercial Vehicles
HSD	High Speed Diesel
I & M	Inspection and Maintenance
IC	Internal Combustion
IGL	Indraprastha Gas Limited
IIP	Indian Institute of Petroleum, Dehradun
IIT	Indian Institute of Technology
IOCL	Indian Oil Corporation Limited
IS	Indian Standard
ITRC	Industrial Toxicology Research Centre, Lucknow
KMPH	Kilometer per Hour
kwh	Kilowatt hour
LCVs	Light Commercial Vehicles
LDO	Light Diesel Oil
LEV	Light Emission Vehicle
LMV	Light Motor Vehicle

LPG	Liquefied Petroleum Gas
LSD	Low Sulphur Diesel
MBI	Market Based Instruments
M &M	Mahindra & Mahindra Limited
MDPM	Market Determined Pricing Mechanism
MMTPA	Million Metric Tonnes Per Annum
MMT	Million Metric Tonnes
MNES	Ministry of Non – Conventional Energy Sources
MOBILE	Mobile Source Emissions Factor
MoEF	Ministry of Environment and Forests
MON	Motor Octane Number
MoPNG	Ministry of Petroleum and Natural Gas
MoRTH	Ministry of Road Transport and Highway
MS	Motor Sprit (Gasoline / Petrol)
MTBE	Methyl Tertiary Butyl Ether
MUVs	Multi Utility Vehicles
MVR	Motor Vehicle Rules
NAAQS	National Ambient Air Quality Standards
NAAQM	National Ambient Air Quality Monitoring
NAMP	National Air Quality Monitoring Programme
NCR	National Capital Region
NCT	National Capital Territory
NEP	National Environmental Policy
NEERI	National Environmental Engineering Research Institute
NMHC	Non –Methane Hydrocarbon
NO_2	Nitrogen Dioxide
NOx	Nitrogen Oxide
OBD	On Board Diagnostics
PAH	Polycyclic Aromatic Hydrocarbons
Pb	Lead
PCV	Positive Crankcase Ventilation

PM	Particulate Matter
PPM	Parts Per Million
PSU	Public Sector Undertaking
PT	Public Transport
PUC	Pollution Under Control
RHC	Reactive Hydro Carbon
RON	Research Octane Number
RSPM	Respirable Suspended Particulate Matter
RVP	Reid Vapour Pressure
RTO	Road Transport Offfice
SI	Spark Ignition
SIAM	Society of Indian Automobile Manufactures
SO_2	Sulphur Dioxide
SPM	Suspended Particulate Matter
STUs	State Transport Undertakings
T10	Temperature at which 10% vol. of the fuel evaporates
T50	Temperature at which 50% vol. of the fuel evaporates
T90	Temperature at which 90% vol. of the fuel evaporates
T95	Temperature at which 95% vol. of the fuel evaporates
TC	Turbo –Charged
TCAC	Turbo Charged After Cooled
TERI	The Energy Research Institute, New Delhi
THC	Total Hydro Carbon
ULEV	Ultra Low Emission Vehicles
UNEP	United Nations Environmental Programme
USEPA	United States Environmental Protection Agency
UT	Union Territories
VGT	Variable Geometry Turbocharger
VLI	Vapour Lock Index
VOC	Volatile Organic Compounds

VRDE	Vehicle Research and Development Establishment, Ahmednagar
WHO	World Health Organisation

CONTRIBUTIONS

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1.0 Introduction:

Air pollution is one of the serious environmental concern of the urban Asian cities including India where majority of the population is exposed to poor air quality. The health related problems such as respiratory diseases, risk of developing cancers and other serious ailments etc. due to poor air quality are known and well documented. Besides the health affects, air pollution also contributes to tremendous economic losses, especially in the sense of financial resources that are required for giving medical assistance to the affected people. The poor are often the most affected segment of the population as they do not have adequate measures to protect themselves from air pollution.

Most of the Indian Cities are also experiencing rapid urbanization and the majority of the country's population is expected to be living in cities within a span of next two decades. Since poor ambient air quality is largely an urban problem this will directly affect millions of the dwellers in the cities.

The rapid urbanization in India has also resulted in a tremendous increase the number of motor vehicles. The vehicle fleets have even doubled in some cities in the last one decade. This increased mobility, however, come with a high price. As the number of vehicles continues to grow and the consequent congestion increases, vehicles are now becoming the main source of air pollution in urban India. Although, the air quality can be improved through a combination of technical and non-technical measures, legislative reforms, institutional approaches and market-based instruments, there are certain unique challenges which the country has to face in tackling the problem of urban air pollution. These include, the transport features which are different from the developed countries particularly in terms of the types of vehicles commonly used, the manner in which the road network is operated and sharing of the limited space by pedestrians and non-motorized modes with modern vehicles in Indian cities. Vehicles in India are often much older and usually comprise technologies considered as out-dated in the developed world. The institutions responsible for managing urban air quality are also not as well developed as those in the

developed countries. The country has however taken a number of measures for the improvement of the air quality in cities. These include, right from the improvement in the fuel quality, formulation of necessary legislation and enforcement of vehicle emission standards, improved traffic planning and management etc. The non-technical measures taken include, awareness raising regarding the possible economic and health impacts of air pollution and available measures for improving air quality, increasing use of cleaner fuels and purchase of vehicles with advance emission control devices, increasing institutional framework and capacity building for the monitoring of vehicle emissions.

The document presents a review of the vehicular emission problems in Indian cities, the various developments that have taken place in the past including the studies conducted for assessment of the air quality in cities, the legislation and standards adopted for the control of vehicle emissions, the role of the various concerned agencies, the steps taken for improvement in the quality of the automotive fuel, the overall impact of these measures and the future strategy to be adopted for vehicular emission reduction and related issues.

2.0 Vehicular pollutants and their health/environmental effects

2.1 Contribution of various sources towards ambient air quality

Organization like TERI, UNEP/ WHO, World Bank, BARC/CESE/IIT, etc have carried out studies in the past to estimate the contribution of various sources towards the ambient air quality. The summary of the results of the above studies for Delhi & Mumbai are given pollutant wise in **Table 2.0**

2.2 Major vehicle/fuel pollutants

Automotive vehicles emit several pollutants depending upon the type of quality of the fuel consumed by them. The release of pollutants from vehicles also include fugitive emissions of the fuel, the source and level of these emissions depending upon the vehicle type, its maintenance etc. The major pollutants released as vehicle/fuel emissions are, carbon monoxide, nitrogen oxides, photochemical oxidants, air toxics namely benzene, aldehydes, 1-3 butadiene, lead, particulate matter, hydrocarbon, oxides of sulphur and polycyclic aromatic hydrocarbons. While the predominant pollutants in petrol/gasoline driven vehicles are

hydrocarbons and carbon monoxide, the predominant pollutants from the diesel based vehicles are Oxides of nitrogen and particulates. Details on emissions emitted by vehicles is given at **Annexure-I**

Table 2.0: Summary of the results of various studies

S.No.	Parameter	Delhi			Mumbai		
		Transport	Industrial	Domestic & other sources	Transport	Industrial	Domestic & other sources
1.	CO	76% to 90%	37% to 13%	10% to 16.3%	92%	8%	Nil
2.	NOx	66% to 74%	13% to 29%	1% to 2%	60%	40%	Nil
3.	SO_2	5% to 12%	84% to 95%	Nil to 4%	2% to 4%	82% to 98%	Nil to 16%
4.	PM	3% to 22%	74% to 16%	2% to 4%	Nil to 16%	34% to 96%	53% to 56%

Source: Auto Fuel Policy Report

2.3. Health and environmental effects of vehicular pollutants

2.3.1 General/Overall Effects

The vehicular emissions have damaging effects on both human health and ecology. There is a wide range of adverse health/environmental effects of the pollutants released from vehicles. The effects may be direct as well as in-direct covering right from reduced visibility to cancers and death in some cases of

acute exposure of pollutants specially carbon monoxide. These pollutants are believed to directly affect the respiratory and cardiovascular systems. In particular, high levels of Sulphur dioxide and Suspended Particulate Matter are associated with increased mortality, morbidity and impaired pulmonary function. The overall effects of vehicular emissions are summarized in **table 2.1**. The pollutant wise health effects are summarized in **table 2.2** and detailed in **Annexure II**.

Table-2.1: Vehicles emit significant amounts of several pollutants with varying effects as summarized.

	Health Effect					Climate Change	
Pollutant	**Direct**	**Indirect**	**Acid rain**	**Eutrophication**	**Visibility**	**Direct**	**Indirect**
CO	X						X
HC	X	X[a]					X
NOx	X	X[a]	X	X	X	X	
PM	X				X	X	
SOx	X		X		X		X

CO = carbon monoxide, HC = hydrocarbon, NOx = nitrogen oxides, PM = particulate matter, SO2 = sulfur oxide , [a] Ozone

Table 2.2: Health effects associated with

Pollutant	Effect on Human Health
Carbon Monoxide	Affects the cardio vascular system, exacerbating cardiovascular disease symptoms, particularly angina; may also particularly affect fetuses, sick, anemic and young children, affects nervous system impairing physical coordination, vision and judgments, creating nausea and headaches, reducing productivity and increasing personal discomfort.
Nitrogen Oxides	Increased susceptibility to infections, pulmonary diseases, impairment of lung function and eye, nose and throat irritations.
Sulphur Dioxide	Affect lung function adversely.
Particulate Matter and Respirable Particulate Matter (SPM and RPM)	Fine particulate matter may be toxic in itself or may carry toxic (including carcinogenic) trace substance, and can alter the immune system. Fine particulates penetrate deep into the respiratory system irritating lung tissue and causing long-term disorders.
Lead	Impairs liver and kidney, causes brain damage in children resulting in lower I.Q., hyperactivity and reduced ability to concentrate.
Benzene	Both toxic and carcinogenic. Excessive incidence of leukemia (blood cancer) in high exposure areas.
Hydrocarbons	Potential to cause cancer

2.3.2 WHO Guidelines on Air Quality

The 2005 *WHO Air quality guidelines* (AQGs) of World Health Organization(WHO)are designed to offer global guidance on reducing the health impacts of air pollution. The guidelines first produced in 1987[1] and updated in 1997[2] had a European scope. The new (2005) guidelines apply worldwide and are based on expert evaluation of current scientific evidence. They recommend revised limits for the concentration of selected air pollutants: particulate matter (PM), ozone (O3), nitrogen dioxide (NO2) and sulfur dioxide (SO2), applicable across all WHO regions

The key facts and guideline values for selected air pollutants as recommended in the WHO guidelines are given in **Annexure III**

3.0 Vehicular Pollution and Climate Change

3.1 Global Warming and Climate Change

The world average temperature has risen by about 1 F° over the past century. It is widely accepted that the global warming is related to anthropogenic Green House Gases (GHGs). GHGs include, the common gases namely , carbon dioxide and water vapor, and rarer gases such as nitrous oxide, methane and chlorofluorocarbons (CFCs) whose properties relate to the transmission or reflection of different types of solar radiations. The increase in such gases in the atmosphere is a result of the burning of fossil fuels, emission of pollutants into the atmosphere by power plants and vehicle engines, etc. Of all human activities, driving motor vehicles produces the most intensive CO2 emissions and other toxic gases per capita. A single tank of gasoline releases 140 ~180 kilograms of CO2. Over 25% of transportation-related GHG emissions originate from urban passenger travel (Yang M. 1998). Unsustainable trends in urban transportation have already manifested in frequent congestions, periodic gridlock and evidence linking respiratory illnesses and deaths to poor air quality.

3.2 Global Emissions of GHG's from Transport Sector

Transport sector contributes around 14% towards the global emissions of green house gases. Carbon dioxide represents the largest proportion of basket of greenhouse gas emissions. During, the past three decades, carbon dioxide emissions from transport have increased faster than those from all other sectors and are projected to increase more rapidly in future. The Road transport alone emits around 16% of the global CO_2 emissions (Source: OICA). From 1990 to 2004, carbon dioxide emissions from the world's transport sector have increased by 36.5%.For the same period, road transport emissions have increased by 29%

in industrialized countries and 61% in the other countries (IEA, 2006). The global emissions of GHG's from different sectors have been shown in **figure 3.0.**

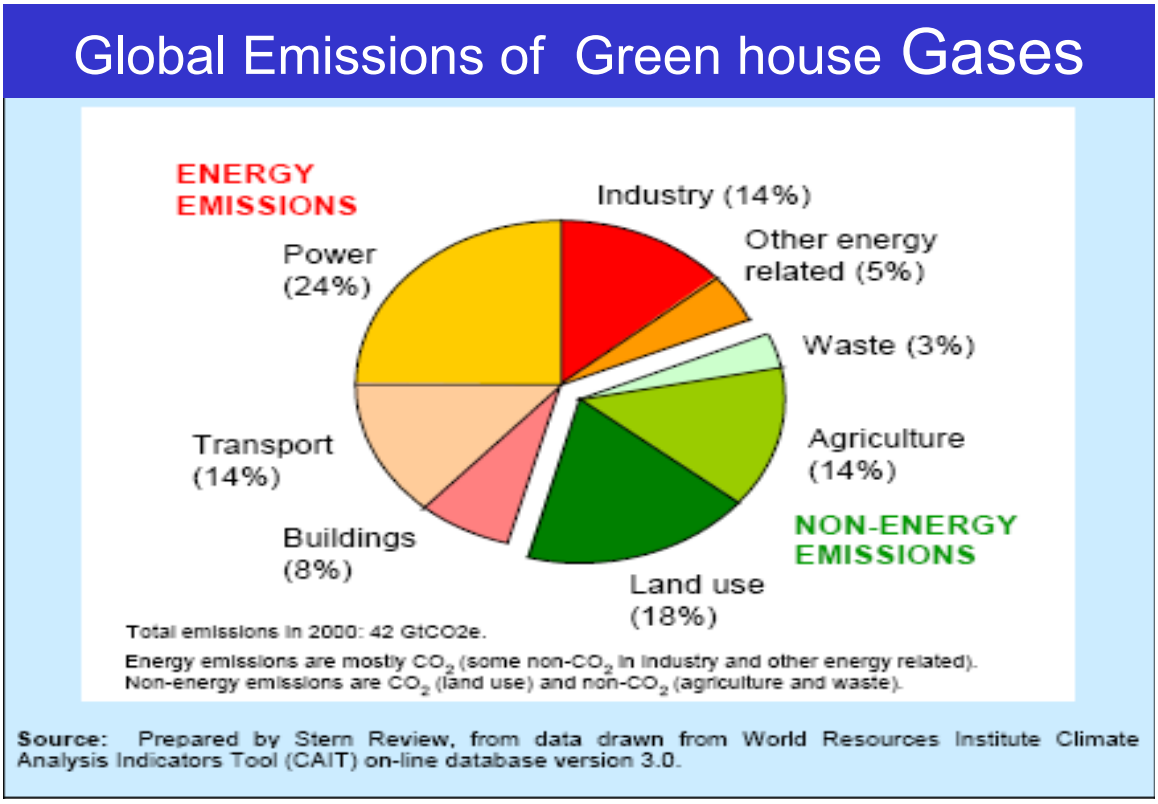


Figure 3.0 : Global emissions of GHG's from different sectors

The CO2 emissions in the major developed and developing countries around the world during 1980 to 2030 is shown in **figure 3.1**. The figure shows that the global CO2 emissions are going to get stabilized in the developed countries in the near future, the CO_2 are likely to increase in the developing countries owing to its due economic growth as well rising human population. However, in terms of per capita emissions the emissions from developing countries alike developed countries, are also expected to stabilize in the near future

The mode wise distribution of CO_2 emissions amongst transport section (**See figure 3.2**), reveals that road transport contributes major share of around 73% towards total CO_2 emissions from transport sector. Aviation, International shipping & Railways sector emissions of CO_2 from transport sector are about 11%, 9% & 2% respectively.

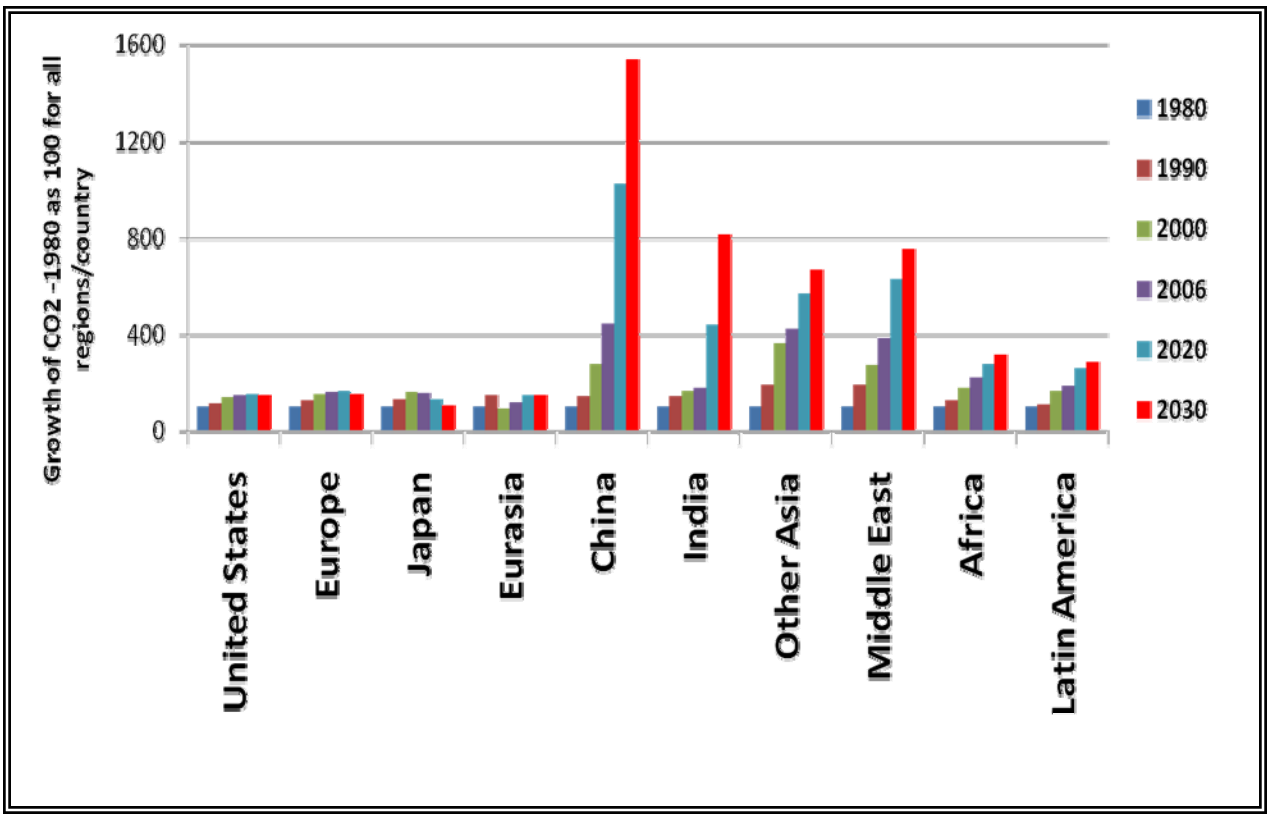


Figure 3.1 : CO2 emissions Transport sector 1980 - 2030
Source: Modified from IEA 2008, World Energy Outlook

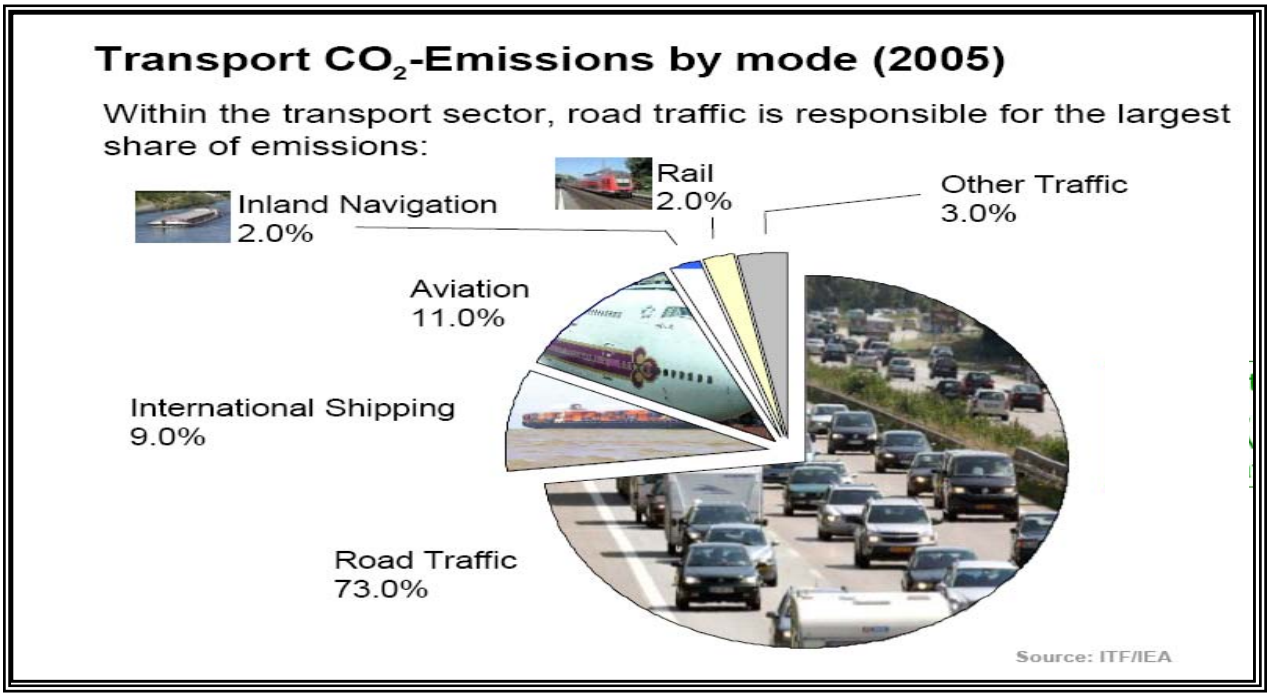
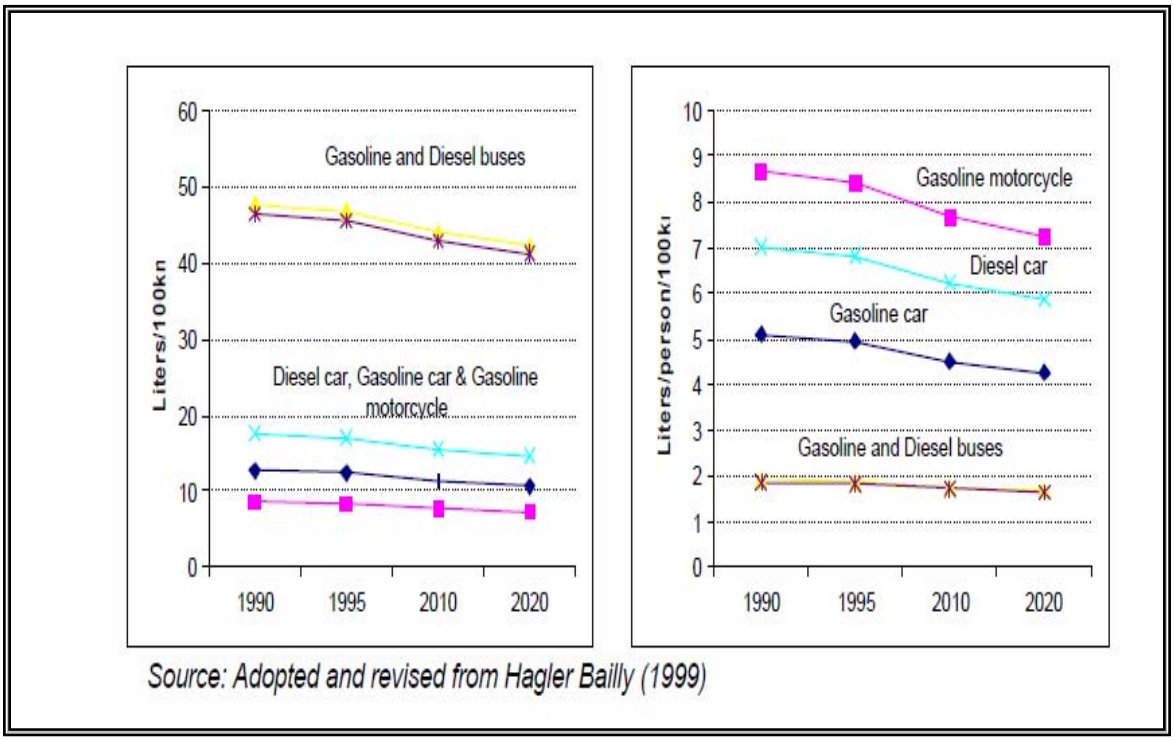


Figure 3.2 : Global GHG's emissions from Transport sector (Mode-Wise)

3.3 Vehicle's and Fuel specific emissions of the GHG's

3.3.1 Emissions from different vehicles

The left side in **Figure 3.3** shows energy intensity of buses, cars and motorbikes in Canada in 1999. Gasoline and diesel buses rank the highest at the range of 40 to 50 liters per 100 km traveled. The least energy intensive vehicle is motorbikes, consuming less than 10 litters per 100 km. Diesel and gasoline cars burn about 10 to 20 liters per 100 km. The right hand of the figure shows energy intensity in liters per person per 100 km. We assume that all the vehicles are half loaded, i.e., 25 people for a bus, 2.5 for a car and one person for a motorbike. Then, energy intensity range order will be inversed when compared with the case in the left chart. Gasoline motorbike requires 7-9 liters per person-100 km travel, but a bus rider consumes no more than 2 liters. Diesel and gasoline cars are in the range between 4 to 7 litters per person-100km.



Source: Adopted and revised from Hagler Bailly (1999)

Figure 3.3: Average Fuel Efficiency Factors for Urban Travel (Canada)

3.3.2 Emissions from different fuels

The weighted GHG emissions in moles of CO2 equivalent per vehicle-mile traveled (VMT) which is equal to the un-weighted quantity multiplied by the global warming potential per mole of each gas, relative to carbon dioxide is shown in **table 3.0.** It can be seen that the compressed natural gas (CNG) and liquefied

petroleum gas (LPG) vehicles emit least GHGs among all the transportation fuels and alternatives.

Table 3.0 : Weighted emissions from Gasoline and Alternative Fuels (Unit : Moles of CO_2 eq per VMT (Weighted)

Greenhouse Gas	Gasoline	Methanol from Natural Gas	Ethanol from Corn	Compressed Natural Gas	Liquefied Petroleum Gas
Carbon Dioxide (CO_2)	7.9	8.7	7.4	5.64	6
Methane (CH_4)	0.22	0.35	0.39	0.91	0.17
Nitrous Oxide (N_2O)	0.54	0.54	2.98	0.54	0.54
Nitrogen Oxide (NOx)	1.06	1.45	2.33	0.97	0.92
Carbon Monoxide (CO)	0.99	0.98	0.78	0.97	0.96
Total	10.71	12.02	13.88	9.03	8.61

3.4 Emissions of GHG's from Transport Sector in India

An well to exhaust study for CO_2 emissions carried out by a Delhi based organization Centre for Science and Environment has depicted that the emissions of CO_2 on Indian roads is expected to reach a value of 1212 million tones during 2035 from a value of 208 million tones during 2005.Total CO_2 emission from well to exhaust in Indian roads from 2005 to those projected in 2035 are mentioned in **figure 3.4.**

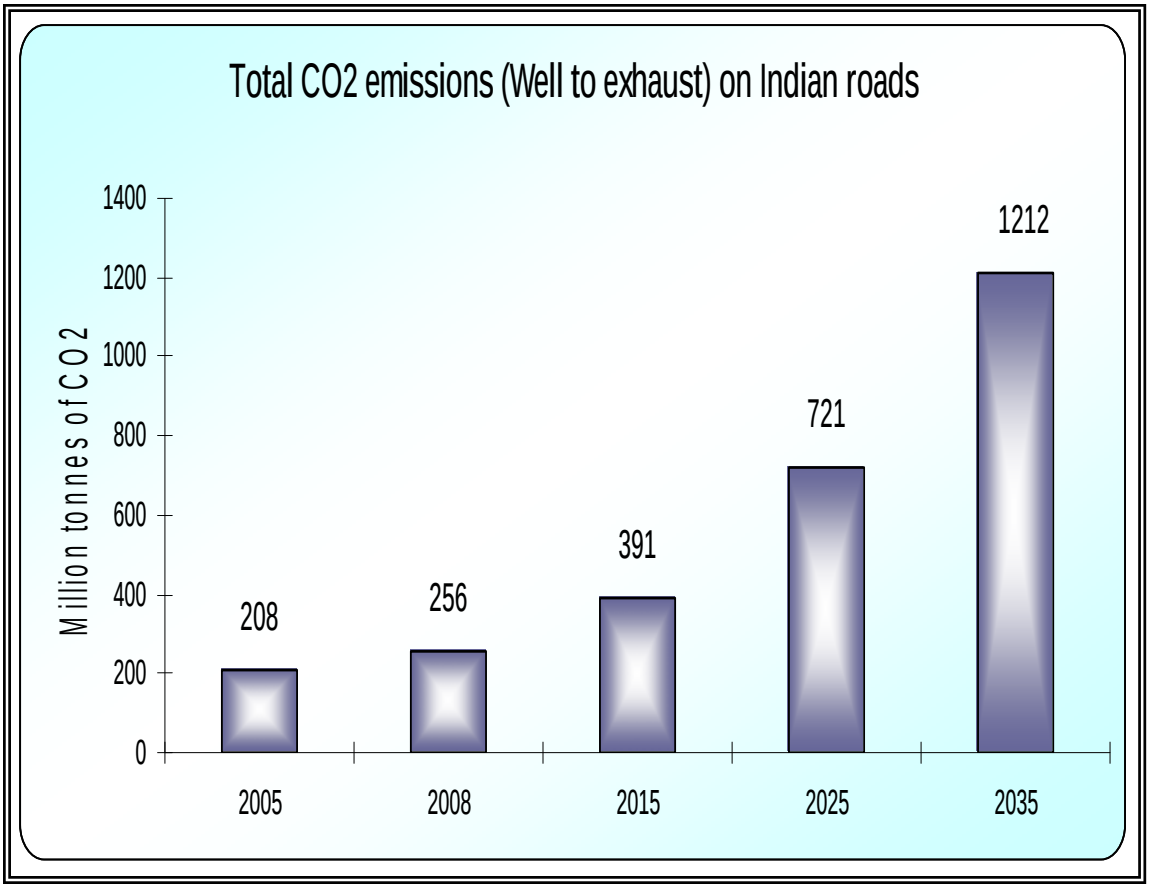


Figure 3.4 : Total CO_2 emissions (well to exhaust) on Indian Roads

Source : CSE, New Delhi

4.0 Overview of Transport sector in India

4.1 Growth of Transport Sector with Indian Economy

Indian economy reached to a landmark of 9% GDP in 2007-08. This has put India into the group of one of the fastest growing major economy after China. The service sector emerged as one of the main driving force in country's high GDP. The Sector wise GDP Growth rates are depicted in **Table 4.0.**

Table 4.0: Sector –wise GDP Growth rates

Sector	2002 - 03	2003 - 04	2004 - 05	2005 - 06	2006- 07	2007 -08
Agriculture*	-7.24	9.96	-0.05	5.92	3.76	4.55
Industry	6.79	6.00	8.51	8.02	10.63	8.09
a. Manufacturing	6.81	6.63	8.65	8.98	12.00	8.78
b. Mining /Quarry	8.84	3.09	8.15	4.87	5.70	4.75
c. Electricity	4.75	4.77	7.90	4.68	5.98	6.27
Services	7.52	8.84	9.87	11.01	11.18	10.66
a. Construction	7.95	11.98	16.14	16.46	11.98	9.81
b. Trade, hotels	***9.44***	***12.01***	***10.69***	***11.51***	***11.82***	***12.02***
c. Finance / Insurance+	7.98	5.58	8.69	11.41	13.92	11.79
d. Community++	3.93	5.41	6.85	7.21	6.89	7.25
GDP at factor cost	***3.84***	***8.52***	***7.45***	***9.40***	***9.62***	***9.03***

* - includes forestry & fishing, ** - includes transport & Communication
+ - includes real estate & business service, ++ - includes social and personal services

The transport demand in India has been growing rapidly, which is the second largest consumer of energy, next only to Industry. The installed capacity of Indian automobile industry is also increasing over the year based on the domestic and international demand. The installed capacity of automobile industry for year 2005-6 & 2006-07 and production & sale trends (Domestic & Export) are given in **Table 4.1** and **Table 4.2.** The percentage of domestic market share of vehicle under various categories during 2008 - 09 is shown in **Fig. 4.0**.

Road freight transport demand is expected to grow by around 10% per annum in the backdrop of a targeted annual GDP growth of 9% during the Eleventh

Five Year Plan. Road transport and the railways account for the majority of this contribution. Commercial energy consumption in the transport sector, about 98% of which is in the form of HSD and gasoline, grew at the rate of 3.1% per annum in the 1970s and at 5.6% per annum in the 1990s.

Table 4.1: Installed Capacities in the Indian Automobile Industry

Vehicle type	Installed capacity (in Millions)	
	2005 -06	2006 – 07
a. Four Wheelers	1.79	2.24
b. Two & Three Wheelers	10.59	12.69
c. Others	0.29	0.39

Source: *SIAM(Society of Indian Automobile Manufacturers)*

Table 4.2: Indian Automobile Industry Production /Sale Trends

Category		2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09
Passenger Vehicles	P	7,23,330	9,89,560	12,09,876	13,09,300	15,45,223	17,77,583	18,38,697
	D	7,07,198	9,02,096	10,61,572	11,43,076	13,79,979	15,49,882	15,51,880
	E	72,005	1,29,291	1,66,402	1,75,572	1,98,452	2,18,401	3,35,739
Commercial Vehicles	P	2,03,697	2,75,040	3,53,703	3,91,083	5,19,982	5,49,006	4,17,126
	D	1,90,682	2,60,114	3,18,430	3,51,041	4,67,765	4,90,494	3,84,122
	E	12,255	17,432	29,940	40,600	49,537	58,994	42,673
Three Wheelers	P	2,76,719	3,56,223	3,74,445	4,34,423	5,56,126	5,00,660	5,01,030
	D	2,31,529	2,84,078	3,07,862	3,59,920	4,03,910	3,64,781	3,49,719
	E	43,366	68,144	66,795	76,881	1,43,896	1,41,225	1,48,074
Two Wheelers	P	50,76,221	56,22,741	65,29,829	76,08,697	84,66,666	80,26,681	84,18,626
	D	48,12,126	53,64,249	62,09,765	70,52,391	78,72,334	72,49,278	74,37,670
	E	1,79,682	2,65,052	3,66,407	5,13,169	6,19,644	8,19,713	10,04,174
Grand Total	P	62,79,967	72,43,564	84,67,853	97,43,503	1,10,87,997	1,08,53,930	1,11,75,479
	D	59,41,535	68,10,537	78,97,629	89,06,428	1,01,23,988	96,54,435	97,23,391
	E	3,07,308	4,79,919	6,29,544	8,06,222	10,11,529	12,38,333	15,30,660

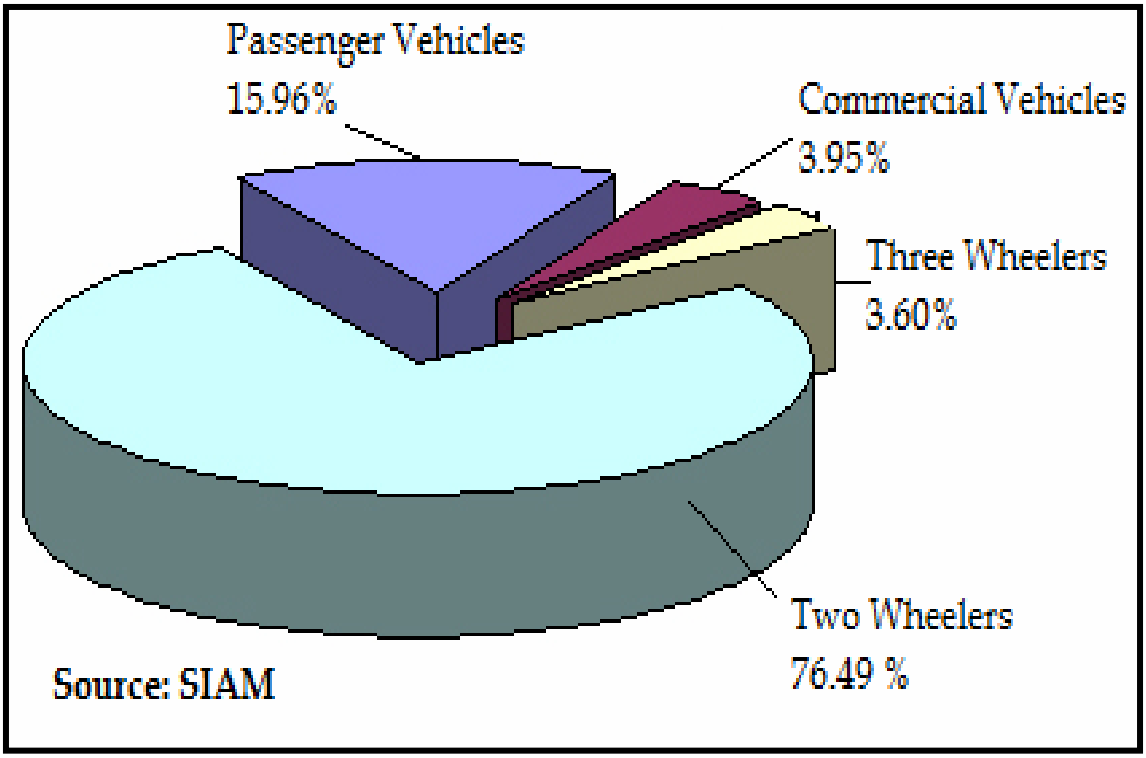


Fig.4.0: Domestic market share of vehicles in 2008-09
Source: SIAM **P**: Production **D**: Domestic Sale **E**: Export Sale

4.2. Vehicular Population Growth

The total motor vehicles population in India has increased from about 3,10,000 in 1951 to about 89,00,000 at the end of fiscal year 2005-06. The growth of registered vehicles under various categories over the years up to 2004 is shown in **Fig. 4.1**. The actual number of motor vehicles use in the country may be 20 – 30% lower, as registration procedures do not remove many of the out of service vehicles from the records. It can be seen from this figure that , the motor cycle registrations in the country are more than five times than as cars. The National Capital Delhi itself accounts for about 8% of the total registered vehicles and has more registered vehicles than those in the other three metros namely Mumbai, Kolkata and Chennai taken together.

The numbers and percentage of various types of vehicles registered during year 2004 and sold in year 2007 in India are given in **Table 4.3**. The car and motorized two wheelers sales have averaged 16% and 9% annual growth rates, respectively, over the past five years.

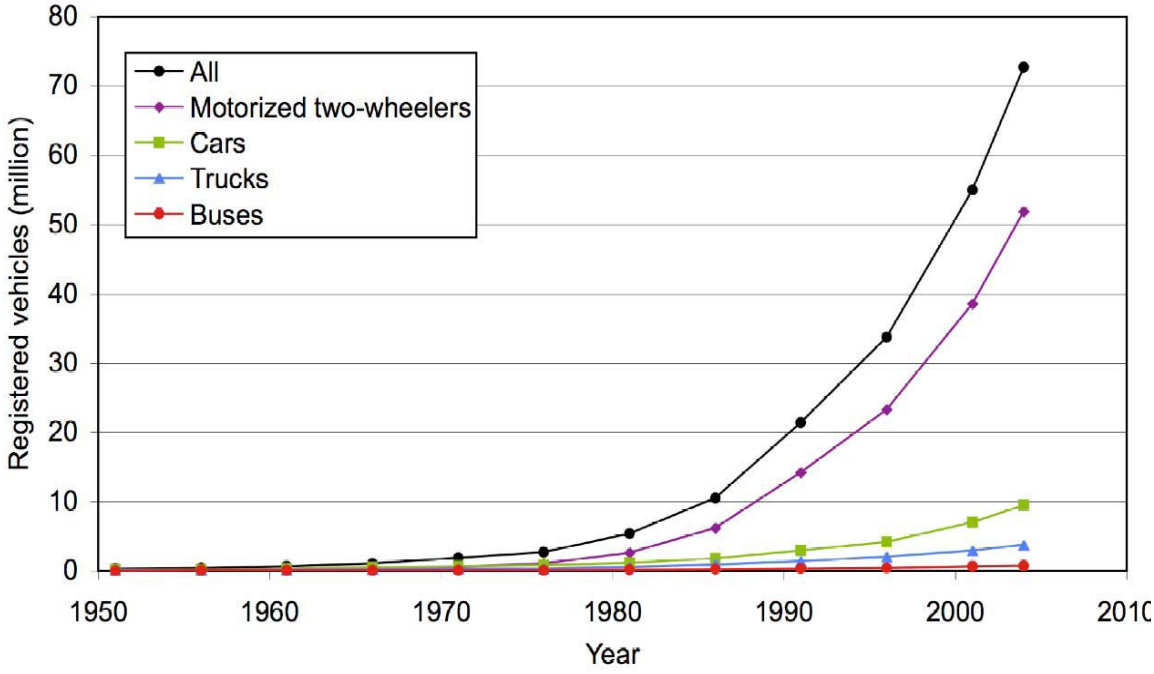


Fig.4.1: Registered Vehicles under various categories in India

Source: Department of Road Transport & Highways, 2008

Table 4.3: Types of Vehicle Registered (2004) and Sold (2007)

Vehicle type	Registered in 2004*		Sold in 2007**	
	Numbers (Million)	Percent	Numbers (Million)	Percent
Two –Wheeler	51.92	71	7.42	78
Car	9.45	13	1.27	13
Bus	0.77	1	0.48	5
Truck	3.75	5		
Other	6.83	9	0.38	4
Total	***72.72***	***100***	***9.55***	***100***

Source: * Department of Road Transport and Highways (2008)
** Society of Indian Automobile Manufacturers (2008)

The composition of vehicle population and its share in percentage is given in **Table 4.4**. The table reveals that personalized mode (constituting mainly two wheelers and cars) accounted for more than four-fifth of the motor vehicles in the country compared to their share of little over three-fifth in 1950. Further break up of motor vehicle population reflects preponderance of two wheelers with a share of more than 72% in total vehicle population, followed by passenger cars at 13% and other vehicles (a heterogeneous category which includes 3 wheelers (LMV Passengers), trailers, tractors, etc.) around 9%. In contrast to personalized mode, the share of buses in total registered vehicles has declined from 11.1% in 1951 to 1.1% during 2006. Also, the share of goods vehicle at about 5% in vehicle population is modest in comparison to the size of the economy. The share of buses in the vehicle population at about 1 per cent possibly indicates the slow growth in public transport.

Table 4.4: Composition of Vehicle Population in % of total

Year (March end)	2 Wheelers	Cars , Jeeps etc.	Buses	Goods Vehicle	Others	Total (Million)
1951	8.8	52.0	11.1	26.8	1.3	0.31
1961	13.2	46.6	8.6	25.3	6.3	0.66
1971	30.9	36.6	5.0	18.4	9.1	1.86
1981	48.6	21.5	3.0	10.3	16.6	5.39
1991	66.4	13.8	1.5	6.3	11.9	21.37
2001	70.1	12.8	1.2	5.4	10.5	54.99
2002	70.6	12.9	1.1	5.0	10.4	58.92
2003	70.9	12.8	1.1	5.2	10.0	67.01
2004	71.4	13.0	1.1	5.2	9.4	72.72
2005	72.1	12.7	1.1	4.9	9.1	81.50
2006(P)	72.2	12.9	1.1	4.9	8.8	89.61

Note: Others include Tractors, Trailers, 3 Wheelers & etc. (P): Provisional

Source: *Road Transport Year Book 2006-07, MoRTH*

4.3. Share of Road Users

India has a rural road network of over 30,00,000 km, and urban roads total more than 2,50,000 km. The national highways, with a total length of 65,569 km, serve as the arterial network across the country. Roads carry about 61% of the freight and 85% of the passenger traffic. While , the highways amounts to only 2% of the roads, they carry 40% of the road traffic in the country.

The growth of vehicular traffic on roads has been far greater than the growth in road network; as a result the main arteries face capacity saturation. Between 1951 and 2004 the motor vehicle population grew at a compound annual growth rate (CAGR) of close to 11% (10.9 %) compared to CAGR of 3.6% in the total road length with National Highway segment increasing by 2.3% onlyThere has been the step-up in the growth of National Highway network in recent years which has grown at CAGR of about 4.5 per cent with total vehicle population growing at 10% CAGR during 1991-2006, the same is revealed in **Table 4.5**.

Table 4.5: Compound Annual Growth Rate in Vehicles and Road Length

Period	Vehicles (in %)					Roads (in %)					
	Two - Wheelers	Cars	HVs	Others	Total	NHs	PWD	Rural	Urban	Project	Total
2006/ 1951	15.2	8.1	7.2	14.8	10.9	2.2	-	-	-	-	-
1961/ 1951	12.5	6.9	6.8	26.5	8.1	1.9	4.0	-	-	-	2.7
1971/ 1961	20.7	8.2	6.9	15.0	10.9	0.0	2.6	6.0	4.5	-	5.7
1981/1971	16.3	5.5	5.1	18.1	11.2	2.9	4.5	5.9	5.5	3.5	5.0
1991/1981	18.4	9.8	8.9	10.9	14.8	0.6	2.1	4.0	4.3	1.2	3.0
2001/1991	10.5	9.1	7.8	8.6	9.9	5.5	3.1	1.4	3.0	0.6	2.1
2004/1991	10.5	9.4	7.9	7.9	9.9	5.3	2.3	1.9	3.7	1.7	2.3
2006/1991	10.6	9.5	8.1	7.9	10.0	4.5	-	-	-	-	-

Note: *HVs includes buses & trucks, NHs: National Highways; SHs : State Highways; PWD: Public Works Department*

Source: *Road Transport Year Book 2006-07, MoRTH*

The ongoing project of four-laning the 5,900 km Golden Quadrilateral connecting Delhi, Mumbai, Chennai, and Kolkata is nearing completion. The

ongoing four-laning of the 7,300 km North-South East-West (NS-EW) corridor is to be completed by December 2009. The National Highway Development Programme, involving a total investment of US$ 55 billion up to 2012, has been proposed for constructing 1,000 km of new expressways, six-laning 6,500 km of the four-lane highways comprising the Golden Quadrilateral and certain other high-density stretches, four laning the Golden Quadrilateral and NS-EW corridors, four-laning 10,000 km of high-density national highways, and upgrading 20,000 km of smaller rural roads into two-lane highways.

The average modal shares of road in the country as per data collected by the MoRTH (Ministry of Road Transport & Highways) at sample stations on national highways in different states during 2006 were as follows: 33% for cars and three wheeled vehicles, 29% for motorized two-wheelers, 29% for trucks, 7% for buses, and 2% for tractors. Accurate estimates for non- motorized road user share on Indian roads are not available, but the data from the study done in late 1990s gives the following ranges: 4 -25% on four lane divided highways and 9-39% on two lane highways (Tiwari et al., 2000).

4.4 State-wise vehicles population & its growth

Growth in terms of CAGR of registered vehicles amongst the States and Union Territories at the ending 2006 (2001-2006) (Annexure-IV) shows that total vehicle population in terms of registration grew at 10.3%. Several States exceeded the all-India growth rate and clocked CAGR of over 11%. These States include Andhra Pradesh, Assam, Chhattisgarh, Karnataka, Kerala, Orissa, Sikkim, Tamil Nadu, Tripura and Uttarakhand.

4.5 Age profile of On-road vehicles in India

Age profile of different type of vehicles in India is described in **table 4. 6**. In the case of 2 wheelers, with the existing population of around 52 millions, nearly 50% 2 wheelers are less than 5 yrs old and about 27% of the 2W population is 6-10 year old. Around 10% of 2W are 15-25 years old on Indian roads. In case of cars also around 50% of existing 7 million populations is less than 50%, while 30% are between ages of 6-10 years old. Less than 8 % of the Indian on road cars are in between ages of 15-25 years. In Light Commercial Vehicles about 37% of the vehicles are less than 5years old . Thus on the whole around 50% of the 2W and cars population on Indian roads is less than 5 years. However 60% of air pollution is caused by vehicles > 10 years (< 30% of total vehicle pool).

Table 4.6 : Age profile of On-road vehicles in India

S .NO	Vehicle Type	Population (In Millions)	< 5 yrs (%)	6-10 yrs (%)	11-15 yrs (%)	16-20 yrs (%)	20-25 yrs. (%)	> 25yrs (%)
1	2-wheelers	52	48.7	27.2	14.3	7.8	1.8	0.3
2	Cars	7	50.3	29.5	12.9	6.0	1.1	0.2
3	LCV	2	36.8	21.5	26.5	11.3	3.2	0.8

4.6 Fuel consumption in India

Since the birth of automotives in the 19th century, diesel and gasoline are used as the primary source of energy for the vehicles. As per information available with CIA's World Factbook , 2008, India is one of the top ten oil consuming country in the world. With the oil consumption of 2,438,000 barrels per day, India stands 6th amongst top ten oil consuming countries of the world. Further as per PCRA (Pollution Conservation Research Association) , an average consumption pattern of petroleum products in India is as follows:

Table 4.7: Consumption Pattern of Petroleum products in India

S.no	Sector	Consumption (%)
1	Transport (Petrol, Diesel, CNG, Aviation fuel)	51
2	Industry (Petrol, Diesel, Fuel oil, Naphtha, Natural Gas)	14
3	Commercial & other	13
4	Domestic (LPG & Kerosene)	18
5	Agriculture (Diesel)	4

The transport sector alone consumes more than 50% of the total oil consumption in the country. Fuel consumption pattern in nine metro cities of the country during 2000-01 is described in **figure-4. 2**

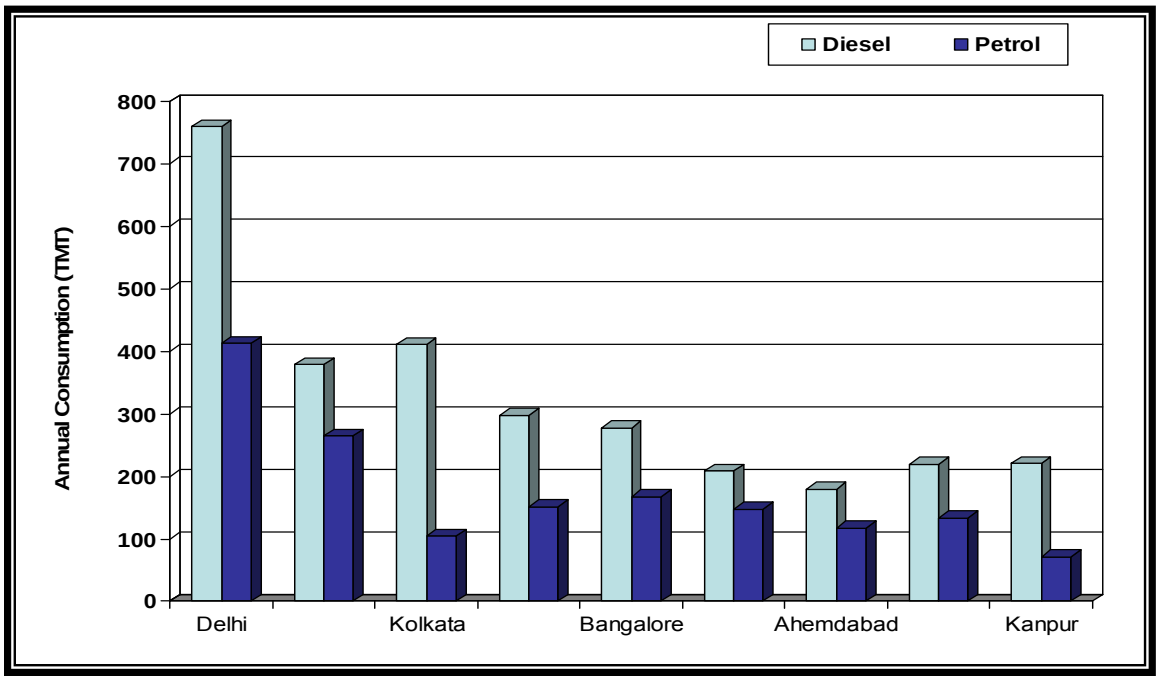


Fig 4.2: Fuel consumption pattern in nine metro cities of the country during 2000-01

All buses in Delhi along with majority of the on-road taxis and three wheelers switched over to CNG mode. It's now 3-4 years that Delhi buses and commercial vehicles like Auto's, Taxis etc are using CNG and as anticipated there have been remarkable shifts in air quality. CNG has been introduced as automotive fuel in the cities of Mumbai, Ahemdabad, Surat & Vadodra as well.

Table 4.8 - CNG VEHICLES IN INDIA AS ON JANUARY 1,2004						
Item	Delhi	Maharastra	Gujarat			
	IGL	MGL	Vadodra	Surat/GGCL	Ankelashwar	Total
No. of Vehicles						
Cars	15876	47870	450	663	123	64982
Autos	56846	61497	16	429	0	118788
MiniBuses	5164	7	0	0	0	5171
Buses	10075	47	0	0	0	10122
Total	87961	109421	466	1092	123	199063
Average Consumption						
Thousand Kgs/day	816.00	382.30	0.57	3.00	.30	1202.17
MMSCMD	1.1805	0.543	0.001	0.003	0.0003	1.72733

4.7 Vehicular emissions load in India

In India, the number of motor vehicles has grown from 0.3 million in 1951 to approximately 50 million in 2000, of which, two wheelers (mainly driven by two stroke engines) accounts for 70% of the total vehicular population. Two wheelers, combined with cars (four wheelers, excluding taxis) (personal mode of transportation) account for approximately four fifth of the total vehicular population. The problem has been further compounded by steady increase in urban population (from approximately 17% to 28% during 1951-2001; Sharma; 2001 and larger concentration of vehicles in these urban cities specially in four major metros namely, Delhi, Mumbai, Chennai and Kolkatta which account for more than 15% of the total vehicular population of the whole country, whereas, more than 40 other metropolitan cities (with human population more than 1million) accounted for 35% of the vehicular population of the country. Further, 25% of the total energy (of which 98% comes from oil) is consumed by road sector only. Vehicles in major metropolitan cities are estimated to account for 70% of CO, 50% of HC, 30-40% of NOx, 30%of SPM and 10% of SO_2 of the total pollution load of these cities, of which two third is contributed by two wheelers alone. These high level of pollutants are mainly responsible for respiratory and other air pollution related ailments including lung cancer, asthma etc., which is significantly higher than the national average (CSE, 2001; CPCB, 2002) . Status of vehicular emissions (mega cities and state wise) in India is described in detail in the section ahead.

4.7.1 Country's status

A decentralized emission inventories study for road transport sector of India was carried out at Indian Institute of sciences, Bangalore (T.V. Ramachandra and Shwetmala). Total Indian transport emission of CO2, CO, NOx, CH4, SO2, PM,HC, N2O and NMVOC are summarized in Table 4. 9. During 2003–2004, total transport emission of CO2 was 258.10 Tg CO2 contribution of road sector, aviation, railways and shipping was 243.82 Tg (94.5%), 7.60 Tg (2.9%), 5.22 Tg (2%) and 1.45 Tg (0.6%), respectively. Road sector and aviation mainly contribute 3.03 Tg (53.3%) and 2.57 Tg (45.1%) of CO. Among all type (road, shipping, railways and aviation) of transport, road and aviation are the major contributor of air pollution.

4.7.2 Emissions from different vehicle type of India

The emissions calculated for different type of road transport vehicles are summarized in Table 4.10 . Among different type of vehicles, trucks and lorries contribute 28.8% CO2 (70.29 Tg), 39% NOx (0.86 Tg), 27.3% SO2 (0.19 Tg), and 25% PM (0.03 Tg), which constitute 25% of the total vehicular emission of

India. Similarly two wheelers are major source of CO (0.72 Tg; 23.7%), CH4 (0.06 Tg; 46.4%), and HC (0.46 Tg; 64.2%) and buses are emitting NOx (0.68 Tg; 30.7%) and PM (0.03 Tg; 20.5%). Vehicular emissions vary with type, efficiency and type of fuel used. Emission analysis based on the vehicle type reveal that bus and omni buses contribute higher CO2 (CO2: 96.5%, NOx: 2.28%) compared to two wheelers (CO2: 86.8%, CO: 7.18%, HC: 4.6%), passenger light motor vehicles (CO2: 86.8%, CO: 7.6%, NOx: 1.9%), cars and jeeps (CO2: 98.8%), taxi (CO2: 94.6%, SO2: 4.68%), trucks and lorries (CO2: 97.6%, NOx: 1.2%), goods light motor vehicles (CO2: 98.4%), and trailers and tractors (CO2: 98.4%) are different.

Table 4.9 : Total emissions from Indian transport for 2003/04 (Gg)

	CO_2	CO	NO_x	CH_4	SO_2	PM	HC	N_20	NMVOC
Shipping									
High speed diesel	782.28	10.66	8.5273	0.533	-	-	-	0.0064	2.13
Light diesel oil	162.18	2.21	1.7679	0.011	-	-	-	0.0013	0.442
Fuel oil	510.19	6.55	5.24	0.033	-	-	-	0.0039	1.31
Railways									
Coal	5.280	0.0155	0.0121		0.0421	-	-		
Electricity	Not considered				-	-	-		
High Speed diesel	5186.58	70.6712	56.54	0.353	-	-	-	0.0424	14.13
Light diesel oil	6.360	0.0867	0.0693	0.004	-	-	-	0.0001	0.0173
Fuel Oil	25.04	0.3215	0.2572	0.0016	-	-	-	0.002	0.0643
Aviation-									
High speed diesel	85.860	1.17	0.9359	0.0058	-	-	-	0.0007	0.2340
Light diesel oil	6.360	0.0867	0.693	0.004	-	-	-	0.0001	0.0173
Fuel oil	222.23	2.835	2.2828	0.0143	-	-	-	0.0017	0.5707
Aviation turbine fuel	7294.14	2565.35	8.7331	6.549	-	-	-	-	-
Road transport	243816.6	3032.104	2213.85	126.78	709.09	153.127	723.409	-	-
Total	258103.14	5692.16	2298.29	133.8038	709.135	153.127	723.409	0.0568	18.9219

Table 4.10 : Emissions from different vehicle type of India (Gg)

Categories	CO_2	CO	NO_x	CH_4	SO_2	PM	HC
Bus	28748.16	207.26	679.73	5.02	79.24	31.36	51.72
Omni buses	8508.42	60.94	200.53	1.49	23.45	9.28	15.11
Two wheelers	8701.08	719.64	62.15	58.88	4.25	16.36	464.49
Light motor vehicles (Passenger)	4378.10	370.29	92.93	13.07	2.11	14.52	10.16
Cars and jeeps	23901.22	212.30	22.14	18.17	5.67	3.22	28.01
Taxi	2367.08	10.23	5.68	0.11	117.05	0.80	1.48
Trucks and lorries	70288.92	491.15	859.51	12.28	193.73	38.20	118.69
Light motor vehicles (Goods)	44654.58	442.04	110.94	7.80	123.08	17.33	12.13
Trailers and tractors	46563.85	460.94	115.69	8.13	128.34	18.08	12.65
Others	5705.22	57.41	64.54	1.83	32.19	3.98	8.96

4.7.3 Pollution Load from road traffic in various mega cities

The vehicle pollution load as estimated through a joint study conducted by Central Road Research Institute (CRRI), National Environmental Engineering Research Institute (NEERI) & Indian Institute of Petroleum (IIP) in the year 2002 for four key pollutants (i.e. CO, NOx, HC and PM) in eight mega cities namely Delhi, Mumbai, Kolkata, Chennai, Bangalore, Hyderabad, Kanpur & Agra are given in **Table 4.11.** This is attributable to the highest number of

automobiles operating in Delhi. From the table it can be seen that Delhi has the maximum vehicle pollution load compared to any other city in the country.

Table 4.11: Estimated Pollution Load in the cities (2002)

City	Pollution Load in Metric tones per day			
	CO	NOx	HC	PM
Delhi	421.84	110.45	184.37	12.77
Mumbai	189.55	46.37	89.93	10.58
Kolkata	137.50	54.09	47.63	10.80
Chennai	177.00	27.30	95.64	7.29
Bangalore	207.04	29.72	117.37	8.11
Hyderabad	163.95	36.89	90.09	8.00
Kanpur	28.73	7.25	11.70	1.91
Agra	17.93	3.30	10.28	0.91

Source: Auto Fuel Policy Report

4.8 Vehicular pollution problems in India

Motor vehicles have been closely identified with increasing air pollution levels in urban centers of the world (Mage et al, 1996; Mayer 1999) . Besides substantial CO_2 emissions, significant quantities of CO, HC, NOx, SPM and other air toxins are emitted from these motor vehicles in the atmosphere, causing serious environmental and health impacts. Like many other parts of the world, air pollution from motor vehicles is one of the most serious and rapidly growing problems in urban centers of India (UNEP/WHO, 1992). The problem of air pollution has assumed serious proportions in some of the major metropolitan cities of India and vehicular emissions have been identified as one of the major contributors in the deteriorating air quality in these urban centers The problem has further been compounded by the concentration of large number of vehicles and comparatively high motor vehicles to population ratios in these cities . Reasons for increasing vehicular pollution problems in urban India are as below

- High vehicle density in Indian urban centers.
- Older vehicles predominant in vehicle vintage
- Predominance of private vehicles especially cars and two wheelers, owing to unsatisfactory public transport system, thereby causing higher idling emissions and traffic congestion.
- Absence of adequate land use planning in development of urban areas, thereby causing more vehicle travel and fuel consumption
- Inadequate inspection & maintenance facilities.
- Adulteration of fuel & fuel products
- Improper traffic management system & road conditions
- High levels of pollution at traffic intersections
- Absence of effective mass rapid transport system & intra-city railway networks
- High population exodus to the urban centers.
- Increasing number Skyrocketing buildings in the urban areas causes stagnation of the vehicular emissions to the ground level and unable its proper dispersion.

5.0 Vehicular Pollution Control Measures taken in India

For containing vehicular pollution, the Government has taken important initiatives in recent years. The Union Government and the Provincial Governments in India have been emphasizing the need for planning and developing strategies to implement mitigation measures to maintain the urban air quality and make the cities cleaner and greener for achieving better air quality and good health for its citizens. Over the past decade or so, the government has bought in statutes aimed at regulating and monitoring industrial and vehicular pollution across the country.

5.1 History of the Events

The sequence of events covering the various measures /initiatives /action taken for vehicular pollution prevention and control in the past 25 years are as follows

(i) During January 15, 1985 an expert committee was constituted by the Secretary, Department of Environment (Now MoEF) under the chairmanship of director ARAI with Member Secretary from CPCB. The terms of reference of the committee were:

a) To finalize vehicular emission standards at the manufacturing stage and also at the road side
b) To finalize the frequency and method of testing of vehicles at the manufacturing stage
c) To approve laboratories in India to carry out chassis dynamometer test on vehicles

The committee recommended mass emission norms and in-use emission norms for different categories of vehicles along with testing method (The recommendations of the committee were notified later under Environment (Protection) Act 1986 during 1990).

(ii) During February 5, 1990, under Section 25 of Environment (Protection) Act 1986, Environment (Protection) Second Amendment Rule 1990 was notified where mass emission norms and in-use emission norms were prescribed for the first time in the country.

(iii) The Hon'ble Supreme Court of India constituted a committee on Vehicular pollution control under the chairmanship of Retd. Justice Shri. K.N. Sakia with CPCB and MoEF as members. The terms of reference of the committee were to make an assessment of the technologies available for vehicular pollution control in world and in India to look at the low cost alternatives for operating vehicles at reduced pollution levels in the metropolitan cities of India and to examine the feasibility of measures to reduce pollution from motor vehicles both on short term and long term basis and make appropriate recommendations in this regard. The recommendation of the Sakia committee submitted to Hon'ble Supreme court in 1991 are as follows:

- For phasing out leaded petrol and phasing in unleaded or lead free petrol in Delhi by 01.04.1992 and with that end in view allowing fiscal and other incentives to lead free petrol users;
- For prescribing of strict medium and long term standards for different vehicular pollutants and strict enforcement of the same;
- To expand and strengthen the air pollution monitoring system and its working in Delhi to encourage public awareness and reaction to vehicular pollution;

- To encourage and finance advanced research and development in the field of vehicular pollution control through indigenous efforts, inter-regional and international exchange of data, co-operation and coordination;
- Of making it compulsory for all petrol vehicle on the road to retrofit a suitable catalytic converter or a suitable emission control device so as to control CO and HC with effect from 1.4.1992 and also a suitable emission control device on diesel vehicles so as to control particulate gases and smoke;
- Of issuing a directive by the Hon'ble Supreme court to the appropriate Ministry of the Central Government to stop forthwith the criminal waste of flaring up of natural gas in the different oil fields of the country, and to store and make the gas available for use as vehicular fuel;
- Of issuing of a directive by the Hon'ble Supreme Court to the appropriate departments of the central government to spread a national gas grid with network of pipelines reaching the metropolitan cities and supply compressed natural gas through such network for use as vehicular fuel at economic prices;
- Of issuing of a direction by the Hon'ble Supreme Court to Delhi transport Cooperation to convert at least $1/5^{th}$ of its bus fleet every year to CNG and to purchase henceforth only new buses that use CNG as fuel and if licenses are issued to private buses those should be issued only for buses running on CNG or on batteries in Delhi;
- For Delhi Transport Cooperation itself operating a fleet of electric trolley buses in Delhi area or inviting private enterprises including NRIs to operate such a system;
- Of improving the circular railway and treating it as a unit and increasing frequency of trains and issuing tickets on board like trams and buses;
- Of issuing of a directive for taking immediate steps for a metro for Delhi so as to function by 2000.
- These propositions led to the start of introduction of CNG in Delhi and phasing out of lead in gasoline.

(iv) In 1992, MoEF brought out two documents namely, National Conservation Strategy & Policy Statement on Environment and Development and Policy Statement for Abatement of Pollution which identified that ambient air quality trends with respect to SPM in metro cities were higher than the prescribed limits especially during summer time. The levels of nitrogen di-oxide are increasing in urban centers with growth in vehicular emissions. For prevention and control of vehicular pollution and for development of environmentally compatible transport system, the following steps to be taken:

- Improvement in mass transport system to reduce increasing consumption of fuel, traffic congestion and pollution;

- Improved transport system based on bio-energy and other non-polluting energy sources
- Rail transport and pipelines transport instead of road transport, where ever possible, by appropriate freight pricing so as to reduce congestion, fuel consumption and environmental hazards;
- Improvement in traffic flow through proper maintenance of roads, updated traffic regulation and strict enforcement of prescribed standards;
- Enforcement of smoke emission standards for containing vehicular exhaust, at the manufacturer and user level;
- Phasing out of use of lead in motor spirit; and
- Regulation from environmental safety in transportation of hazardous substances

(v) On May 16, 1991, CPCB constituted a committee to evolve mass emission standards for motor vehicles for year 1995 and 2000 under the chairmanship of Prof. H.B. Mathur. The terms of reference of the committee were:

- o To suggest the emission standards for 2, 3 & 4 wheelers to be implemented from year 1995 and 2000 with respect to carbon monoxide, hydrocarbons and oxides of nitrogen.
- o To identify the nature of changes required in engine design and types of devices to be installed to meet the suggested standards.

(vi) During 1992 the committee recommended emission norms for vehicles applicable from 1995 and 2005 with technological options for meeting these norms. It also recommended redrafting the Indian standards to specify the fuel parameters affecting the emissions and make commercial fuel available. The lead free petrol has to be made available in limited quantity by 1995 and all commercially available petrol will have to be lead free by the year 2000. The recommendations of the committee were also deliberated at MoEF where 1995 norms were reviewed & postponed to 1996 and submitted to Ministry of Road Transport & Highways (MoRTH) for notification.

(vii) During the year 1992 a policy for providing clean fuels for power plants and motor vehicles were prepared by CPCB during its Board meeting and recommended to MoEF for Ministry of Petroleum and Natural Gas (MoPNG) to take necessary action. During May 1994 a draft specification for motor gasoline and diesel was proposed by CPCB and submitted to MoEF.

(viii) A meeting on fuel and fuel quality of automobiles was held on 17.6.1994 under the chairmanship of the Hon'ble Shri. Kamal Nath, Minister of

- From April 1, 1995 unleaded petrol (i.e. petrol with lead content less than 0.013 g/l) will be supplied in metropolitan cities, along with leaded petrol as at present.
- All new vehicles (4 wheelers) sold in metros after 1st April 1995, will have to be equipped with catalytic converters.
- Diesel supplied in metro cities will have only 0.5% sulphur content as compared to 1% at present, from 1st April, 1996.
- All 2 stroke engine 2 – wheelers and 3 wheelers will have to meet notified norms of emission by 1st April, 1996, if not, production of 2 stroke engines not meeting the norms will have to cease.
- Norms for year 2000 were discussed and it was decided to finalize these within six months, after some more discussions. Thus there will be adequate time for technical changes in design, etc.
- Fiscal mechanism was discussed-price differentials for different types of fuels.
- Also administrative mechanism such as staggering peak--- etc., were also discussed.
- Fuel standards comments from IIP, Dehradun within 15 days.

(ix) Low leaded fuel (0.15 g/l) was made available by MoPNG for metro from January 1994.

(x) During October 21, 1994 Hon'ble Supreme Court passed following order:

- o Petrol with 0.15 g/l TEL to made available by December 1996 to entire country.
- o Lead free petrol to be made available at selected outlets in 4 metro cities by April 1995.
- o New vehicles (Petrol driven) should be equipped with catalytic converter by April 1995.

(xi) On January 20, 1995 MoEF has constituted a committee to finalize fuel quality specification for motor gasoline and diesel. The recommendations of the committee with respect to emission related fuel quality specification were later notified under EPA.

(xii) Bureau of Indian Standards incorporated the emission related specifications and prescribed fuel quality specifications. Based on MoEF recommendations and Supreme Court order, unleaded Petrol was made available in four metro cities during June 1995 and passenger cars are made to fit catalytic converter.

(xiii) During April 20, 1996 the fuel quality specifications were notified under EPA Act and directives were issued by CPCB to various refineries under Section 5 of EPA for compliance of the specifications. In the same year revised ambient air quality standard were notified.

(xiv) During May 1997 a policy paper on control of automobile exhaust pollution was prepared by CPCB which recommended:

- Introduction of Inspection and maintenance programme for in-use vehicles
- Phasing out of 15 years old vehicles
- Improving Public Transport system by introducing high capacity bus system on dedicated pathways
- Introduction of fleet of alternate fuel vehicles

(xv) During August 1997 mass emission norms for vehicles (equivalent to Euro-I norms) with effect from 1.4.2000 were notified under Motor vehicle Act.

(xvi) During August 1997 MoEF brought a white paper on pollution in Delhi. To implement the recommendations of white paper, MoEF constituted "Environmental Pollution Control Authority" on January 1998 on the directions of the Supreme Court. The important directions issued by the Hon'ble court on 26.7.1998 are as follows:

- Augmentation of public transport to 10,000 buses by 1.4.2001
- Elimination of leaded petrol from NCT Delhi by 1.9.1998
- Supply of only pre-mix petrol by 31.12.1998 for two stroke engines of two wheelers and autos
- Replacement of all pre-1990 autos and taxis with new clean vehicles on clean fuels by 31.3.2000
- No 8-year-old buses to ply except on CNG or other clean fuels by 1.4.2000
- Entire city fleet (DTC & Private) to be converted to single fuel mode on CNMG by 31.3.2001
- New ISBTs to be built at entry point in North and south west to avoid pollution due to entry of Interstate buses by 31.3.2000
- GAIL to expedite and expand from 9 to 80 CNG supply outlets by 31.3.2000
- Two independent fuel testing laboratories to be established by 1.6.1999
- Proper inspection and maintenance facilities to be set up for commercial vehicles with immediate effect

- Comprehensive inspection & maintenance programme to be started by transport department and private sector by 31.3.2000
- CPCB/DPCC to setup a few more monitoring stations and strengthen the air quality monitoring stations for monitoring critical pollutants by 1.4.2000. The Hon'ble Court also directed that the time frame as fixed by Environment Pollution (Prevention & Control) Authority should be strictly adhered to by all the authorities
- Some of these orders have led to phasing out of diesel commercial vehicles especially buses and petrol three wheelers will be replaced with CNG vehicles in Delhi

(xvii) During September 1998 lead in petrol was phased out in Delhi while during February 2000 lead in petrol was phased out from petrol all over the country.

(xviii) During November 1998, EPCA brought up the issue of phasing out of diesel private vehicles in Delhi. CPCB recommended to EPCA that these vehicles should meet Euro-II norms otherwise they should not be allowed to ply. During the hearing in Supreme Court, the court ordered that Euro-I norms has to be made applicable for private non-commercial vehicles registered after June 1999 in Delhi. This led to introduction of Euro-II norms for other categories of vehicles and in other cities of the country.

(xix) CPCB constituted a working group to formulate the transport fuel specifications for the year 2005 under the chairmanship of Dr.P.K. Mukhopadhyay, Ex-Director IOC (R&D). The terms of reference of the working group were as follows:

- To recommend the fuel specifications of automotive commercial fuels (gasoline and diesel) for the year 2005
- To recommend the reference fuel quality specifications at the testing stage
- To recommend technology to be adopted to meet the fuel quality specifications recommended for the year 2005
- To draw-up a strategy for monitoring the fuel quality at petrol pump stations to check adulteration

(xx) As per decision taken by the committee of secretaries Ministry of Petroleum and Natural Gas constituted an-inter ministerial task force on auto fuel specifications and vehicular emission standards on August 14, 2000 under the chairmanship of the chairman CPCB. The committee in its report submitted to MoPNG on 31.3.2001 recommended the road map for introduction of Bharat stage –II norms in entire country along with fuel quality specifications.

(xxi) In a meeting taken by the prime Minister on 30 August 2001 it was decided to constitute a committee of the experts of national repute under the chairmanship of Dr. R. A. Mashalkar which was formed on September 13, 2001. The expert committee on Auto fuel policy has proposed an auto fuel policy for India and also for selected major cities and a road map for its implementation. It has also recommended suitable auto fuels with their specification, taking into account the availability and logistic of fuel supplies, the economics of processing auto fuels and possibilities multiple fuel use in different categories of vehicles.

(xxii) The Hon'ble Supreme Court of India, in the matter of CWP No. 13029 of 1985, passed the orders on 05.04.2001, regarding formulation and implementation of action plans for control of pollution in cities namely Kanpur, Lucknow, Varanasi, Agra, Jharia, Patna, Jodhpur, and Pune & Faridabad.

(xxiii) During May 2002 the Hon'ble court has also asked the union of India to prepare a scheme for compulsory switch over to CNG/LPG as automotive fuels in the cities those are equally or more polluted than Delhi. Later CPCB identified these cities as Ahemdabad, Kanpur, Kolkata and Pune.

(xxiv) In the year 2003 the Hon'ble Supreme Court Court vide its order dated 16.8.2003 directed Union of India and State Government to prepare action plan for lowering the rate of RSPM level for cities of Kanpur, Ahemdabad, Sholapur, Bangalore, Lucknow, Chennai, Hyderabad, Mumbai, Kolkata. Hon'ble Supreme Court also asked respective State Boards to place the proposed action plans before EPCA.

(xxv) In the year 2004 new PUC norms have been implemented for in-use vehicles.

(xxvi) In the year 2005 Bharat stage-III emission norms have been implemented in 11 megacities for all the new vehicles except 2 & 3 wheelers while Bharat stage-II norms have been implemented all over the country .

5.2 Legislative and Implementing Agencies

The environmental legislation concerning vehicular pollution and the implementation authorities are as follows:

Legislation / Act	Authority	Responsibility / Notifications
The Environment (Protection) Act, 1986, amended 1991 • *Environmental (Protection) Rules, 1986 (amended in 1999, 2001, 2002, 2002, 2002, 2003, 2004)*	Ministry of Environment & Forests	Notification of standards for emission or discharge of environmental pollutants from the industries, operations or process. The notified standards related to vehicular are as follows: ✓ Specification of Motors Gasoline for emission related parameters ✓ Specification of Diesel for emission related parameters ✓ Specifications of two- stroke engine oil ✓ Standard for emission smoke, vapour etc from motor vehicles ✓ Noise limits for Automobiles at the manufacturing stage
The Central Motor Vehicles Act, 1988 • *The Central Motor Vehicles Rules, 1989 (Second amendment 2009)*	Ministry of Road Transport and Highways	Makes rules regulating construction, equipment and maintenance of motor vehicles and trailers as per section 110 of Motor Vehicle Act. The notified emission standards related to vehicular are as follows: ✓ Relating to Emission of smoke and vapour from agricultural tractors driven by diesel engines ✓ Relating to Diesel vehicles with original equipment fitment - Replacement of in-use diesel engine by new LPG engine - Applicable emissions norms ✓ Relating to Diesel driven Agricultural tractor for standards of gaseous pollutants ✓ Relating to idling emissions standards for petrol / CNG/LPG driven vehicles ✓ Mass emission standards Bharat Stage III for four wheeled vehicles in NCR & other cities ✓ Mass emission standards Bharat Stage III for two and three wheelers manufactured on and from 1st April, 2010. ✓ Mass emission standards Bharat Stage IV for M and N category vehicles

5.3 Technical and Non-Technical Measures

Vehicular Pollution Control Initiatives in India can broadly be categorized into Technical & Non-Technical Measures. Technical Instruments for controlling vehicular Pollution includes Implementation of stringent emission norms for both new & In-Use Vehicles, Improvement in Vehicular Technology, Improvement in the Quality of fuels, Switching over to cleaner vehicles as well as fuels, Implementation of I/M system etc. While Non Technical instruments like Better Traffic Management system, Augmentation in public transport system, Implementation of Market based instruments i.e fiscal instruments, generating mass awareness, drives for checking adulteration etc. Forth coming section will discuss in details about various measures those have been taken all over the country for controlling this menace of Vehicular Pollution

6.0 Technical Measures for controlling vehicular pollution in India

6.1 Vehicular Emission Standards

Vehicle emission standards are the primary technical policy for controlling emissions from vehicles. The Motor Vehicles Act, 1988, and the Central Motor Vehicles rules (CMVR) 1989, are the principal instruments for regulation of motor vehicular traffic /emissions throughout the country. The implementation of various provisions of this Act rests with the state governments. The Ministry of Road Transport and Highways acts as a nodal agency for the formulation and implementation of various provisions of the Motor Vehicle Act and CMVR. The Ministry of Road Transport & Highways is advised by the CMVR–Technical Standing Committee on various technical aspects related to CMVR. This Committee has representatives from organizations such as the Ministry of Heavy Industries, Ministry of Road Transport and Highways (MoRT&H), Bureau of Indian Standards, testing agencies such as the Automotive Research Association of India, Vehicle Research and Development Establishment, Central Institute of Road Transport, and industry representatives from the Society of Indian Automobile Manufacturers and Automotive Component Manufacturers Association

Although the Air Act, 1981, and the Environment (Protection) Act, 1986 provide for the prescription of automobile emission standards by the CPCB (Central Pollution Control Board) or Ministry of Environment and Forests, implementation and enforcement of these standards is the responsibility of the Union Ministry of Road Transport and Highways or the Transport Commissioner at the state level. For issues related to the implementation of emission regulations the MoRT&H is advised by a separate committee the Standing Committee on Implementation of

Emission Legislation. The MoRT&H has formed this committee to discuss future emission norms, related test procedures and the implementation strategy

6.1.1 Emission standards for controlling pollution from New vehicles in India

The first initiative to regulate vehicle emissions in India started in the year 1989 when Ministry of Environment & Forests constituted an expert committee to notify the emission standards for both new and in-use vehicles under the Environment (Protection) Act. The first Indian emission regulations were idle emission limits which became effective in 1989. These idle emission regulations were soon replaced by mass emission limits for both gasoline (1991) and diesel (1992) vehicles. From 1995 all new gasoline passenger cars in the four metros were required to compulsorily fit catalytic converters, which were further, made applicable to all metros, state capitals and Union Territories from 1998. Sooner the need for tighter emission norms surfaced owing to the growing problems of vehicular emissions particularly in the metro cities and in 1996 more stringent norms came into force. In year 1998 the Government notified emission norms for vehicles fitted with catalytic converters, which were over 50% stricter than the 1996 norms. In 2000, following the European model, Euro-I equivalent emission norms called India Stage-I were notified throughout the country which were overtaken by Euro-II equivalent Bharat Stage-II norms in the four metro cities by 2001. Bharat Stage II norms, were introduced in the National Capital Region (NCR) for passenger vehicles up to GVW 3.5T from 1 April 2000 and for heavier vehicles from 24 October 2001 in the National Capital Territory (NCT) of Delhi. In Mumbai, were extended from 1 January 2001 and 31 October 2001 respectively. For both Chennai and Kolkata, the corresponding dates are 1 July 2001 and 31 October 2001, respectively. Fitness norms for commercial vehicles were tightened with effect from 28 March 2001. The emission norms for CNG and LPG vehicles were notified in the year 2000 and 2001, respectively. The Central Motor Vehicles Rules have been frequently amended to take into account the changing requirements. The emission norms in India are behind European ones by four to five years for all categories of vehicles except for two- and three-wheelers. For them, Bharat 2000 norms are far stricter than the Euro II norms and are one of the most stringent in the world.

The Notified emissions standards for gasoline and diesel powered vehicles are given in **Table 6 .0** and **Table 6.1**.

Table 6.0: Emission Norms for Gasoline Powered Vehicles

Vehicle	Year	Emission Standards in g/km				
		CO	**HC**	**NOx**	**HC + NOx**	Deterioration Factor DF)
Two wheelers	1991	12 – 30	8 – 12	-	-	-
	1996	4.50	-	-	3.60	-
	2000	2.00	-	-	2.00	-
	2005 BSII	1.50	-	-	1.50	1.2
	2010 BS III	1.0	-	-	1.0	1.2
Three Wheelers	1991	12 – 30	8 – 12	-	-	-
	1996	6.75	-	-	5.40	-
	2000	4.00	-	-	2.00	-
	2005 BSII	2.25	-	-	2.00	1.2
	2010 BSIII	1.25	-	-	1.25	1.2
Car	1991	14.3 - 27.1	2.0 - 2.9	-	-	-
	1996	8.68 - 12.4	-	-	3 - 4.36	-
	1998	4.34 - 6.20	-	-	1.5 - 2.18	-
	2000	2.72	-	-	0.97	-
	BS II*	2.2	-	-	0.5	-
	BS II**	2.2 - 5.0	-	-	0.5 - 0.7	-
	BS III*	2.30	0.20	0.15	-	1.2
	BS III**	2.3 - 5.22	0.20 - 0.29	0.15 - 0.21	-	
	2010 BS IV*	1.00	0.10	0.08	-	1.2
	2010 BS IV**	1.00 - 2.27	0.10 – 0.16	0.08 – 0.11	-	

Note: For Catalytic Converter Fitter Vehicles

***** Upto 6 seaters and Gross Vehicle Weight (GVW) upto 2500 kg

****** More than 6 seaters and GVW upto 3500 kg.

Table 6.1: Emission Norms for Diesel Powered Vehicles

Vehicle	Year	Emission Standards					Type
		CO	HC	NOx	HC+ NOx	PM	
	***By Engine Dynamometer* in g/kwh**						
	1992	14.0	3.5	18	-	-	
	1996	11.20	2.40	14.4	-	-	
	2000	4.5	1.1	8.0	-	0.36/ 0.61 #	
	B.S II	4.0	1.1	7.0	-	0.15	4 wheeler
	BS III	2.1	1.6	5.0	-	0.10	
	(or) By Chassis Dynamometer in g/km						
	1992	17.3 - 32.6	2.7 - 3.7	-	-		Light duty
Diesel vehicles (GVM up to 3.5 tons)	1996	5.0 - 9.0	-	-	2.0 - 4.0		
	2000	2.72 - 6.90	-	-	0.97 - 1.7	0.14 - 0.25	
	B.S II	1.0 - 1.5	-	-	0.7 - 1.2	0.08 - 0.17	4 wheeler
	B.S. III	0.64 - 0.95	-	0.50 - 0.78	0.56 - 0.86	0.05 - 0.10	
	B.S II 2005	1.00	-	-	0.85	0.10	2& 3 wheeler
	BS III	0.50 DF 1.1	-	-	0.50 DF 1	0.05 DF 1.2	
Diesel vehicles (GVM >	**By Engine Dynamometer in g/kwh**						
	1992	17.3 -	2.7 –	-	-	-	

Vehicle	Year	Emission Standards					Type
		CO	HC	NOx	HC+ NOx	PM	
3.5 tons)		32.6	3.7				
	1996	11.20	2.40	14.4	-	-	
	2000	4.5	1.1	8.0		0.36/ 0.36 #	
	B.S II	4.0	1.1	7.0		0.15	
	2005 BS III	2.1	0.66	5.0	-	0.10/0.13	Smoke 0.8 m^{-1}
	2010 BS IV	1.5	0.46	3.5	-	0.02	Smoke 0.5 m^{-1}
Cars	**By Chassis Dynamometer in g/km**						
	B.S II*	1.0	-	-	0.7	0.8	
	B.S II**	1.0 - 1.5	-	-	0.7 - 1.2	0.08 – 0.17	
	2005 B.S III*	0.64	-	0.50	0.56	0.05	DF: CO 1.1, NOx 1.0, PM 1.2
	2005 BSIII**	0.64 - 0.95	-	0.50 - 0.78	0.56 - 0.86	0.05 - 0.10	
	2010 B.S IV*	0.50	-	0.25	0.30	0.025	DF: CO 1.1, NOx 1.0, PM 1.2
	2010 BSIV**	0.50 - 0.74	-	0.25 - 0.39	0.30 - 0.46	0.025 – 0.06	

For Engines with Power exceeding 85 kw/ For engines with power upto 85 kw

***** Upto 6 seaters and GVW upto 2500 kg

****** More than 6 seaters and GVW upto 3500 kg.

BS III & IV Norm's for CNG or LPG engine:

For CNG Vehicles, HC to be replaced by Non Methane Hydrocarbon (NMHC),
NMHC = HC X (1-K/100), where K is % Methane Content in Natural Gas.
For LPG Vehicles, HC to be replaced by Reactive Hydrocarbon (RHC),
RHC = 0.5 X HC

6.1.2 Auto Fuel Policy's Road Map for control of vehicular pollution from New Vehicles

Indian cities have different climatic conditions, human population, different vehicle population density and source of pollution. The Indian cities with a population of more than one million people with high vehicle population and the cities in which prescribed standards are violated in one or additional parameters in 72 non attainment cities are discussed in Chapter 1, which require actions for vehicle pollution control ahead of the rest of the country. Since the year 2000, India started adopting European emission and fuel regulations for four-wheeled light-duty and for heavy-duty vehicles. In respect of 2& 3 wheeler norms, India is already ahead of most of the advanced world as far as the emission norms are concerned. The road map for vehicular emission norms Bhart Stage II, III and IV is given in **Table 6. 2**

Table 6.2 : Road map for Vehicular Emission norms for new vehicles

Emission Norms	**Date of effective**	**Entire Country**	**Identified Cities**
New Vehicles Except 2 & 3 Wheelers			
Bharat Stage II	From Year 2000 & 2001	-	Delhi, Mumbai, Kolkata and Chennai
	From Year 2003	-	NCR, Bangalore, Hyderabad, Ahmadabad, Pune, Surat, Kanpur and Agra
	From April 01, 2005	Yes	-
Bharat Stage III	From April 01, 2005		For all private vehicles, city public service vehicles and city commercial vehicles in indentified cities*

Emission Norms	Date of effective	Entire Country	Identified Cities
	From April 01, 2010	Yes	-
Bharat Stage IV	From April 01, 2010		For all private vehicles, city public service vehicles and city commercial vehicles in indentified cities*
New 2 & 3Wheelers			
Bharat Stage II	From April 01, 2005	Yes	
Bharat Stage III	Preferably from April 01, 2008 but not later than April 01, 2010 in any case	Yes	

6.1.3 Emission standards for In-Use Vehicles and I/M practice

6.1.3.1 Inspection & Maintenance (I/M) Practice in India

In major cities there exists a mandatory system for inspection and maintenance but it is now increasingly felt to upgrade the present system to a more effective one in the near future. Various studies conducted worldwide have indicated that with the implementation of proper I/M system there could be 30-40% reduction in pollution load from vehicles. The existing practice of I &M is described in **Fig. 6.0.** Every commercial vehicle in India has to go for a mandatory fitness test. The renewal period for fitness certification in general is 2 years for new commercial vehicle and every 1 year for old vehicles. For private vehicles no mandatory periodic fitness check is required in India but there exist a system of re-registration of private vehicles after 15 years of initial registration. But all in-use vehicles are required to obtain emission check certificate called Pollution Under Control (PUC). Frequency of this PUC certification varies from 2 to 4 times a year. This PUC is issued based on conformity to idle emission test for gasoline vehicles and free acceleration smoke test for diesel vehicles.

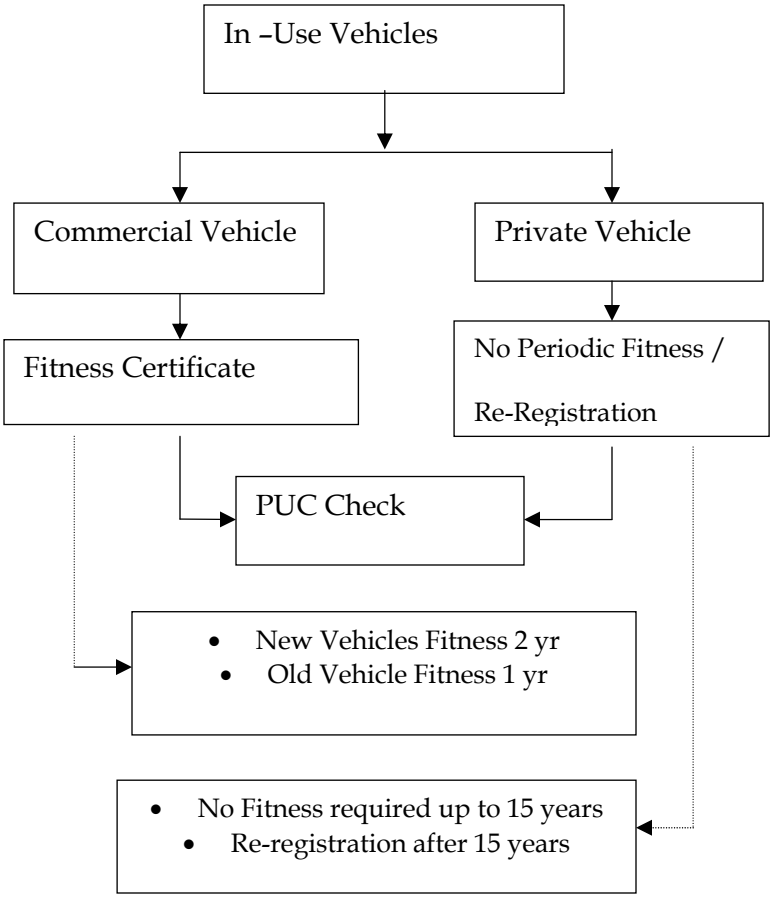


Fig.6.0: Existing Inspection and Maintenance System

6.1.3.2 Pollution Under Control (PUC) Certification system

The first initiative to regulate vehicle emissions in India started in the year 1989 when Ministry of Environment & Forests constituted an expert committee to notify the emission standards for both new and in-use vehicles under the Environment (Protection) Act. The emission norms notified for compliance to PUC certification are stated in **Table 6.3**

Table: 6.3 : First PUC norms in India

Type of Vehicle	Emission	Limit
Gasoline 4 wheeler	CO	3%
Gasoline 2 / 3 wheeler	CO	4.4%
Diesel vehicle	Smoke	65 HSU

Note: HSU – Hartidge Smoke Unit

The in-use vehicle emission norms have been tightened with effect from 1st October 2004 and computerization model for emission check has been developed by Society of Indian Automobile Manufactures (SIAM), which is already in place in the major metro cities, same is depicted in **Fig.6.1**.

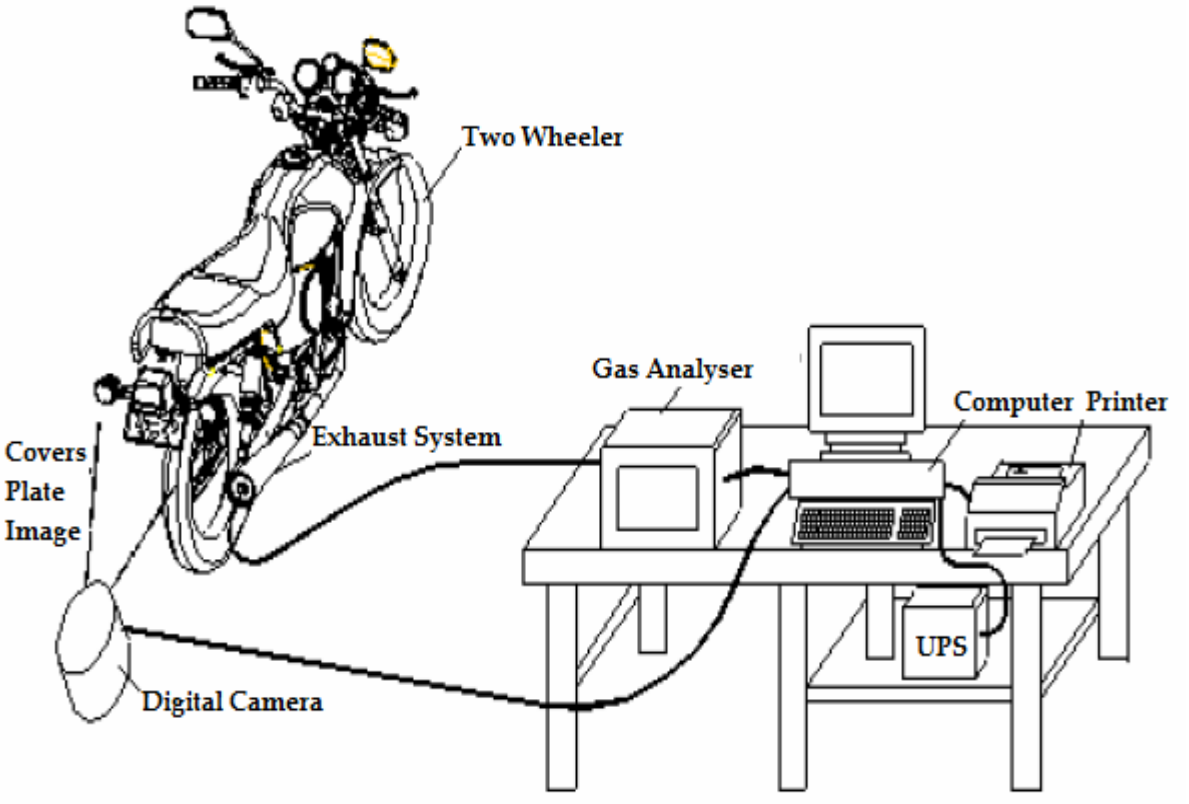


Fig.6.1: Computerized PUC system

The LAMBDA (dimensionless value representing burning efficiency of engine in terms of the air / fuel ratio in the exhaust gases) measurement and tighter emission norms for in-use vehicles with such priority as may be warranted, after ensuring that gas analyzers capable of measuring the values, duly approved by the testing agencies, are available in the city or area, is proposed to be introduced in the respective state or union territory for vehicles provided that in case of petrol vehicles fitted with three way closed loop catalytic Converters operating in a specific city or area like Delhi.

Pollution Under Control (PUC) Norms for in-use Petrol/CNG/LPG vehicles were notified by MoRT&H for implementation throughout the country from 1st October 2004, to comply with the idling emission standards for CO and HC in case of petro vehicle and smoke density for Diesel vehicles are given in **Table 6.4** and

Table 6.6 respectively. Implementation of the same has been delayed owing to initial problems pertaining to the new analyzers.

Table: 6.4 : PUC Norms for in-use Petrol / CNG /LPG driven Vehicles

Vehicle Type	CO (%)	*HC (ppm)
2&3 wheelers (2/4 stroke) (vehicles manufactured before 31/3/2000)	4.5	9,000
2&3 wheelers (2- stroke) (vehicles manufactured after 31/3/2000)	3.5	6,000
2&3 wheelers (4 stroke) (vehicles manufactured after 31/3/2000)	3.5	4,500
Bharat Stage -II compliant 4 wheelers	0.5	750
Four wheelers other than Bharat Stage -II compliant	3.0	1,500

* For CNG and LPG vehicles the measured Hydrocarbon value shall be converted using the following formula and then compared with the limits

- For CNG Vehicles- Non Methane Hydrocarbon (NMHC) = 0.3 X HC
- For LPG Vehicles- Reactive Hydrocarbon (RHC) = 0.5 X HC

Table: 6.5 : PUC Norms for in-use Diesel driven Vehicles

Method of Test	Maximum Smoke Density	
	Light Absorption Coefficient (1/m)	HSU
Free Acceleration Test for Turbo Charged engine and Naturally aspirated engine	2.45	65

Notes: 1. Test should be done at Authorized Pollution Check Centers
2. Test should be done every six months or as per State Government's direction
3. No vehicle shall ply in the country without a valid pollution under control certificate

The Safety Regulations are being aligned with the Economic Commission for Europe (ECE) regulation and the Road Map prepared by SIAM envisages alignment by 2010. The SIAM has developed a computerized emission checking system for improving the credibility of the emission test system. In this system the Gas analyzer is connected to a Computer, which has a printer and a web Camera. The emission values from the Gas analyzer is sent directly to the computer and the photograph of the registration number plate of the vehicle is also captured. The emission data generated is stored in the computer, which is sent periodically to the Transport Department.

6.1.3.3 Road map for in-use vehicles

The road map, as recommended by the expert committee on Auto Fuel Policy is given in **Table 6.6** for reducing pollution from the in-use vehicles. In addition to the recommendations made in the road map, State Governments / Union Territories can take such special city specific measures as may be necessary to deal with any local problem. These measures should take into account the availability of auto fuels and the security of their supplies to guard against disruption in transport system and hardship to people.

Table 6.6: Road Map for In-use / Old Vehicles for the entire country

For the Entire Country
New PUC checking system for all categories of vehicles · to be put in place by 1 April, 2005 **Inspection & Maintenance (I&M) System for all categories of vehicles** · to be put in place by 1 April, 2010 **Performance checking system of catalytic converters and conversion kits installed in vehicles** · to be put in place by 1 April, 2007 **Augmentation of city public transport system** · finalisation of plans by the State Governments/ local authorities. : Not later than 1 April, 2005

6.2 Improvements in Engine Technologies

Mass emission norms for vehicles for the first time at manufacturing stage as well as for in-use vehicles have been notified during 1990-91, the manufacturers did not require any major modification for meeting these norms. The emission norms along with fuel quality specifications laid down in 1996 required the automobile manufacturers to make modifications in the engine design particularly in regard to crankcase emission and evaporative emission control. From April, 1995 new passenger cars were allowed to register only if these were fitted with catalytic converters. Emission norms for such cars were tightened by 50% as compared to 1996 norms. All petrol cars manufactured after April 1, 1996 are equipped with positive crankcase ventilation (PCV) system. Retrofitting of in-use pre 1996 petrol cars with PCV system helped to reduce total hydro carbon emissions. Activated charcoal canisters for engines for diurnal soak vent vapor recovery controlled evaporative emissions. Activated charcoal absorbs fuel vapors from fuel tank and carburetor fuel bowl and purges it into the engine. Vehicles manufactured in India after April 01, 1996 has evaporative emission control system. The testing method for passenger cars norms was changed to cold start from hot start from April 01, 1998, which is a strict procedure than previous one. The norms for the year 2000 notified under the Motor Vehicle Rules require major modification in the engine design especially in regard to the fuel injection system in passenger cars and fitment of catalytic converters in 2-stroke engine. These standards are akin to Euro-I norms adopted in the European countries in 1992.

The technologies for vehicle emission control which are achievable with reference to European Union regulations for Combustion Ignition (CI) and Spark Ignition (SI) engines are listed in **Table 6.7** and **Table 6.8** respectively.

Table 6.7 : Combustion Ignition Engine for Compliance of Emission Norms

Emission Norms	Technology options
Euro-I / India 2000	• Retarded injection timing • Open/re-entrant bowl • Intake, exhaust and combustion optimization • FIP~700-800 bar, low sac injectors • High swirl • Naturally aspirated
Euro-II / Bharat stage-II	• Turbo charging • Injection pressure> 800 bar, moderate swirl • High pressure inline/rotary pumps, injection rate control • VO nozzles • Re-entrant combustion chamber • Lube oil combustion control • Inter-cooling (optional, depend on specific power) • EGR (may be required for high speed car engines) • Conversion to CNG with catalytic converter
Euro-III / Bharat stage-III	• Multi valve • Low swirl-high pressure>120 bars • Rotary pumps, pilot injection rate shaping • Electronic fuel injection • Critical lube oil consumption control • Variable Geometry Turbocharger(VGT) • Inter-cooling • Oxy-cat and Exhaust Gas Recirculation (EGR) • CNG/LPG • High specific power output
Euro-IV/ Bharat stage-IV	• Particulate trap • NOx trap • On Board Diagnostic system • Common rail –injection pressure>1600 bar • Fuel cell • CNG/LPG

Source: ARAI

Table 6.8: Spark Ignition Engine for Compliance of Emission Norms

Emission Norms	2 / 3 wheelers*		4 wheelers
	2 stroke engine	4 stroke engine	4 stroke engine
Euro-I / India 2000	• Intake, exhaust, combustion optimization • Catalytic converter	• 4-stroke engine technology	• Intake, exhaust combustion optimization • Carburetor optimization
Euro-II/ Bharat stage II	• Secondary air injection • Catalytic converter • CNG/LPG (3 wheelers only)	• Hot tube • Secondary air injection • CNG/LPG • (3 wheelers only)	• Fuel injection • Catalytic converter • Fixed Exhaust Gas Recirculation (EGR) • Multi-valve • CNG/LPG
Euro-III/ Bharat stage III	• Fuel injection • Catalytic converter	• Fuel injection • Carburetor +Catalytic converter	• Fuel injection + Catalytic converter • Variable EGR + variable valve timing • Multi valve • On-Board Diagnostic (OBD) system • CNG/LPG
Euro-IV/ Bharat stage IV	• To be developed	• Lean burn • Fuel injection + catalytic converter	• Direct cylinder injection • Multi-brick catalytic converter • On-Board Diagnostic (OBD) system

Note:* Euro norms are not applicable for 2/3 wheelers in India
Source: ARAI

6.3 Noise Standards for Vehicles

The noise level in cities is rapidly increasing due to heavier traffic and more powerful engines. On top of that there is a growing number of vehicles which are much louder and do not adhere to Noise Standards. In the combustion engines

fuel explodes in cylinders 1000 times/min (for 4-stroke, 2-cylinder engines at 1,000 rpm) creating sound with 16.7 Hz fundamental frequency and many harmonics. Without an engine block/enclosure and muffler these explosions will be very noisy (194 dB at close distance) and deadly. The vehicles with modified mufflers or straight pipes can produce sound levels which are deafening (up to 120 dB at 15.2 m distance) and are up to 40 dB louder than vehicles equipped with stock mufflers (Marek Roland-Mieszkowski). The noise limits for vehicles at manufacturing stage were notified by MoEF under the Environmental (Protection) Rules, 1986. The noise limits for vehicles applicable at manufacturing stage from year 2003 and 2005 are given in **Table 6.9** and **Table 6.10 respectively**. The test method to be followed shall be IS: 3028-1998.

Table: 6.9 : Noise limits for vehicles applicable at manufacturing stage from 2003

S. No.	Type of vehicle	Noise Limits dB(A)	Date of implementation
1.	Two wheeler • Displacement upto 80 cm^3 • Displacement more than 80 cm^3 but upto 175 cm^3 • Displacement more than 175 cm^3	75 77 80	1st January,2003
2.	Three wheeler • Displacement upto 175 cm^3 • Displacement more than 175 cm^3	77 80	1st January,2003
3.	Passenger car	75	1st January, 2003
4.	Passenger or commercial vehicle • Gross vehicle weight upto 4 tonne • Gross vehicle weight more than 4 tonne but upto 12 tonne • Gross vehicle weight more than 12 tonne	80 83 85	1st January, 2003

Table 6.10 : Noise limits for vehicles applicable at manufacturing stage applicable from 1st April, 2005

S. No.	Type of vehicle	Noise Limits dB(A)
1	***Two wheeler***	
	• Displacement upto 80 cc	75
	• Displacement more than 80 cc but upto 175 cc	77
	• Displacement more than 175 cc	80
2	***Three wheeler***	
	• Displacement upto 175 cc	77
	• Displacement more than 175 cc	80
3	***Vehicles used for carriage of passengers and capable of having not more than nine seats, including the driver's seat***	74
4	***Vehicles used for carriage of passengers having more than nine seats, including the driver's seat, and a maximum gross Vehicle Weight(GVW) of more than 3.5 tonnes***	
	• With an engine power less than150 KW	78
	• With an engine power of 150 KW or above	80
5	***Vehicles used for carriage of passengers having more than nine seats, including the driver's seat: Vehicles used for carriage goods***	
	• With maximum GVW not exceeding 2 tonnes	76
	• With maximum GVW greater than 3 tonnes but not exceeding 3.5 tonnes	77
6	***Vehicles used for transport of goods with a maximum GVW exceeding 3.5 tonnes***	
	With an engine power less than 75 KW	77
	With an engine power of 75 KW or above but less than 150 KW	78
	With an engine power of 150 KW or above,	80

6.4 Improvement in Fuel Quality

Much of the pollution control depends on the quality of the fuel. There are various constituents/parameters in the fuels (Gasoline & Diesel) together contributes towards emissions from the vehicles. There exist code of standards or specifications for the gasoline and diesel to be sold in the market in every country. National or other legally enforceable specifications represent the minimum quality that must be supplied and it is implicit that engine designers should ensure that their vehicles would run satisfactorily on such a quality of fuel. In India the Bureau of Indian Standards (BIS) notifies the requisite specifications for gasoline and diesel. There are a total of 15 parameters in gasoline specifications out of which 4 are environment related parameters. Similarly, there a total 16 parameters in diesel specifications, out of which 4 are environment related parameters. The fuel quality parameters of gasoline and diesel those affects the air quality are described in **Table 6. 11** & **Table 6.12** respectively.

Table 6.11 : Gasoline Fuel Quality Parameters

S. No.	Parameters	Characteristic future
1.	Lead	Lead alkyl additives have historically been used to enhance the octane rating of gasoline, but in course it was eliminated from gasoline for health effects associated with it. Also, even small lead contamination in the gasoline can destroy a modern vehicle emission control technologies, like catalytic converters and oxygen sensors.
2.	Benzene	Benzene, the smallest aromatic compound with no alkyl group, is a carcinogen. It is emitted from gasoline as a result of evaporation and as unconverted benzene from the exhaust pipe. Benzene has an extremely high octane rating, and is hence a good gasoline blending component from point of view of combustion. An effective way to reduce human exposure to benzene is to control benzene in gasoline.
3.	Sulphur	Sulphur affects efficiency of the catalyst used in after treatment devices and also adversely affects heated exhaust gas oxygen sensors. Vehicle manufacturers recommend for conventional catalytic converters that the level of sulphur in gasoline be kept below 5000 ppm, and preferably below 100 ppm. Sulphur not trapped in catalytic converters is emitted as SO_x, some of which undergoes chemical transformation to become secondary particulate matter or acid rain.
4.	Reid Vapor Pressure	The Reid Vapor Pressure is a measure of gasoline volatility. During operation of spark ignition engines both performance

S. No.	Parameters	Characteristic future
	(RVP)	and emissions are affected by the volatility of gasoline. Lowering RVP is a cost effective way of controlling VOC emissions, including light olefins. This requires lowering level of butanes, and possibly C5 hydrocarbons. Butanes are the cheapest source of octane and their removal typically adversely affects refinery economics. Lowering RVP, however, can make starting carbureted vehicles difficult, particularly in cold weather, and may cause misfires and higher tailpipe HC emissions. RVP should be within a certain range depending on vehicle technology and ambient conditions.
5.	Aromatics	Aromatics with two or more alkyl groups are photo-chemically reactive and contribute to ozone formation. The photochemical reactivity of aromatics and their decomposition to benzene are the two primary concerns with aromatics. Aromatics have extremely high octane ratings, and hence are good gasoline blending components from point of view of combustion. High aromatic content can increase engine deposits, these deposits formation in combustion chamber increase tailpipe emissions, including HC and NOx.
6.	Olefins	Olefins in gasoline are formed primarily during cracking processes. Olefins are photo chemically reactive and are ozone precursors. In addition at elevated levels, olefins increase the emission of NOx, which is a precursor for ozone, particulate matter and acid rain. At the same time olefins have fairly high octane rating and higher olefins in gasoline may lead to deposit formation and increased emissions of reactive hydrocarbons and undesirable compounds.
7.	Alkylates	Alkylates are high octane paraffin hydrocarbons with essentially no adverse effects on air quality. However, alkylation is an expensive process and requires presence of a catalytic cracking unit at the refinery.
8.	Volatile Organic Compounds (VOCs)	Volatile organic compounds contain photo chemically reactive hydrocarbons. Reduction in VOCs will therefore reduce the amount of ozone precursors in the atmosphere. VOCs could also absorb onto particulate and increase particulate mass. Evaporative emissions consist entirely of VOCs; VOCs are also found in exhaust gas.
9.	Oxygenates	Oxygenates organic compounds such as ethers and alcohols may be added to increase octane number. The presence of oxygen in oxygenates also cause clean combustion in vehicles. However the use of oxygenates can increase the emissions of undesirable compounds such as aldehydes. Oxygenates also dilutes gasoline, thereby decreasing the amount of such undesirable gasoline components i.e. benzene, sulphur, total aromatics, and olefins. Oxygenates are

S. No.	Parameters	Characteristic future
		however more miscible with water than gasoline.
10.	Additives	Gasoline in industrial countries contains additives to prevent the accumulation of deposits in engine and fuel supply system. Deposits can increase tail pipe emissions. Ash forming additives can adversely affect the operation of catalyst and other components (e.g. Oxygen sensors) in a way that increase emissions.
11.	Octane Number	Octane rating denotes the ability to resist auto-ignition which can cause engine knock. Petrol octane number is measured as Research Octane Number (RON) and Motor Octane Number (MON). RON correlates best with low speed, mild knocking conditions and MON correlates with high temperature knocking conditions and with part-throttle operation. RON values are higher than MON and the value difference between these is the sensitivity which is mostly less than 10. The average of RON and MON is called the Anti Knock Index (AKI). Vehicles are designed for a particular octane number; petrol with an octane number lower than that required may result in knocking which could lead to severe engine damage. Octane number has no direct correlation with emissions.

Table 6.12 : Diesel Fuel Quality Parameters

S. No.	Parameters	Characteristic future
1.	Density	Diesel fuel is metered volumetrically, so that the higher the density, the more mass is injected. The use of a fuel with greater density than that used in the pump calibration could even result in over fueling at maximum load, resulting in substantially higher smoke emissions. The reduced density will reduce particulate emissions from all diesel vehicles and NOx emissions from heavy duty vehicles. The reduction in fuel density decreases engine power output and increases volumetric fuel consumption.
2.	Viscosity	Problems like inadequate fueling and pump distortion may be faced with high viscosity fuel. Low viscosity will increase leakage from the pumping elements, and in worse cases (low viscosity, high temperature) can result in total leakage. To allow optimization of engine performance, it is important to minimize the range between minimum and maximum viscosity limits as it is impacted by ambient temperature.

S. No.	Parameters	Characteristic future
3.	Sulphur	Sulphur in diesel contributes to fine particulate emissions, through the formation of sulfates both in the exhaust stream and later in the atmosphere. It also decreases the efficiency of oxidation catalysts and degrades advanced treatment devices. The percentage reduction of particulate matter on account of sulphur reduction is dependent on the level of engine technology.
4.	Aromatics	Poly aromatic hydrocarbons have been linked to higher particulate emissions.
5.	Distillation Characteristics T90, T95	T_{90} and T_{95} are the temperatures at which 90 & 95 percent respectively, of diesel evaporates. Decreasing T_{90} or T95 could have a favorable impact on emissions, especially if heavy PAHs are removed as a result.
6.	Cetane number	Cetane number is a measure of the compression ignition quality of a diesel fuel; it influences cold startability, exhaust emissions and combustion noise. A high Cetane number indicates a shorter lag between fuel injection and fuel ignition. A Cetane index is an approximation of the cetane number calculated from the density and distillation temperatures. Cetane improvement additives will increase the cetane number but not the cetane index and hence many countries set cetane specifications as minimal cetane index or cetane number.
7.	Cleanliness	With respect to satisfactory operation of diesel vehicles, cleanliness refers to the absence of water and particulate contamination. Dirt and water can plug fuel filters and cause serious damage to the fuel infector system because of close tolerance of fuel pumps and injectors. Diesel engine is equipped with fuel filters to protect the fuel delivery system.
8.	Stability	Stability is the ability of a fuel to resist the formation of gums and insoluble oxidation products. Fuels with poor oxidation stability contain insoluble particles that can plug fuel filters, potentially leading to decreased engine performance or engine stalling from fuel starvation.
9.	Flash Point	The flash point is the temperature to which a fuel must be heated to produce an ignitable mixture of fuel and air above the surface of the liquid. This property has no impact on engine performance because the auto ignition temperature of the fuel – air mixture is not affected by variations in flash point.

6.4.1 Improvements made in Gasoline Quality

- ***Phasing out of lead,*** the specification of lead in India was 0.56 gm/l max up to 1994. It has been totally phased out and there is no leaded gasoline

production. India has been totally stopped from February 1, 2000. The lead phase out is summarized in **Table 6.13.**

Table6.13: Gasoline Lead Phase out in India

Phase	Date of Introduction	Lead Content	Areas Covered
I	June 1994	Low lead (0.15 g/l)	Delhi, Mumbai, Kolkata, Chennai
II	01.04.1995	Unleaded (0.013 g/l) + low leaded	Delhi, Mumbai, Kolkata, Chennai
III	01.01.1997	Low leaded	Entire country
IV	01.09.1998	Only unleaded	National Capital Territory (NCT)
V	31.12.1998	Unleaded + Low leaded	Capitals of states and Union Territories
VI	01.01.1998	Unleaded	National Capital Region (NCR)
VII	01.02.2000	Unleaded	Entire Country

- ***Increasing the Octane Number,*** increase in the octane number (RON – 88 and AKI - 84) has been done with effect from April 1, 2000. This has been achieved through installation of new facilities and change in refinery operations. Premium grade of gasoline with octane number 93 is now supplied in all major cities.
- ***Introduction of benzene content limit,*** A limit of 3% (vol) max has been introduced in the four mega cities w.e.f April 1, 2000. The content of benzene in the gasoline has been further reduced to 1% w.e.f April 1, 2005 in 11 mega cities states ahead. However, gasoline with 3% benzene content is made available throughout the country from April 01, 2005. Benzene reduction programme in Gasoline in India is summarized in **Table 6.14**

Table6.14: Gasoline Benzene Reduction in India

Phase	Date of Introduction	Benzene Content	Areas Covered
I	Before 1996	No specification	Entire Country
II	April 1996	5% benzene	Entire Country
III	April 2000	3% benzene	Metro Cities
IV	November 2000	1% benzene	NCT & Mumbai
V	April 2005	1% benzene	All Metro cities

- ***Reduction of sulphur content, t***he sulphur content in gasoline has been reduced from 0.2 % max to 0.05 % from April 1, 2005 all over the country. Further w.e.f 01.04.2010, the content of sulphur in gasoline is proposed to be reduced to 0.005% (50 mg/kg) from existing 0.015% (150 mg/kg, in 11 mega cities namely Delhi, Mumbai, Kolkata, Chennai, Bangalore, Hyderabad including Secunderabad, Ahemdabad, Pune, Surat, Kanpur & Agra). However, all over the country, content of sulphur in gasoline is proposed to be 0.015% (150 mg/kg) from 01.04.2010.

6.4.2 Fuel Quality Specifications for Gasoline

Indian petrol specifications required for meeting Bharat II, Bharat III and Bharat IV equivalent emissions norms are compared in **Table 6.15.**

Table6.15 : Indian Gasoline Specification required meeting Bharat Stage II, III, & IV Emission Norms

Sl. No	Characteristics	Unit	Bharat Stage II		Bharat Stage III		Bharat Stage IV	
			Unleaded Regular	Unleaded Premium	Unleaded Regular	Unleaded Premium	Unleaded Regular	Unleaded Premium
1	Colour, visual		Orange	Red	Orange	Red	Orange	Red
2.	Density 15 ^{0}C	Kg/m^3	710-770	710-770	720-775	720-775	720-775	720-775
3.	Distillation:							
	a) Recovery up to 70 ^{0} C (E70)	%Volume	10-45	10-45	10-45	10-45	10-45	10-45
	b) Recovery up to 100 ^{0} C (E100)	%Volume	40-70	40-70	40-70	40-70	40-70	40-70
	c) Recovery up to 180 ^{0}C (E180)	%Volume	90	90	-	-	-	-
	d) Recovery up to 150 ^{0} C (E150)	%Volume	-	-	75min	75min	75min	75min
	e) Final Boiling Point (FBP), Max	^{0}C	215	215	210	210	210	210
	f) Residue, Max. % Volume	%Volume	2	2	2	2	2	2
4.	Research Octane Number (RON),	min	88	93	91	95	91	95
5.	Anti Knock Index (AKI) or (MON)	Min	84 (AKI)	88 (AKI)	81 (MON)	85 (MON)	81 (MON)	85 (MON)
6.	Gum content (sol vent washed) max	mg/100ml	Existent Gum, max 40 g/m3 Potential Gum, max 50 g/m3		5	5	5	5
7.	Oxidation	min	-	-	360	360	360	360

Sl. No	Characteristics	Unit	Bharat Stage II		Bharat Stage III		Bharat Stage IV	
			Unleaded Regular	Unleaded Premium	Unleaded Regular	Unleaded Premium	Unleaded Regular	Unleaded Premium
	stability							
8.	Sulphur, Total , max	% mass	0.05	0.05	150 mg/Kg	150 mg/Kg	50mg/Kg	50mg/Kg
9.	Lead Content (as Pb), max	g/l	0.013	0.013	0.005	0.005	0.005	0.005
10.	Reid Vapour Pres. (RVP) max	kpa	35 - 60	35 - 60	60	60	60	60
11.	Benzene, Content, Max	% volume	For the metros 3.0 & For the rest 5.0		1	1	1	1
12.	Copper strip corrosion for 3hrs @ 50 ^{0}C	Rating	Not more than No.1		Class I	Class I	Class I	Class I
13.	Olefin content, max	% volume	-	-	21	18	21	18
14.	Aromatic content, max	% volume	-	-	42	42	35	35
15.	Oxygen content, max	% mass	-	-	2.7	2.7	2.7	2.7
	Oxygenates content	% volume						
	a) Methanol, max	% volume	-	-	3	3	3	3
	b) Ethanol, max	% volume	-	-	5	5	5	5
	c) Iso-Propyl alcohol, max	% volume	-	-	10	10	10	10
	d) Iso - butyl alcohol, max	% volume	-	-	10	10	10	10
	e) Tertiary - butyl alcohol, max	% volume			7	7	7	7
	f) Ether containing 5 or more	% volume	-	-	15	15	15	15

Sl. No	Characteristics	Unit	Bharat Stage II		Bharat Stage III		Bharat Stage IV	
			Unleaded Regular	Unleaded Premium	Unleaded Regular	Unleaded Premium	Unleaded Regular	Unleaded Premium
	carbon atoms max g) Other Oxygenates, max	% volume	-	-	8	8	8	8

6.4.3 Improvements made in Diesel Quality

- ***Increase in Cetane number***, Cetane number has been increased from 45 to 48 from April 1, 2000. Presently, diesel with cetane number of 51 is being sold in the 11 mega cities of the country, while for the entire country; diesel with cetane number 48 is being sold from April1, 2005.
- ***Reduction of sulphur content,*** the sulphur content in diesel has been reduced from 1% max as on April 01, 1996 to 0.25% max. w.e.f. January 1, 2000. The Indian refineries have installed Diesel Hydro-De-Suplhurisation (DHDS) plants for reducing the diesel sulphur content from 0.1% max to 0.25 % max at a total cost of Rs. 5568.31 crores in June 1997. This has enabled supply of diesel with 0.25% sulphur in the entire country from January 2000. In addition, in the 4 metro cities, sulphur content in diesel has been reduced to 0.05 % max. Further the Sulphur content in Diesel is proposed to be reduced further to 0.005 % (50 mg/kg) in the 11 mega cities by 01.04.2010. The amount of sulphur in diesel is proposed to be 0.035% (350 mg/kg) all over the country. Sulphur reduction programme in Diesel in India is summarized in **Table 6.16.**

Table 6.16: Diesel Sulphur Reduction in India

Phase	Date of Introduction	Sulphur Content	Areas Covered
IV	January 2000	0.25%	Entire Country
V	April 2000	0.05%	NCR private vehicles
I	April 1996 January 2000 March 2001	0.50% 0.05% 0.05%	Four metros and Taj Mumbai all vehicles Trapezium NCT all vehicles
II	August 1997 June 2001	0.25% 0.05%	Delhi and Taj Trapezium NCR all vehicles
III	April 1998	0.25%	Metro Cities

	July 2001	0.05%	Chennai and Kolkata
VI	October 2001	0.05%	All retail outlets of four metros
VII	2003	0.05%	Ahmadabad, Surat, Agra, Pune and Kanpur
VIII	2005	0.05%	Entire country
IX	2005	0.035%	10 metro cities and Agra
X	2010	0.035%	Entire country
XI	2010	0.005%	10 metro cities

- ***Improvements in distillation recovery specification, i***mprovement have been done in the distillation specification of diesel, i.e reduction of distillation recovery to achieve 85% and 95% vol. recovery at 3500°C and 3700°C respectively from April 1, 2000 thereby improving the performance and life of diesel engine and emission reduction. With the introduction of euro equivalent vehicle technology, the refineries also have upgraded their technology to supply commensurate fuel in the market.

6.4.4 Fuel Quality Specifications for diesel

Indian diesel specifications required for meeting Bharat II, Bharat III and Bharat IV equivalent emissions norms are compared in **Table6.17.**

Table6.17: Indian Diesel Specification required meeting Bharat Stage II, III, & IV Emission Norms

Sl. No	Characteristics	Unit	Bharat Stage II	Bharat Stage III	Bharat Stage IV
1	Ash, max	% mass	0.01	0.01	0.01
2.	Carbon Residue (Ramsbottom) on 10% residue, max	% mass	0.3	0.03 without additives	0.03 without additives
3.	Cetane Number (CN), min		48*	51	51
4.	Cetane Index (CI), min		46*	46	46
5.	Distillation 95% vol. Recovery at ^{0}C, max	^{0}C		360	360
6.	Flash point Abel, min	^{0}C	35	35	35
7.	Kinematic Viscosity @ 40 ^{0}C	cst	2 - 5	2 - 4.5	2 - 4.5
8.	Density @ 15 ^{0}C	Kg/m^3	820 – 860 (820-870)*	820 - 845	820 - 845
9.	Total Sulphur, max	mg/kg	0.05 % mass	50	50
10.	Water content, max	mg/kg	0.05 % vol	200	200
11.	Cold filter plugging point (CFPP) a) Summer, max b) Winter, max	 ^{0}C ^{0}C	 18 6	 18 6	 18 6
12.	Total contaminations, max	mg/kg	-	24	24
13.	Oxidation stability, max	g/m3	-	25	25
14.	Polycyclic Aromatic Hydrocarbon (PAH), max	% mass	-	11	11
15.	Lubricity, corrected wear scar diameter (wsd 1,4) @ 60 ^{0}C ,max	µm (microns)	460	460	460
16.	Copper Strip corrosion for 3 hrs @ 50 ^{0}C	Rating	Not worse than No.1.	Class I	Class I

Note: * For diesel process from Assam crude, either CN of 45 min or CI of 43 min and density of 820-870 shall be applicable.

6.5 Indian Initiative for Alternate Fuels

The selection of alternate fuels depends on the load of emission to be allowed, the technology available and the cost of system to be developed. A system that

fulfils the legislative requirements and can be sold at the lowest price is to be generally accepted. The Alternate fuels have to meet the following criteria:

1. Technical Acceptability
2. Economically Competitiveness
3. Environmentally acceptability
4. Safety and Availability

The important fuel that are considered as meeting the above criteria include Natural Gas (CNG/LNG), Propane (LPG), Ethanol, Methanol, Diesel, Electric fuel, Hydrogen, Di-methyl Ether(DME), P-series, Fuel Cell and Solar fuels. Indian Government has taken various initiatives time to time for the development and promotion of cleaner alternative to conventional automotive fuels i.e. diesel and gasoline. The function / role played by various ministries/ Govt. organization in development and promotion of various alternative fuels in India are briefed in **Table6.18**.

Table6.18: Functions / Roles of Ministries in promotion of Alternative Fuels

S. No.	Ministries / Departments	Functions and Roles
1.	Planning Commission	Overall policy direction and funding for alternative fuels especially bio fuels and hydrogen
2.	Ministry of Road Transport and Highways	Regulations on alternative fuel vehicles and fuels
3.	Ministry of Non Conventional Energy Sources	Promotion of Electric Vehicle/Hybrid Electric Vehicle, Bio fuels, Solar Energy, Hydrogen
4.	Ministry of Petroleum and Natural Gas	Supply of CNG, LPG, Bio diesel, Hydrogen and involved in pilot projects on bio fuels, hydrogen
5.	Ministry of Environment and Forests	Policy and Regulations for alternative / clean fuels
6.	Ministry of Heavy Industries and Public Enterprises	Policy direction and coordinating with other ministries in addressing concerns of the Automobile Industry
7.	Department of Science & Technology	Incentivizing Research and Development in Technology development

Based on technical acceptability, economically competitive, environmentally acceptable and safety & availability criteria, several alternative fuels have been considered form time to time all over the world as low cost substitutes for gasoline and diesel. The coming paragraph describes details on the status of development and implementation of various alternative cleaner fuels in India.

6.5.1 Natural Gas

Natural gas is a mixture of hydrocarbons mainly methane (CH4) and is produced either from gas wells or in conjunction with crude oil production. Natural Gas offers a significant potential for reducing harmful emissions from vehicles, especially those of fine particulates, compared to conventional fuel. It stands substantially better than conventional fuels both in life cycle emissions and vehicle exhaust emissions. Due to its low energy density for use as a vehicular fuel, it is compressed to a pressure of 200 - 250 bars to facilitate storage in cylinders mounted in vehicle and so it is called compressed natural gas (CNG). India's recoverable resources of more than 690 billion cubic meters make it a long-term substituted fuel for use in petrol and diesel engines. Specifications for CNG as automotive fuel in India are given in **Table6.19 .** Given the availability and the infrastructure, CNG qualifies to be one of the most prominent alternative fuels. It stands substantially better, than conventional fuel both in life cycle emissions and vehicle exhaust emissions.

Table 6.19 : Proposed automotive CNG Specifications

Constituents	Value	Tolerance
Wobbe number (Btu/ft3)	1340	Variation shall be limited to ± 30 units during normal operation
Free water, mg/m3	8	Maximum
Total sulphur including H2S, mg/m3	20	Maximum
N2 + CO2, vol %	3.5	Maximum*
Oil mist content, ppm	Insignificant	
Oxygen, vol. %	0.5	Maximum
Methane (C1)	87%	Minimum**
Ethane (C2)	6%	Maximum
C3 and higher HC	3%	Maximum
C6 and higher HC	1%	Maximum
Total unsaturated HC	1%	Maximum
Hydrogen (mole %)	0.1	Maximum
Carbon monoxide (mole %)	0.1	Maximum

**Note: ***occasionally may go up to 7 per cent when shutdown of a processing/handling Plants/ facilities happen however such events are to be duly notified and should be limited to 10% of time in a year.

****** In case of process upset/plant s/d may reach a level of 84 however such events are to be duly notified and should be limited to 10% of time in a year. These specifications are free from liquids over the entire range of temperature and pressure encountered in the engine and fuel system and free from solid particulate matter

A study was carried out to evaluate the emissions from Indian CNG buses in comparison with diesel bus with Euro II, III & IV emission norms. The test results are given in **Table 6.20 .**Results show that a stoichiometric CNG bus with a three-way catalyst is far ahead of a comparable diesel bus. It meets the Euro-IV norms for both PM and NOx. Even CO emissions are better than Euro-II norms.

Table 6.20: Emission comparison of CNG with Euro norms

Euro Norms	Emissions in g / kwh			
	HC	NOx	CO	PM
Euro II	1.1	7	4.0	0.15
Euro III	0.66	5.0	2.10	0.10
Euro IV	0.46	3.5	1.50	0.02
Indian CNG Bus	0.04	3.24	3.12	0.014

Source: R.Ramakrishnan 2001, CNG -The clean and cost effective fuel for Delhi vehicles, Mimeo.

Strengthening of CNG vehicles

The introduction of CNG vehicles in Delhi started from the year 1999 and by November of 2002, all diesel busses and non-CNG two-stroke three-wheelers of the city were removed from the streets of Delhi. The city today has the world's largest CNG vehicle fleet. At present there are more than 1, 50,000 CNG vehicles plying in the roads of Delhi. The total CNG vehicles in the country touching over 3.54 Lakh, as per the industry estimates. CNG has also been introduced as automotive fuel in the cities of Mumbai, Hyderabad, Ahemdabad, Surat, Vadodra, Kanpur, Bareli, Agra, Lucknow and Agartala as well.

The state governments of many polluted cities have also taken up the implementation of CNG as automotive fuel for improving the air quality of their respective cities, which are as follows:

- Delhi Transport Corporation is one of the main public transport operators of Delhi and operates more than 3,000 CNG buses on 773 routes throughout Delhi and surrounding areas. Delhi operates one of the largest CNG bus fleets in the world. IGL runs 163 stations in Delhi and caters to nearly 2.25 lakh vehicle, filling over 13 lakh kgs/day as of July, 2008 and planed to to enhance capacity of existing filling stations by installing 54 nos. of electric driven compressors that would enhance the compression capacity from 21 lakh kgs/day to 26 lakh kgs /day.

- In smaller cities too, automobiles run on CNG seem to be getting popular with Vadodara clocking 3,630 vehicles, Kanpur and Bareli 6,801, Agra 5,215 and Lucknow 5,430.

- The cities that have placed orders for CNG buses include Visakhapatnam, Indore, Ujjain, Thane, Navi Mumbai, Pune, Pimpri chinchwad, Agartala, Agra, Kanpur and Lucknow.

6.5.2 Liquefied Petroleum Gas (LPG)

LPG is a by-product of natural gas processing or a product that comes from crude oil refining and is composed primarily of propane and butane with smaller amounts of propylene and butylenes. Liquefied petroleum gas (LPG) consists mainly of propane, propylene, butane, and butylene in various mixtures. Lower carbon-to-hydrogen ratio, higher octane rating and its ability to form a homogeneous mixture inside the combustion chamber enable it to produce lesser emissions compared to conventional fuels. Bureau of Indian Standards (BIS) Specifications for LPG as automotive fuel in India are given in **Table6.21.**

Table6.21: BIS Specifications for automotive LPG (IS 14861- 2000)

S. No.	Characteristics	Requirement
1.	Vapour Pressure (gauge) @ 40°C, kpa minimum maximum	520* 1050
2.	C5 Hydrocarbons and hevier, mol %, max.	2.0
3.	Dienes (as 1,3 Butadiene), mol %, max	0.5
4.	Total volatile sulphur (after stanching) ppm, max	150
5.	Copper strip corrosion @ 40° C for l hour, max	Class I
6.	Hydrogen Sulphide	Pass the test
7.	Evaporation residue, mg /kg, max	100
8.	Free water content	Nil**
9.	Motor octane number (MON), min	88
10.	Odour :Unpleasant and distinctive down to 20% LEL***	

Note: * *In winter, the gauge vapour pressure requirement shall be min. 700kpa at 40°C; winter period shall be from 1st November to 15th February.*

*** The water content shall be determined at the Refinery / First dispatching location*

**** Product shall contain 20 ppm, min, Ethyl mercaptan at the first dispatching location to ensure the detection of leakage by odour*

6.5.3 Ethanol

Ethanol has high octane and relatively clean combustion characteristics. The presence of oxygen in ethanol facilitates combustion reducing CO and HC emissions. Ethanol is a safe replacement for toxic octane enhancers in gasoline such as benzene, toluene and xylene. While the calorific value of ethanol is lower than that of gasoline by 40% it makes up a part by increased efficiency. So far its use as 100% fuel is concerned it has no problem in designing an engine to run on only ethanol. However, for the reason of compatibility as well as availability its

use for blending is only being practiced. It can be blended both in diesel as well as gasoline.

A committee was constituted by the MoPNG to look into all the aspects of introduction of Ethanol-Gasoline blend as an auto fuel in India. Based on the experience of the pilot projects launched by MoPNG, Government of India on 29.11.2001 has taken a decision to introduce petrol blended with 5% ethanol for use in motor vehicles all over the country in a phased manner. Vide G.S.R 644(E) dated September 12, 2002, MoPNG has notified the use of 5% ethanol blended petrol in the nine states (Andhra Pradesh, Goa, Gujarat, Haryana, Karnataka, Maharastra, Punjab, Tamil Nadu and Uttar Pradesh and four union territories (Daman, Dadra and Nagar Haveli, Chandigarh, and Pondicherry) from January 1, 2003.

The Cabinet Committee on Economic Affairs (CCEA) had approved making 10 % doping of petrol “optional” from October 2007 and “mandatory” from October 2008 across the country, except in Jammu & Kashmir, the North-East and the Island Territories. Bureau of Indian Standards (BIS) in 21st Meeting (Emergency) of Petroleum, Lubricants and Their Related Products Sectional Committee, PCD 3 held on 29th January 2008 have finalized the specification of 10% Ethanol Blended Motor Gasoline (E10) by incorporating the provision of 10% Ethanol Blending with Motor Gasoline in the Indian Standard of Motor Gasoline, IS 2796.

6.5.4 Diesel Alcohol Blends

The alcohol may be blended with diesel fuel to produce diesohol, (or) the alcohol may be added to the air intake of the diesel engine. But, control of the quantity of alcohol added to the air intake may be difficult and could cause erratic engine operation and/or failure if a large quantity of alcohol was added to the air intake. Methyl alcohol, because of its highly polar nature, does not mix with diesel fuel. Ethanol can be mixed with diesel fuel provided there is little water in the ethanol. Another problem with adding ethanol to diesel fuel is that the cetane number (ignition characteristic) may decrease below the level recommended by the engine manufacturer. Butyl alcohol can be mixed with diesel fuel in virtually any concentration. It does not separate as water is added or as the temperature is decreased. Further, butyl alcohol does not significantly change the cetane number of diesel fuel. In blends with diesel fuel, butyl alcohol tends to reduce the solidification temperature of the fuel at low temperatures. *(J.L. Smith and J.P. Workman)*

Indian Institute of Petroleum (IIP) has developed a retrofit kit for dual-fuel operation of diesel vehicles with alcohols. IIP used the fumigation concept for this

purpose and successfully demonstrated this system on MSRTC and DTC diesel buses under actual commercial passenger service. The fleet consisted of 25 and 35 buses of Tata and Ashok Leyland respectively with a total cumulative operation of 42,00,000 kms. The methanol fuel consisted of 10% gasoline also; to impart flame luminosity from the safety angle as the methanol flame is almost invisible in sunlight. From the study, it was concluded that 15-20% substitution of diesel by alcohols is possible by a simple retrofit fumigation system. Thou more field trials are required on new generation diesel engines to assess the technical feasibility of the fuel. Government of India sanctioned R & D studies on ethanol-diesel blends. MoP&NG is also working on to introduce 5% ethanol-diesel blend.

6.5.5 Electric Fuel

Electricity is unique among the alternative fuels in that mechanical power is derived directly from it, whereas the other alternative fuels release stored chemical energy through combustion to provide mechanical power. Electric vehicles do not undergo any combustion process. Mechanical power is directly derived from electricity. There are no tailpipe emissions. Water is the only emission when hydrogen is used as the fuel in fuel cells. But the process of commercial hydrogen production to feed the fuel cell is associated with some CO2 emissions. But still they are very far from grabbing the moderate share of the commercial vehicles market.

The Government of India in its effort to encourage and popularize new and environment friendly technologies towards reducing vehicular pollution and thus consequently improving quality of urban air, has announced a Central Subsidy of upto Rs. 75,000 for each REVA Electric Car. The beneficiaries of this subsidy are Public Institutions included Government organization and departments, Public Sector Undertakings, Educational institutions, Hospitals, Tourism and Archaeological sites. Based on the specific requirements of the public institutions as per the direction of the Ministry of Non-conventional Energy Sources (MNES), REVA has introduced a modified range of models named the “REVA Eco” which is eligible for the subsidy. Some of them who have availed this benefit include: ISRO, APEDA, ITPO, KSRTC, BMTC, KSDL, NSTL Vizag, Maharishi Educational Society, Nerlikar Hospital etc.

The government has initiated a national hybrid project under public-private-partnership mode (PPP) to develop hybrid vehicles in the country and many leading auto makers, including Maruti Suzuki India, Tata Motors, Mahindra & Mahindra, TVS and Bajaj, are participating in it.

6.5.6 Hydrogen

Hydrogen is high in energy content as it contains 120.7 MJ/kg, which is the highest for any known fuel. However, its energy content compared to volume is rather low. This poses challenges with regard to its storage for civilian applications, when compared to storage of liquid fossil fuels. When burnt, hydrogen produces water as a by-product and is, therefore, environmentally benign. Although no CO2, etc. are produced if hydrogen is burnt in air, yet NOx will be formed at high temperatures. One of the advantages of hydrogen as a fuel is that it can be used directly in the existing internal combustion engines and turbines. It can also be used as a fuel in fuel cells for electricity generation. Hydrogen applications, besides industrial application, cover power generation, transport applications and heat. However, when compared to other alternatives, use of hydrogen in transport sector appears to be more beneficial as it is possible to store hydrogen on-board. The properties of hydrogen as compared to other conventional fuels are given in **Table6.22**.

Table 6.22 : Properties of Hydrogen Vs Other conventional fuels

Fuel properties	Hydrogen	Natural Gas	Petrol	LPG
Lower heating value (MJ/kg)	120.7	49.54	41.87 - 44.19	46.05
Higher heating value (MJ/kg)	141.89	54.89	43.73 - 47.45	50.24
Density at standard conditions (kg/m3)	0.08	0.6	720 – 780	510
Phase at standard conditions	Gas	Gas	Liquid	Liquid
Auto-ignition temperature[1] in air (°C)	566 – 582	540	257	454 - 510
Ignition limit[2] in air (Vol %)	4.1 – 74	5.3 – 15	1.4 – 7.6	2.2 – 9.5
Diffusion coefficient[3] in air (cm^2/s)	0.61	0.16	0.05	0.11

Source: National Hydrogen Energy Road Map, MoNRE

Note: 1*. Auto-ignition temperature is the lowest temperature at which a fuel will ignite when an external source of ignition is present, 2. Ignition limit is the range of concentration within which the fuel will ignite, if an ignition source is present, 3. Diffusion coefficient is used to determine the rate at which the fuel disperses (the higher the coefficient, the faster the rate)*

The present status of development of hydrogen energy technologies in the country and the need to systematically upgrade these technologies to make them technically and commercially viable, the Road Map has identified two major initiatives; namely Green Initiatives for Future Transport (GIFT) and Green Initiative for Power Generation (GIP). The Green Initiative for Future Transport (GIFT) aims to develop and demonstrate hydrogen powered IC engine and fuel cell based vehicles ranging from small two/three wheelers to heavy vehicles through different phases of development. It is recognized that the performance of hydrogen fuelled vehicles have to be at par with the commercially available options to the consumers in terms of performance, safety, convenience and costs. This would require a well planned and coordinated industry driven action plan. The Indian automobile industry is fully committed and geared to take up the challenges in this task. It is envisaged that if the National Hydrogen Energy Road Map is implemented as proposed, one million hydrogen fuelled vehicles would be on Indian roads by 2020.

Indian's first commercial Hydrogen CNG (H CNG) dispensing station was set up at Dwarka, Delhi with part funding from Ministry of New & Renewable Energy (MoNRE) and rest from Hydrogen Corpus Fund of Oil Industry Development Board (OIDB). Trials were initiated on HCNG blends with different composition on few vehicles by fueling from Hydrogen and HCNG dispensing station. The blend with 18% HCNG was selected for further optimization. Two demonstration projects on use of HCNG blends in automotive vehicles (light duty & heavy duty vehicles) were undertaken by Indian Oil - R&D along with SIAM with funding from MoNRE & OIDB. Bajaj and Mahindra & Mahindra, 3-wheelers were converted for HCNG operation at Indian Oil-R&D.

6.5.7 Biodiesel

India has great potential for production of bio-fuels like bio-ethanol and biodiesel from non-edible oil seeds. The National Mission biodiesel program consists of two phases. The first phase consists of demonstration projects covering both forest and non-forest lands in various states across the country. The phase II of the mission will focus on uncovered areas with a target to achieve 20% blending of bio-diesel with diesel.

The phase II of national mission is proposed to be people driven with the government playing the role of facilitator. It aims to expand the program to cover up to 11 million hectare in phase II. The implementation will be done in phased manner. The first step is to achieve a 5% biodiesel blend in diesel in 9 states; then aim at a 5% biodiesel blend all over the country. Later the biodiesel blend percentage will be increased to 10% across the country and lastly work towards

more than 10% biodiesel blend in the entire country. In order to achieve the set targets, the National Mission will look into nurseries development, plantation on forest and non-forest lands, seed collection and oil extraction centers, transesterification units, blending and marketing arrangements and research and development (R&D) studies to fill gaps in knowledge. The comparison of Biodiesel Specifications of American Society of Testing and Materials (ASTM) and BIS is given in **Table 6.23**

Table 6.23 : Bio Diesel Specifications

Specifications	**ASTM D-6751**	**IS 15607 : 2005**
Density		860 - 900 Kg / m3
Ester Content		96.5 %
Flash point (closed cup)	130°C min. (150°C ave.)	120°C
Water and sediment	0.050% by vol., max.	500 mg / Kg, max.
Kinematic viscosity at 40°C	1.9-6.0 mm2/s	2.5-6.0 mm2/s
Oxidation Stability		6 hours min, at 110°C
Ramsbottom carbon residue, %mass	0.10	
Sulfated ash	0.020% by mass, max.	
Sulfur	0.05% by mass, max.	50 mg / Kg max
Copper strip corrosion 3 hrs. 50°C	No. 3 max	Class 1
Cetane	47 min.	51 min.
Carbon residue	0.050% by mass, max.	
Acid number, mg KOH/g	0.80 max.	0.50 max.

Specifications	ASTM D-6751	IS 15607 : 2005
Methanol or Ethanol		0.2 % m/m, max
Free glycerin	0.020 % mass	0.020 % mass
Total glycerine (free glycerine and unconverted glycerides combined)	0.24% by mass, max.	0.25% by mass, max.
Group I Metal (Na+K)	5 mg/Kg, max	5 mg/Kg, max
Group II Metal (Ca+Mg)		5 mg/Kg, max
Phosphorus content	0.001 max. % mass	10 mg/Kg, max
Distillation	90% @ 360°C	Not Mentioned

Biodiesel is the only alternative fuel to have a complete evaluation of emission results and potential health effects submitted to the USEPA under the Clean Air Act Section 211(b). These programs include the most stringent emissions testing protocols ever required by EPA for certification of fuels in the US Emission results for pure biodiesel (B100) and mixed biodiesel (B20 - 20% biodiesel and 80% petro diesel) compared to conventional diesel are given in **Table 6.24**. The life cycle production and use of biodiesel produces approximately 80% less carbon dioxide and almost 100% less sulphur dioxide compared to conventional diesel.

Table 6.24 : Biodiesel Emissions Compared to Conventional Diesel

Emissions	B 100	B 20
Regulated emissions		
Total Unburned Hydrocarbons	-93%	-30%
Carbon Monoxide	-50%	-20%
Particulate Matter	-30%	-22%
NOx	+13%	+2%

Non- regulated emissions		
Sulphates	-100%	-20%*
Polyciclic Aromatic Hydrocarbons (PAH)**	-80%	-13%
NPAH (Nitrated PAHs)**	-90%	-50%***
Ozone Potential of Speciated HC	-50%	-10%
Life cycle emissions		
Carbon Dioxide (LCA)	-80%	
Sulphur Dioxide (LCA)	-100%	

*Estimated from B100 results. **Average reduction across all compounds measured.

***2-nitroflourine results were within test method variability.

The table reveals that biodiesel gives a distinct emission benefit almost for all regulated and non-regulated pollutants when compared to conventional diesel fuel but emissions of NOx appear to increase from biodiesel. NOx increases with the increase in concentration of biodiesel in the mixture of biodiesel and petro diesel. This increase in NOx may be due to the high temperature generated in the fairly complete combustion process on account of adequate presence of oxygen in the fuel. This increase in Nox emissions may be neutralized by the efficient use of NOx control technologies, which fits better with almost nil sulphur biodiesel then conventional diesel containing sulphur.

7.0 Non-Technical Measures

The non technical measures in the form of Better Traffic Management system; Augmentation in public transport system, Implementation of Market based instruments i.e fiscal instruments, generating mass awareness, drives for checking adulteration etc. have been taken up. Details on non-technical measures those have been taken up for controlling vehicular pollution are described in the subsequent paragraphs

7.1 Traffic Management

7.1.1 Traffic Pattern, Infrastructure & Authorities

Traffic pattern on Indian roads is highly heterogeneous in nature. The 23 metros contribute towards **35%** of the total motor vehicles in the country. In terms of numbers on road two wheelers dominate the scene with about **65%** of share in total number of vehicles whereas in terms of percent share of trips, buses cover the maximum passenger kms of about **36%** of total. The total vehicles ownership is very low in our country with only 22 vehicles per thousand of population as against 675, 598, 517, 586, 272 and 222 motor vehicles per 1000 of population in U.S.A, France, U.K, Japan, Malaysia and Mexico respectively *(Source: International Road Federation's "World Road Statistics, 2008" except for India).* The penetration level of two wheelers (two wheelers/1000 persons) is much higher compared to developed countries.

In India work trips are the most important component of the traffic demand during peak hours of the day. The total number of passengers carried by the 30 reporting State Road Transport Undertakings (SRTUs) for the year ending March, 2008 stood at 2231.70 crore passengers which is higher than 2161.40 crore passengers carried during the year ending March, 2007 (an increase of 3.25% in this period).

Maintenance of transport infrastructure in India is a responsibility of many agencies operating at central and state level. The institutional structure of SRTUs varies from corporations (constituted under the Road Transport Corporations Act) to companies (constituted under the Companies Act) and to those operated departmentally or by the municipal authorities. There are 23 Corporations, 8 Companies, 8 Government Departmental Undertakings and 8 Municipal Undertakings, as of March 2008. Corporations account for about 75% of the bus fleet strength followed by Companies (17%), Municipal Undertakings (4.5%) and Government Departmental Undertakings (3.5%).

India has a total road network of 3.3 million km. The distribution of various categories of road infrastructure and the share of national highways by road length is shown in **Table 7.0.** Although national highways constitute only about 2% of the total network, about 40% of the total road traffic moves on these roads. The MoRTH administers the national highway system, while state highways and other state roads are maintained by state public works departments, and other local roads are maintained by municipalities, districts and villages.

Table 7.0: Road Infrastructure in India

Road Category	Total length(km)
National Highways	66,754
• 1 lane, intermediate lane • 2 lane • 4 – 8 lane	18,350 (27%) 39,079 (59%) 9,325 (14%)
State Highways	1,28,000
Major District Roads	4,70,000
Rural Roads	26,50,000
Total	**33,14,754**

Traffic regulation is the sole responsibility of the traffic police of the area. Apart from these there are many other private and government organizations which act as support agencies. There are institutes like CRRI, VRDE etc. in India involved in the research work in the field of roads and automobile engineering. There are many studies done by the organizations like CRRI, CIRT, RITES etc. on various aspects of Traffic and Transportation Planning in India which include Policies, planning, forecasting, public mass transport, personalized transport, Intermediate public transport and general studies.

7.1.2 Improvement in Traffic flow

Traffic management can improve the flow of traffic on the roads, reducing emissions per vehicle kilometer traveled and enhancing urban mobility. Traffic management comprises both “supply side” measures – traffic management to improve speed of existing traffic volumes - and “demand side” measures - traffic demand management to improve speeds by reducing traffic volume. Traffic management measures have been shown to improve traffic conditions and reduce emissions significantly by reducing the number and duration of stops and permitting higher travel speeds. Traffic management measures are relatively cheap and quick acting. They can, however, induce additional travel that may have to be restrained by introducing traffic demand management measures to ensure the sustainability of the traffic and pollution benefits. A combination of traffic engineering measures, demand management measures, and measures giving priority to public transport vehicles has been shown to be the best approach, especially in large cities with high volume travel demand

corridors. Traffic management strategies need a high and continuing degree of political, institutional and human resource commitment to ensure that their benefits are sustained. The establishment of traffic management units with appropriate authority and ability to plan and implement traffic management measures is essential. The involvement of police authorities working in concert with traffic management units is critical to successful traffic management

7.1.3 Traffic Management Initiatives

Traffic Management techniques in India have been divided into 5 groups which are short term traffic management techniques (which include regulatory techniques, demand management techniques, bus priority techniques and others), passive traffic management systems (fixed time traffic signals, signal hardware, passive passenger information systems, violation detectors), Incremental infrastructure (includes road improvements, flyovers, pedestrian subways, parking lots and others), active traffic management systems (detector based traffic signals, variable message signs for parking/incident/violation detection, traffic sensors) and expert traffic management. The major traffic management initiatives those have been implemented especially in major cities and towns of India for better management of traffic, thereby reducing vehicular pollution are as follows:

- The report of the expert committee on Auto Fuel Policy in its road map for controlling vehicular pollution has recommended for the augmentation for mass transport system all over the country in a time bound manner.
- Augmentation in the Infrastructure i.e construction of flyovers, bridges, road networks & broadening of existing roads.
- Delhi Metro Rail has been
- Demolition of the road side encroachments.
- Incremental technologies for traffic signal hardware like computerized traffic signals as well as installation of monitors displaying stop timing at all the major traffic intersections.
- Restriction in the entry of trucks as well as interstate buses during peak traffic timings.
- Diversion of all interstate trucks and buses through by-pass roads thereby reducing congestion in the main city.
- Implementation of MRTS in Delhi has considerably lightened the traffic load in many areas of Delhi.
- Better signs, route maps and signals.
- Restriction in entry of vehicles at very crowded market places like Chandini Chawk an Karol Bagh in Delhi
- Parking control standardization.

- Procurement of state-of-art violation detection equipment systems like vehicle speed detection cameras etc**.**
- Implementation Bus lane system& automated toll collection for buses.
- Better passenger information systems in the form of variable message signs
- Regular conduction of Mass Awareness Programme for encouraging public transport system , car pooling & Fuel saving tips.

7.2 Check on Fuel Adulteration

7.2.1 Adulteration and Control Initiatives

Adulteration of the transport fuels at the point of sale and during transportation has become an acute problem in the country. Transport fuels are often adulterated with other cheaper or byproduct or waste hydrocarbon stream for monetary gains. For example, gasoline (petrol) is believed to be widely adulterated with naphtha, natural gas liquids, kerosene, waste solvents, byproduct petroleum stream, etc. With large number of adulterants available in the market, both indigenous and imported, the magnitude of the problem of fuel adulteration has grown into alarming proportions in the past few years. Off late India has also taken some initiatives to tackle this problem. As per the Ministry of Petroleum & Natural Gas (MoPNG) following Steps have been undertaken to control Adulteration of Fuel in the country.

- Oil companies carryout filter paper test, density checks, blue dyeing of PDS kerosene and furfural doping of PDS kerosene.

- Further, in order to prevent diversion of kerosene meant for distribution under PDS for adulteration, MoPNG has directed the oil companies to ensure upliftment by the wholesalers as under:

    - 60% by 10^{th} of the month
    - 25% during next week, and
    - Balance 15% during the following week

- MoPNG has also advised State/UT Government from time to time

    - To ensure upliftment of kerosene by the whole sellers from oil companies as per upliftment pattern mentioned above.
    - To identify loopholes in the distribution system.
    - To review scale of distribution of kerosene to various cardholders, with regard to factors as availability of alternative fuels.
    - To discontinue allocation of kerosene to the cardholders having double LPG connection and to discontinue allocation of kerosene for uses other than cooking and illumination.

- MS/HSD control order has been amended for providing testing of MS/HSD for various parameters of specification apart from density like Octane No. of MS, Cetane No. of HSD, and any other parameter of MS/HSD specification indicated in the order.

- The state Govt. authorities are empowered under the MS/HSD control order to conduct inspections at the retail outlets and take appropriate action against the erring dealers in case of any mal-practices/irregularities detected.

- On October 31, 1998, MoPNG has amended the kerosene control order making it mandatory for the parallel marketers to file end use certificate from their industrial customers.

- An independent fuel-testing laboratory has been set up at Noida during November 2000 as directed by Hon'ble Supreme court and as desired by EPCA for testing of samples drawn from retail outlets in the NCT/NCR.
- MoPNG have issued two control orders namely (i) the solvent, Raffinate and Slop (acquisition, sale, storage and prevention of use in automobile) order, 2000 in order to prevent unauthorized usage of these products for adulteration of MS/HSD at retail outlets.
- Other Measures includes:
    - Sealing of tank trucks with security locks
    - Increasing number of mobile laboratories

7.2.2 Committees and Task Forces Constituted for Checking Fuel Adulteration

(i) Bureau of Indian Standards (BIS) has constituted a task force to look into various aspects of fuel adulteration.

(ii) Central Pollution control Board has constituted a working group to formulate fuel specifications for the year 2005 under the Inter- Ministerial Committee to formulate Auto oil Programe for year 2005 constituted by MOEF. One of the terms of reference is to draw out a strategy for monitoring the fuel quality at the petrol pumps to check adulteration.

(iii) Ministry of Petroleum & Natural Gas has constituted a Task Force to examine the use of solvent, raffinate and slop in automobile fuel.

(iv) Government of India has set up an Anti adulteration Cell headed by a Director General. The functions of the Anti Adulteration Cell are:

- Prevention of adulteration and other malpractices in the sale of petroleum products.
- To conduct inquiries into complaints against Dealer Selection Boards.
- To act as a coordinating agency for oil companies and Central/State Governments departments in the matters related to adulteration of fuel.

7.3 Market Based instruments for controlling vehicular Pollution

7.3.1 Advantage of Market based policies

The instruments which are linked to financial implications and aim to charge the polluter for pollution or otherwise help and financially support the polluters to replace the existing pollution technology by a clean technology are called Market Based Instruments (MBIs) or Financial Instruments. Economic instruments generally work through market mechanism to create incentives for less environmentally damaging behavior. MBIs are found to be far more flexible than Command & Control Measures, which often dictate technology choice in contrast to the MBIs, which gives polluters the option of reducing pollution or paying s fee for the “right to Pollute”.

The advantage of incentive based policy lies mainly in giving polluters greater choice in selecting the method of compliance. This can reduce the aggregate cost of compliance, speed up compliance, improve acceptance. Economic instruments (MBIs) put a price on pollution, congestion, etc. and thereby create incentives for sources to produce a socially optimum amount of pollution, congestion etc. (always greater than zero). Vehicle owners do pay some of this cost but not all of it, and not in the economically efficient ways. Policy aim should not necessarily be to make vehicle owners to pay more, but pay differently.

The main categories of fees, taxes and charges are:

- Vehicle ownership fees (import and excise taxes, VAT, registration fees, etc.);
- Fuel or other at-the-pump-charges;
- Other operating (in-use) charges (e.g. maintenance);
- Road pricing including congestion pricing;
- Parking fees;
- Subsidies or cross-subsidies on selected transport modes (e.g. public transport fares) or pattern of use (e.g. high occupancy vehicles).

Command and control policies do not in any way provide dynamic incentives for technological innovation and diffusion. Under the current regulatory structure, the abatement activity is necessarily more expensive and inefficient, as incentives for cost-minimizing adjustments are absent. Thus, there is considerable scope for improvement, given the current state of MBIs in India. Also, considerable wisdom has been accumulated in the use of MBIs in South-East Asia, USA, and Europe. Within price-based MBIs, indirect instruments such as input-output taxes, differential tax rates, and user fees have been used extensively. Such economic instruments are responsible for considerable savings in abatement costs. India can draw lessons from the experiences of such economies and improve the efficiency of its pollution-control strategies.

International experience in environmental regulation under the transport sector reveals that most of the MBIs target fuel consumption, vehicle price, or travel demand itself, is given in **Table 7.1.** Until the late eighties, taxation policies of motor vehicles and motor fuels focused primarily on raising revenue. Since the early nineties, many countries have implemented coordinated fiscal and environmental policies aimed at reducing vehicular emissions.

In India, command and control measures have dominated the environmental regulation in the transport sector. Greater emphasis has been laid on setting standards and promoting specific technologies by mandating their usage. Emission control strategies in this sector, however, do not employ MBIs (market-based instruments) for pollution control. As against the command and control approach, MBIs use market and price mechanisms to promote adoption of environment-friendly practices.A change in the existing fiscal framework to influence vehicle–population mix is therefore suggested. These measures could be used to persuade the consumers of motor vehicles to purchase relatively cleaner vehicles by making the environmentally 'dirty' vehicles more expensive. This can be done by changing the tax structure, so that consumers pay higher taxes while purchasing vehicles that pollute more and *vice versa*.

Table 7.1: International experience in environmentally motivated fiscal policies

Instrument	Developing Countries	Developed Countries
Price differential between leaded and unleaded gasoline	Hungary, Mexico, The Philippines, Portugal, Taiwan, Thailand	Australia, Britain, Denmark, Finland, Germany, Luxembourg, The Netherlands, New Zealand, Norway, Sweden, Switzerland.
Price differential between ultra low sulphur diesel and ordinary diesel		UK, Sweden
Vehicular Tax based on emissions	South Korea	Austria, Belgium , Britain, British Columbia, Germany, Japan, The Netherlands, Sweden
Taxes on non- Catalytic converter cars	Greece	Finland, Sweden
Higher taxes on diesel cars		Germany
Tax incentives to promote use of natural gas for	Pakistan	Argentina, Italy, Germany, Australia, Ireland, Russia,

vehicles		Colombia, Canada, UK
Incentives for promoting natural gas vehicles	Malaysia	Belgium, U.K, USA, Australia, Ireland, Egypt
Annual Road tax differentiated by vintage		Germany
Emission trading	Chile	
Tax on lead acid batteries		British Colombia, USA
Congestion pricing	Chile	Norway

Source: Pandey and Bhardwaj (2000), Gupta (1999) and the European Natural Gas Vehicles Association (2002).

As discussed earlier, environmental regulation in the transport sector has seldom used MBIs. There are, however, various fiscal instruments in the central as well as the state government budgets that influence emission-loading from the transport sector. These include customs duty and excise duty, which are in the purview of the central government, and sales tax in the budgets of state governments. Also, allocations for various activities and government instrumentalities, like STUs (state transport undertakings), have an impact on the environment. Finally, other instruments, such as depreciation allowance and R&D allowances to the manufacturers, are also available to encourage a shift towards production of less-polluting vehicles.

7.3.2 MBI's for vehicular pollution control in India

(i) For Traffic Management

- Congestion charges: Congestion Charges have been imposed at very crowded market places in major cities/towns
- Parking charges: Higher parking fees have been imposed at most of the crowded public places in major cities/towns
- Toll Taxes have been imposed to all interstate vehicles
- Tax saving Incentives for Car pooling
- Subsidy to public transport system
- Differential vehicle taxation for discouraging plying of older vehicles

(ii) Fuel Quality

- Differential Fuel Taxation
- Higher taxation on conventional fuels
- Subsidies on cleaner alternate fuels

(iii) Alternate Fuels / Vehicles

- Subsidies for promoting cleaner alternate fuels & vehicles

(iv) R& D Work related to clean vehicle technologies & fuel Quality

- Carrying out studies for development of more &
- Funding various research organization/universities for the development of cleaner vehicle technologies, Fuel quality & alternate fuels/Vehicles for vehicular pollution control.

(v) Strict enforcement of legislation

- Imposing fiscal and punitive measures for strict enforcement of legislation.

8.0 Specific Actions/Programs for Urban Air Quality Improvement

Besides the measure mentioned in section 7.0 ,for controlling vehicular pollution in the country, some specific actions and programs for urban air quality improvement taken in the country are as follows:

8.1 Pollution Control in 16 Non-Attainment cities

With the objective of controlling this rapidly burgeoning air pollution problem in our country, the Hon'ble Supreme Court of India, in the matter of CWP No. 13029 of 1995, passed various orders, regarding formulation and implementation of action plans for control of pollution in selected cities. The Hon'ble Court stressed the need for such initiatives relating to vehicular pollution in Delhi and directed that action plan for pollution control in the cities/ towns, which do not meet the ambient air quality standards, should be prepared.

The orders covered identification of 16 cities as non-attainment cities.The names of the cities along with autorities to review the action plan are as follows

- Pune, Agra, Varanasi, Patna , Jharia, Jodhpur & Faridabad. : to be reviewed by MoEF

- Ahmedabad, Kanpur, Sholapur, Lucknow, Bangalore, Chennai & Hyderabad: to be reviewed by EPCA

- Mumbai & Kolkata : to be reviewed by respective High Courts.

A brief status of the progress of action plan in 16 cites is enclosed as **Annexure V**

8.2 Environment Pollution (Prevention and Control) Authority For the National Capital Region

During August 1997 Ministry of Environment and Forests (MoEF) brought a white paper on pollution in Delhi. To implement the recommendations of white paper, MoEF constituted “Environmental Pollution Control Authority” on January 1998 on the directions of the Supreme Court.

The EPCA monitored implementation of action points enlisted in the "White Paper on Pollution with an Action Plan", priority measures for vehicular pollution control and implementation .The EPCA also prepared special reports as desired by the Hon’ble Supreme Court. Since its inception, EPCA is monitoring implementation of the action points and priority measures. EPCA also visits several sites to check compliance by various agencies. Concerned Departments/Ministries of the Central Government and State Governments, and other agencies were persuaded for implementation. The issues taken up by the EPCA includes fuel quality, pre-mixed oil dispensers, adulteration of fuels, fuel testing laboratory, vehicle technology, emission warranty for vehicles, setting up of CNG out lets, conversion of public transport fleet to CNG mode, traffic management, construction of ISBTs, Setting up of inspections and certification centers, sewage treatment and common effluent treatment plants. The areas where major progress has already been made as a result of measures taken by EPCA are as follows:

- Fuel Quality
- Premixed Oil Dispensers
- Measures to Prevent Adulteration of Fuels
- Improvement in Vehicle Technology
- .Emission Warranty.
- Review of the action plan for 7 out of 16 non-attainment cities identified by the hon’ble supreme court of India.

8.3 Auditing of PUC centers by Central Pollution Control Board

Inspection and maintenance of the on road vehicles plays very important role in controlling emissions from old on road vehicles. New and more stringent PUC norms for in-use vehicles were notified by MoRTH for implementation from October 2004. Earlier for gasoline vehicles only idling CO% test was carried out in PUC centers which was carried out with the help of 2 gas analyzer, but now with the implementation of new PUC norms testing for HC emissions is also required to be done. A program on auditing of PUC centers in various cities/towns across the country has been under taken by CPCB, with the objective of knowing adequacy OF testing facilities with respect to new norms have been procured by all the PUC centers and also to cross check procedure and protocols followed while vehicle testing. Further, it also assisted in

assessment of any scope for false passes, if present in the new system. The scope of the study also included checking if the testing instruments have been certified by approving agencies and further to know the status of compliance of the vehicles with new PUC norms. The objective of the PUC auditing were as follows

1. Assessment of the status of compliance of vehicles with respect to new PUC norms in centers in various cities/towns across the country l

2. Verify if the required testing facilities/instruments with respect to new PUC norms have been procured by PUC centers and further to verify if these instruments /facilities have been certified by approving agencies.

3. Assessment of Code of Practice followed by the PUC centers which includes procedure and protocols followed during vehicle testing along with instrument calibration procedure.

4. To know if lambda measurements is being carried out in gasoline vehicles.

5. To identify any scope for false passes, if present in the new system.

So far PUC auditing has been carried out in the cities of Delhi, Bangalore & Jodhpur . Auditing at PUC centers in Chennai & Patna is proposed short**.**

9.0 International Programs on vehicular pollution control involving India

9.1 Asian Development Bank (ADB) Programs

9.1.1 ADB's efforts

With increasing incidences of air pollution in the Asian countries, policymakers concerned have turned very concerned on this issue and are working to design economically feasible and socially viable solutions for air quality improvement. To assist in this effort, ADB has published a series of policy guidelines to reduce vehicle emissions in Asia. ADB has also sponsored a number of action plans and studies in selected developing member countries. Some of these are summarized in the subsequent paragraphs:

A. Policy Guidelines for Reducing Vehicle Emissions in Asia

A project on development of guidelines for reducing emissions in Asian countries was taken up by ADB. A key output of this project is the publication of policy guidelines for reducing vehicle emissions in Asia. The six-part policy guidelines are based on the five regional workshops organized by this Regional Technical Assistance. These guidelines provide an in-depth analysis of the different

components of an integrated strategy to reduce pollution from mobile sources as below

- Reducing Vehicle Emissions in Asia
- Cleaner Fuels
- Cleaner Two and Three Wheelers
- Vehicle Emissions Standards and Inspection and Maintenance
- Transport Planning and Traffic Management for Better Air Quality
- Appendix: Adverse Health and Environmental Effects of Vehicle Emissions

Policymakers in Asia are encouraged to combine the general principles outlined in the policy guidelines with their knowledge of the local situation in their respective countries and cities to arrive at effective strategies.

A publication on policy guidelines for reducing vehicles emission in Asia is one of the outputs of ADB's Concluding Workshop on Reducing Vehicle Emissions held on 28 February to 1 March 2002 in Manila, Philippines. It is the first volume in a series of policy guidelines derived from the five regional workshops organized by ADB from 2001 to 2002. The complete set provides an in-depth analysis of the different components of an integrated strategy to reduce pollution from mobile sources.

B. Study on "Pricing and Infrastructure Costing for Supply and Distribution of ULSD and CNG to the Transport Sector in Mumbai, India" Sponsored by ADB

A Study on "Pricing and Infrastructure Costing for Supply and Distribution of ULSD and CNG to the Transport Sector in Mumbai, India" was sponsored by ADB . The objectives and scope of the study were as follows:

- Estimate the demand and supply potential of CNG and ULSD (50 ppm maximum sulfur content in diesel) as road transport fuels in Mumbai over a 10-year perspective (2000-2010)
- Analyze the resultant emissions loading of CO, HC, NOx, and PM under alternative scenarios
- Determine the cost of supplying the two fuels
- Analyze the price build-up of these fuels to understand the financial implications
- Suggest institutional arrangements for safe and speedy supply of CNG and prevent adulteration of ULSD in Mumbai

This study was undertaken by the Tata Energy Research Institute (TERI), New Delhi for ADB as a part of the overall initiative to develop action plans for reducing vehicle emissions in Asia. It seeks to assess the potential benefits of using CNG and ULSD on a widespread scale in Mumbai.

The results and recommendations of this study would be relevant not only for other cities in India but also for other Asian cities.

Methodology

- Setting up a Multi-Sectoral Advisory Group - TERI has set up an Advisory Group, which consists of representatives from government, the oil and gas industry, NGOs and academia. The Advisory Group will monitor and review the progress of the study, help strengthen the methodology, and ensure quality output and timely completion of the study. The Advisory Group will ensure that the recommendations are accepted by the stakeholders and are implemented successfully.
- Interviewing consumer groups - It is essential to get feedback on the perception of people regarding cleaner fuels, adulteration problems, speedy supply of CNG, safety and efficiency of CNG vehicles, and the impact of CNG pricing on the poor.
- Collating information from secondary sources - A small team has been set up to collect information for analyzing the demand for the two fuels (CNG and ULSD) and to estimate the cost of supplying these two fuels in the city from 2000 to 2010.
- CNG and ULSD demand-supply assessment - The information collected will be analyzed to determine parameters such as passenger and freight travel demand, modal split by technology and fuel, operating energy intensity, fuel demand by mode (1990-2010), extent of switch from one fuel to another, and the demand-supply balance of CNG and ULSD.
- Comparative analysis of the cost of CNG and ULSD supply in Mumbai - This would help determine the production, transportation and distribution costs to be expressed in (1) cost of fuel per liter and (2) cost of fuel per vehicle-km across different modes.
- Addressing issues of adulteration of ULSD - This will require the identifying adulteration problems that could arise given the current institutional arrangements and suggesting strategies to prevent these from occurring.

Outputs

- Research paper on appropriate pricing of CNG and ULSD including fiscal and financial incentives necessary to promote the use and availability of "environmentally acceptable fuels" for transportation in Mumbai
- Recommendations on the institutional arrangements needed for the safe and speedy distribution of CNG and for the prevention of ULSD adulteration in Mumbai

9.2 The World Bank Programs

9.2.1 The World Bank's Efforts

The World Bank has been engaged on air quality management issues in India for almost ten years. For the first time in 1995, an assessment by the World Bank

assigned monetary values to the health impacts of urban air pollution – an effort that contributed to the movement for clean air in Indian cities. Since then the political economy of decision making with regards to urban air quality management (UAQM) in India has evolved, with an active role being played by civil society and judiciary in influencing policy decisions. Over the years, the World Bank has been involved in la number of projects related to Air Quality management, a brief of some of the activities of the world bank related to ait quality management are given in the following paragraphs

A. World Bank study on Urban air Quality in India:

While in 1995 the World Bank helped provide impetus to the movement for clean air in urban India, it has made limited efforts to scale-up its engagement on urban air quality management since then. With a large and growing portfolio of projects in India – across sectors which are likely to present many challenges and opportunities for addressing urban air quality concerns - it is important for the World Bank to take stock, and understand the key issues and challenges. The questionnaire was part of the study to assess the status of Urban Air Quality in India. The study was being conducted by undertaking an assessment of air quality in six major cities, namely - Delhi, Mumbai, Chennai, Hyderabad, Bangalore, and Kolkata.. A copy of the questionnaire used during survey is enclosed as **Annexure-VII**

B. Environmental Management Capacity Building Technical Assistance Project in India

The goal of the Environmental Management Capacity Building Technical Assistance Project is to assist the Government of India to implement its environmental priorities as outlined in the Environmental Action Program (EAP). The specific objective of the project is to enhance environmental management capacity to ensure effective implementation of EAP priorities. The Project includes six components: a) environmental policy planning; b) environmental administration; c) decentralization of environmental management; d) environmental law implementation; e) monitoring and compliance in high priority environmental problem areas; and f) Gujarat- where the project will strengthen the Department of Forests and Environment and the Gujarat Ecology Commission, as well as prepare a State Environmental Action Program.

C. The Energy Sector Management Assistance Program (ESMAP)

The Energy Sector Management Assistance Program (ESMAP) is a global technical assistance program which helps build consensus and provides policy advice on sustainable energy development to governments of developing countries and economies in transition. ESMAP also contributes to the transfer of technology and knowledge in energy sector management and the delivery of modern energy services.

ESMAP was established in 1983 under the joint sponsorship of the World Bank and United Nations Development Program (UNDP) as a partnership with UNDP in response to global energy crises. ESMAP's mandate has evolved over time to meet the changing needs of its clients. ESMAP suggests innovative and strategic "cutting edge" solutions to governments, in the areas of both traditional and non-traditional energy use, complementing and facilitating the work of other development institutions and the private sector. ESMAP is focused on upstream, that is pre-investment, issues that have clear potential for key policy formulation and energy investment.

Under the aegis of ESMAP a number of newsletters pertaining to Air Quality improvement in South Asia and India have been published time to time, involving issues of air quality management. In South Asia, Indoor Air Pollution Fuel Adulteration, Traffic Management, Emission Testing , PUC, auditing etc.,

D. Sustainable Urban Transport in India

A study on development of sustainable urban transport in India is proposed to be carried out collaboratively by the World Bank and Ministry of Urban Development, MoUD, India. The project aims at promoting environmentally sustainable urban transport nationally and to improve the usage of environment-friendly transport modes through demonstration projects in selected cities.' The project aims to achieve this objective by supporting the implementation of India National Urban Transport Policy (NUTP), particularly those aspects of the policy that emphasize:

(a) Priority to the use of public transport;

(b) Priority to non-motorized transport; and

(c) Capacity building for developing and implementing sustainable transport systems (at both national and local levels).

9.3 The Clean Air Initiative for Asian Cities (CAI-Asia)

9.3.1 The CAI – Asia Activities

Clean Air Initiative for Asian Cities (CAI-Asia) promotes innovative ways to improve air quality in Asian cities by sharing experiences and building partnerships. CAI-Asia was established in 2001 by the Asian Development Bank, the World Bank, and USAID, and is part of a global initiative that includes CAI-LAC (Latin American Cities) and CAI-SSA (Sub-Saharan Africa).

CAI-Asia brings together stakeholders to build knowledge and capacity, develop policies and implement on-the-ground measures for improved air quality while simultaneously addressing health, climate change, energy and transport issues. Since 2007, this multi-stakeholder initiative consists of three parts:

- CAI-Asia Center, a regional, Manila-based non-profit organization that is the implementing arm of CAI-Asia
- CAI-Asia Partnership, a United Nations Type II partnership, with over 165 members representing cities, governments, academia, NGOs, private sector, and development agencies
- Country Networks in China, India, Indonesia, Pakistan, Philippines, Nepal, Sri Lanka, and Viet Nam

CAI-Asia programs aim to integrate AQM and sustainable transport into policies and programs of developing countries in Asia by

- Enhancing frameworks for sound policy and program development
- Improving monitoring, measurement, and information on air quality, health, transport, climate change and energy
- Strengthening and harmonizing national and regional standards and policies
- Integrating co-benefits of air pollution and climate change into policies and programs

Some of the air quality improvement programs for Asian countries taken up by CAI-ASIA are as follows:

A. ASIA CLEAN FUELS AND VEHICLES

The CAI-Asia Center is working with together with UNEP in a program entitled "Asia Clean Fuels and Vehicles." The objectives of the program are: to reduce sulphur levels in vehicle fuels, to improve clean fleet management in Asia; c) to have cleaner and more efficient 2-3 wheelers in Asia.

B. Sustainable Urban Mobility in Asia (SUMA) program

The Sustainable Urban Mobility in Asia (SUMA) program works with Asian cities and countries to strengthen the formulation and implementation of sustainable urban transportation and air quality management policies.. SUMA is jointly implemented by its partners and experts. SUMA outputs usually have a partner as a major proponent and the rest of the partners are expected to provide technical or logistical contribution where applicable. The SUMA partners and experts are ADB, CAI-Asia Center, CAI-Asia Local Networks GTZ-SUTP, ITDP, I-CE, UNCRD, WRI-EMBARQ, Christopher Cherry and Marie Thynell.. SUMA will deliver studies, a policy action plan, training, conferences, pilot projects, news digests, and a contact directory on sustainable urban transportation. Its special focus areas include social impacts of transportation, bus rapid transit, non-motorized transportation, electric bicycles, motorized 2-3 wheelers, transportation demand management and fiscal measures.

C. Fuel Economy in ASEAN

The CAI-Asia Center is working with the FIA Foundation, International Energy Agency, the International Transport Forum, and UNEP PCFV in promoting fuel economy, specifically for the Southeast Asian Region as part of the Global Fuel Economy Initiative. A pre-event on "Fuel Economy: Towards a Global Framework" was organized as part of the Better Air Quality 2008 in Bangkok on 12-14 November 2008.

D. Better Air Quality Program (BAQ)

Better Air Quality Programm initiated by CAI-Asia is the biggest gathering on air quality in Asia, covering transport, energy, industry and climate change. It has grown into a community of practitioners who meet every two years for networking, learning and sharing experiences • BAQ has proven to influence policies, initiate new projects and establish partnerships. First BAQ meet was hel in 2002 in Hong kong, India hosted BAQ meet in the year 2004 at Agra. BAQ 2006 & 2008 were held at Indonesia & Thailan respectively. Further BAQ 2010 is proposed at Singapore.

10.0 Future Strategies for India

10.1 General Experience and Basis

The policy instruments dealing with factors meant for vehicular emission reduction and control can be implemented in a number of ways, including legislation, infrastructure investment, standard setting, and enforcement or fiscal incentive or disincentives. Last one decade substantial work has been done to improve the auto fuel quality in India, and other non – technical measure initiatives have already been taken up by the government for controlling vehicular pollution in the country. The future strategy/plans for vehicular pollution control by the government based on the success stories in the past, technology evolution and R&D initiatives at both national as well as international level, is summarized in the following paragraphs:

10.2 Auto Fuel Policy upto 2010 - What next?

Auto Fuel Policy report has laid down a road map for controlling pollution from both new as well as In-use vehicles all over the country upto the year 2010 only. The road map proposed has been implemented as per the time frame. The road map beyond 2010 is the prime concern for policy makers, regulating

and implementing bodies, and stakeholders involved. Hence in order to review Auto Fuel Policy beyond 2010, a three member committee has been constituted by MoPNG. This committee also will examine all aspects (inter-alia emission reduction, economics and roadmap considering the availability of gas in the country) of using LPC/ CNG/ H_2 – CNG as auto fuel.

10.3 Strengthening of Mass Transportation System

Adequate and effective mass transportation system plays a major role in discouraging use of private vehicles, which at present are issue of prime concern for controlling pollution. It has been realized that lack of adequate public transportation system in cause shift in the interest of public from public to private transportation system. In the absence of efficient public transport in cities, this has resulted in the growing use of personalized vehicles. Here, experience has shown that a two - prong approach is required. The first is to raise the cost of private vehicle use. Options include traffic management (Example: one-way systems, closing streets, downtown exclusive pedestrian zones, and provision of exclusive bus lanes etc.) and demand management (such as increased parking fees, road tolls, fuel taxes, and carpooling programs). The second is to provide alternatives to private automobiles, which can be in favour of either larger vehicles (vans, buses, or mass transit), or non-motorized options, primarily bicycles. Without viable transit alternatives, the higher road user fees would lead to higher financial costs of travel with relatively little decrease in actual travel.

Considering the benefits of mass transportation system in controlling traffic as well as pollution, government has already taken steps for increasing and improving existing mass transportation in major cities/towns of the country and the future policy of the government will definitely focus on further strengthening of mass transportation system all over the country.

10.4 Incorporation of adequate land use planning instruments in transport policy

Incorporation of adequate land use planning instruments has been a missing ingredient in our existing vehicular pollution control policy, which requires consideration in our future policies. We are required to look forward for appropriate land use planning tools to reduce trip lengths, placing restraints on vehicles movements through parking policies, and location and time specific charges or bans on certain categories of vehicles. For the structure of land use, high population density and the concentration of employment and retail in a centrally located central business district is likely to encourage public transport and reduce trip length.

10.5 Progressive improvement in the fuel quality and vehicular technology

Improved fuels and vehicle technology have enormous potential for reducing vehicle emissions, and fuel and vehicle standards are often most widely discussed policy options for tackling vehicular emissions. In this context it is very important to treat fuels and vehicles as a joint system, since cleaner vehicle technology generally requires improved fuel quality. The ultimate objective is to adopt a fuel and vehicle system embodying high standards and best practice technology that have proven cost-effective. Enormous improvement has been observed in both fuel quality and vehicles technology during past 2 decades and future policies of the government will stress on further improvements in both the aforesaid fronts.

10.6 Zero Emission Vehicles and Cleaner Fuels

Promotion of cleaner fuels, especially zero-emission technologies in the urban Indian context and to promote R & D leading to their commercialization, the available technology options should be evaluated with a view to identify vehicle technologies and fuels for the future. Eliminating emissions from the tailpipe goes even further to cut down on harmful air pollutants.

The conventional fuels in use contain significant amount of sulphur and other compounds, removing sulphur content from the fuel and cutting down on the amount of light hydrocarbons helps pollution control technology to work better and cut down on evaporative and refueling emissions. The large scale reductions of other tailpipe emissions and CO_2 can be accomplished with a shift away from conventional fuels to alternative fuels (inherently burn cleaner than diesel and petrol) such as natural gas, methanol, ethanol, hydrogen. The implementation of CNG as an automotive fuel in Delhi has been a landmark for implementation in other cities of the country as well for improving the air quality. It is also a fact that CNG alone can not be implemented all over the country as solution for improving air quality. There is need to decentralize our policy on alternative fuels based on the resource availability at local level. While the government at national levels should assist and support technically as well as financially these initiatives at local levels.

10.7 Improvement and augmentation in transport related infrastructure

It has been realized that development of transport related infrastructures like roads, widening of roads, express ways, flyovers, under bridges, by passes has helped a lot easing traffic congestion and smooth flow of vehicles and the same approach is intended to be implemented all over the country.

10.8 Improved PUC programme and development of Inspection and Maintenance (I&M) system for In-Use vehicles

Policies/programmes for reducing emissions from in-use vehicles play a pivot role in over all reduction of vehicular emissions. Future strategies of the government will focus on further improving existing PUC system in order to make it more reliable and fool proof. Development of I&M system for controlling emissions from in-use vehicles is also one of the recommendations of the Auto Fuel Policy. I & M system will help in reducing emissions from in-use vehicles by inspecting and subsequently maintaining its malfunctioning / defects / component failure etc.

Also advanced technique like remote sensing techniques which have been very well deployed in various developed countries for the real life monitoring of emission from in-use vehicles and development of control policies are to be tried. To begin, we may use this technique in metro cities and subsequently its uses may be extended to other cities as well.

10.9 Old vehicles phase-out programme and Development of guidelines for scrap page of old vehicles

There is no limit on the age of the vehicle that one can ply on the Indian roads. Given the progressive degeneration of the engines of these vehicles due to lack of proper maintenance as well as their being manufactured when emission norms were far more lax, they tend to emit inordinate levels of pollutants. Hence development of a rationale vehicle phase out programme all over the country hold an important place in future policies of the government. Further assessment of exact working life of a catalytic converter in vehicles is expected to be carried out for development of related policies.

Development of appropriate vehicle scrappage guidelines are very essential after implementation of old vehicle phasing out programme in India. Within this purview Government will direct automotive industry to strengthen its R& D endeavors for making most of its automotive components as recyclable and to be reused while scrapping a vehicle and generate least possible pollution (solid waste, water & air pollution) during scappage.

10.10 Bus Rapid Transit System

A number of Traffic management tools have already been implemented in the major cities/towns of the country. Future Policies on traffic management to stress upon segregation of traffic, Bus Rapid Transit (BRT) System, also known as the High Capacity Bus System, is one of the cost effective mechanisms for cities to rapidly develop a public transport system. To meet growing demand, the Government of the National Capital Teritory of Delhi decided to build six BRT Corridors in Delhi, besides expanding the Metro rail in Delhi, by 2010. The

same is likely to be other parts of the city as well as other cities. Demarcation of pedestrian and non-motorized vehicles (NMV) lanes to encourage to usage of NMV's and walking.

10.11 Studies on Inventory and Source Apportionment of Air Pollution

Studies on inventory and source apportionment of air pollution will play a crucial role in development of future strategies for air pollution control. Absence of these kinds of studies makes it difficult to evaluate the impact of different measures in combating pollution and to set clear targets that need to be achieved in a specified time frame, and prioritize them for purposes of implementation especially when budgetary constraints make prioritization imperative.

10.12 Area Specific Approach

Development of area/city specific policy by taking into consideration problems on the ground level and availability of the resources will cause implementation of pertinent and feasible measure for control of pollution and will bring consideration improvement as compared to implementation of generalized policy (without taking into consideration local problems and resources available). There is no simple or universal strategy for reducing vehicular emissions .The pursuit of the various measures in a haphazard and piecemeal manner would not result in obtaining the maximum benefit from them or make a discernible impact on air pollution in different cities. Approach for reducing emissions from vehicular sources will vary from city to city It required to formulate city specific policy and for this we requires compiling credible data and a methodology for setting up a database, tools for analyses, and setting up of an institutional and regulatory framework to address city specific issues.

10.13 Awareness Raising

Public awareness and participation is a key to bringing about policy change. Widespread environmental education promotes understanding of linkages between pollution and health and encourages public involvement. Raising mass awareness among general public has been perceived as one of the major tool in the success of our vehicular pollution control policy framework. Private sector participation through innovative schemes like accepting delivery only from trucks that meet emission standards, Adopt a street campaigns, and air quality monitoring displays should be encouraged / strengthened. Media can also participate in awareness raising by disseminating air pollution related data.

10.14 Implementation of more Market based instrumentations for pollution control

It has been realized that so far in India for vehicular pollution control we have been stressing upon CAC measures only, while very little market based instruments have been adopted so far. Thus there is a lot more scope for improving our air quality with implementation of more market based instruments like incentives for promoting clean technologies and charging heavy from polluting technologies.

A transport policy must develop and promote cost-effective policies, mitigate emissions into the atmosphere and other adverse environmental effects of the transport sector while taking account of development priorities as well as social and poverty related concerns. An integrated approach is called for the entire transport sector to ensure that various modes develop to complement one another. Mechanisms for integrated transport planning strategies and urban and regional settlement strategies to reduce environmental impacts of transport need to be put in place.

10.15 Developing fuel economy standards

Adopting fuel economy standards will not only help check the growing consumption of petrol and diesel, it will also reduce the transport sector's contribution to accumulation of CO_2, not to speak of conventional air pollutants such as particulate matter, oxides of nitrogen and hydrocarbons. The less fuel burned/consumed per km travelled, the less will be the emissions.

The International Council on Clean Technology (ICCT) is working to improve the environmental performance and efficiency of cars, trucks, buses and transportation systems in order to protect and improve public health, the environment, and quality of life. The Japan has increased stringency of its fuel economy standards. In India, the Petroleum Conservation and Research Association (PCRA), an autonomous research body under the Union ministry of petroleum and natural gas, has signed a memorandum of understanding with the Bureau of Energy Efficiency to develop fuel economy standards under the Energy Conservation Act, 2001. The fuel efficiency standard is applicable for all types of vehicles, including cars, trucks and buses. According to government projections, the country could save up to $36 billion if fuel efficiency is improved by 50% by 2030 in all sectors. A committee of experts is now being set up by PCRA to set target values.

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Annexure-I

Pollutants in Gasoline Vehicles Emissions

Emissions from Gasoline Vehicles primarily consisting of CO, HC, oxides of nitrogen (NOx), SO2, and partial oxides of aldehydes, besides particulate matters including Pb salts account for the larger chunk of all pollution from gasoline-run vehicles. Gasoline powered engines are of two types- four stroke and two stroke . Table below gives various sources of emissions in the two cases.

Sources of Emissions from Gasoline Vehicles

Sources	Amount of Emissions (%)		Remarks
	4 stroke	2 stroke	
Crankcase blowby	20		Carbureted air fuel mixture and combustion fuel under pressure escape the combustion chamber past the engine piston and ring and enter the crankcase to be discharged into atmosphere through vents.
Evaporative Emissions	20	3	Fuel vapour lost to the atmosphere from tanks and carburetor
Exhaust Emissions	60	97	Exhaust gases emitted with pollutants trough tailpipe.

Pollutants in Diesel cvehicles Emissions

As diesel engines breathe only air, blow by gases from the crankcase (consisting primarily of air and HC) are rather low. Moreover, due to its low volatility, evaporative emissions from the fuel tank can safely be ignored. Though the concentration of CO and un-burnt HC in the diesel exhaust are rather low, they are compensated by high concentration of NOx (higher than that in gasoline vehicles). There are smoke particles and oxygenated HC, including aldehydes and odour-producing compounds which have high nuisance value.

Smoke from diesel engines comes in three different hues – white smoke emitted during cold start idling and at low loads; blue smoke from the burning of lubricating oil and additives; and black smoke, a product of incomplete combustion. Black smoke, the most obvious type of vehicular air pollution, consists of irregular shaped agglomerated fine soot/particulates, the formation of which depends on injector nozzle parameter and type of combustion chamber (direct or indirect injection).

Annexure-II

Pollutants specific health effects :

There is a wide spectral of adverse health/environmental effects of the pollutants released from vehicles. The effects may be direct as well as in-direct cover right from reduce visibility to cancers and death in some cases of acute exposure of pollutants specially carbon monoxide. Pollutant specific health effects of vehicular emissions are as below:

(i) Carbon monoxide (CO)

Carbon monoxide (CO is an odorless, invisible gas created when fuels containing carbon are burned incompletely—poses a serious threat to human health. CO is known to cause death at high levels of exposure. The affinity of blood hemoglobin is 200 times greater for carbon monoxide than for oxygen, CO hinders oxygen transport from the blood into the tissues. The effects of this gas in human have been shown even at low level of exposure. The low level of exposure accelerate and angina (chest pain) in people having coronary artery diseases. Healthy individuals are also affected, but only at higher levels. .Exposure to elevated CO levels is associated with the impairment of visual perception, work capacity, manual dexterity, learning ability and the performance of complex tasks.

(ii) Nitrogen Oxides

Nitrogen dioxide (NO2) has been linked with increased susceptibility to respiratory infection, increased airway resistance in asthmatics, and decreased pulmonary function. It has been shown that even short-term NO2 exposures have resulted in a wide-range of respiratory problems in school children; cough, runny nose and sore throat are among the most common. The oxides of nitrogen also contribute to acid deposition on plans and surface water resulting into damages of trees and aquatic life. NOx emissions also increase the levels of particulate matter by changing into nitric acid in the atmosphere and forming particulate nitrate.

(iii) Photochemical Oxides (Ozone)

There is no release of ozone as such from the vehicles but it is formed as a result of chemical reactions of volatile compound and NOx in the presence of heat and sun light. In other words, the pollutants release from vehicles also results into formation of ozone through chemical reactions. The ground level ozone which is the main part of the smoke can cause respiratory problems such as chest pain, cuffing etc. The ozone gas is known to cause inflammation respiratory tracks, reduction in the ability to breath (lung function), increase in asthma and other lung diseases.

In addition to effects on human health, ozone is also known to adversely effect the environment in many ways including reduce yield for crops, fruits, commercial forests, eco-system etc. It also damages urban grass, flowers, shrubs and trees etc.

(iv) Oxides of Sulphur

High concentrations of sulfur dioxide (SO2) can result in temporary breathing impairment for asthmatic children and adults who are active outdoors. Short-term exposures of asthmatic individuals to elevated SO2 levels while at moderate exertion may result in reduced lung function that may be accompanied by such symptoms as wheezing, chest tightness, or shortness of breath. Other effects that have been associated with longer-term exposures to high concentrations of SO2, in conjunction with high levels of PM, include respiratory illness, alterations in the lungs' defenses, and aggravation of existing cardiovascular disease

(V) Gaseous Air Toxic

The hydrocarbons emissions release from vehicles also contained toxic air pollutants that may have a significant effect on public health.

Benzene

Benzene is a known human carcinogen by all routes of exposure. Low term respiratory exposure to high level of ambient benzene has been shown to cause cancer all the tissues that formed white blood cells. Exposure to benzene or its metabolites has also been linked with genetic changes in human and animals. The occurrence of certain chromosomal changes in individuals with known exposure to benzene may serve as a marker for those at risk of contracting leukemia.

Formaldehyde

Formaldehyde has been classified as a probable human. Epidemiological studies suggest that long-term inhalation of formaldehyde may be associated with tumors of the nasopharyngeal cavity (generally the area at the back of the mouth near the nose), nasal cavity, and sinuses. Formaldehyde are also known to produces mutagenic activity.

1,3-Butadiene

1,3-Butadiene has also been classified as a Group B2 (probable human) carcinogen based on evidence from two species of rodents and epidemiologic data.

(VI) Lead

Lead affects many organs and organ systems in the human body, with sub-cellular changes and neurodevelopment effects appearing to be the most sensitive. Lead also causes impaired sensory motor function and renal functions. A small increase in blood pressure has also been associated with lead exposure. Airborne lead can be deposited on soil and water, thus reaching humans through the food chain and drinking water. Atmospheric lead is also a major source of lead in household dust.

(VII) Particulate

Particulate matter (PM) represents a broad class of chemically and physically diverse substances that exist as discrete particles (liquid droplets or solids) over a wide range of sizes. Particles may be emitted directly to the atmosphere or may be formed by transformations of gaseous emissions such as sulfur dioxide or nitrogen oxides The key health effects associated with PM include premature death; aggravation of respiratory and cardiovascular disease, as indicated by increased hospital admissions and emergency room visits, school absences, work loss days, and restricted activity days; changes in lung function and increased respiratory symptoms; changes to lung tissues and structure; and altered respiratory defense mechanisms.Exposure to coarse fraction particles is primarily associated with the aggravation of respiratory conditions such as asthma. Fine particles are most closely associated with health effects such as premature death or hospital admissions, and for cardiopulmonary diseases.

Annexure- III

The 2005 WHO Air quality guidelines (AQGs)

KEY FACTS

- Air pollution is a major environmental risk to health and is estimated to cause approximately 2 million premature deaths worldwide per year.
- Exposure to air pollutants is largely beyond the control of individuals and requires action by public authorities at the national, regional and even international levels.
- The WHO Air quality guidelines represent the most widely agreed and up-to-date assessment of health effects of air pollution, recommending targets for air quality at which the health risks are significantly reduced.
- By reducing particulate matter (PM_{10}) pollution from 70 to 20 micrograms per cubic metre, we can cut air quality related deaths by around 15%.
- By reducing air pollution levels, we can help countries reduce the global burden of disease from respiratory infections, heart disease, and lung cancer.
- The WHO guidelines provide interim targets for countries that still have very high levels of air pollution to encourage the gradual cutting down of emissions. These interim targets are: a maximum of three days a year with up to 150 micrograms of PM_{10} per cubic metre (for short term peaks of air pollution), and 70 micrograms per cubic metre for long term exposures to PM_{10}.
- More than half of the burden from air pollution on human health is borne by people in developing countries. In many cities, the average annual levels of PM_{10}(the main source of which is the burning of fossil fuels) exceed 70 micrograms per cubic metre. The guidelines say that, to prevent ill health, those levels should be lower than 20 micrograms per cubic metre.

The new (2005) guidelines apply worldwide and are based on expert evaluation of current scientific evidence. They recommend revised limits for the concentration of selected air pollutants: particulate matter (PM), ozone (O3), nitrogen dioxide (NO2) and sulfur dioxide (SO2), applicable across all WHO regions.

Guideline values for selected air pollutant

(I) PARTICULATE MATTER

Guideline values

$PM_{2.5}$	PM_{10}
10 µg/m^3 annual mean 25 µg/m^3 24-hour mean	20 µg/m^3 annual mean 50 µg/m^3 24-hour mean

The 2005 AQG set for the first time a guideline value for particulate matter (PM). The aim is to achieve the lowest concentrations possible. As no threshold for PM has been identified below which no damage to health is observed, the recommended value should represent an

acceptable and achievable objective to minimize health effects in the context of local constraints, capabilities and public health priorities.

(II) OZONE (O_3)

Guideline values

O_3
100 µg/m^3 8-hour mean

The previously recommended limit, which was fixed at 120 µg/m^3 8-hour mean, has been reduced to 100 µg/m^3 based on recent conclusive associations between daily mortality and ozone levels occurring at ozone concentrations below 120 µg/m^3.

(III) NITROGEN DIOXIDE (NO_2)

Guideline values

NO_2
40 µg/m^3 annual mean 200 µg/m^3 1-hour mean

The current WHO guideline value of 40 µg/m^3 (annual mean) set to protect the public from the health effects of gaseous NO_2 remains unchanged from the level recommended in the previous AQGs.

(IV) SULFUR DIOXIDE (SO_2)

Guideline values

SO_2
20 µg/m^3 24-hour mean 500 µg/m^3 10-minute mean

A SO_2 concentration of 500 µg/m^3 should not be exceeded over average periods of 10 minutes duration. Studies indicate that a proportion of people with asthma experience changes in

pulmonary function and respiratory symptoms after periods of exposure to SO_2 as short as 10 minutes.

The revision of the 24-hour guideline for SO_2 from 125 to 20 $\mu g/m^3$ is based on the following considerations:

- Health effects are now known to be associated with much lower levels of SO_2 than previously believed.
- A greater degree of protection is needed.
- Although the causality of the effects of low concentrations of SO_2 is still uncertain, reducing SO_2 concentrations is likely to decrease exposure to co-pollutants.

Annexure -IV

State /UT wise registered vehicles population

(As on 31st March)

States / Union Territories	2000	2001	2002	2003	2004	2005	2006
States							
Andhra Pradesh	3636	3966	4389	5002	5720	6458	7218
Arunachal Pradesh	*21	*21	*21	*21	*21	22	22
Assam	453	542	596	657	727	815	914
Bihar	#871	949	1024	1121	1251	1352	1432
Chhattisgarh	-	857	948	1076	1216	1375	1541
Goa	319	341	366	397	436	482	529
Gujarat	5189	5576	6008	6508	7087	7817	8622
Haryana	1733	1949	2122	2279	2548	2854	3087
Himachal Pradesh	193	217	244	269	289	301	334
Jammu & Kashmir	299	330	364	399	439	478	524
Jharkhand	-	909	984	1101	1217	1357	1505
Karnataka	3393	3537	3636	3738	3977	5436	6220
Kerala	1782	2112	2315	2552	2792	3122	3559
Madhya Pradesh	3457	3095	3173	3459	3804	4188	4609
Maharashtra	6114	6760	7414	8134	8969	9936	10966
Manipur	$77	$77	90	97	106	114	124
Meghalaya	58	62	67	73	^73	92	104
Mizoram	27	31	34	37	42	47	52
Nagaland	145	150	157	162	172	172	184
Orissa	982	1096	1215	1359	1525	1715	1932
Punjab	**2296	2910	3103	3308	3529	3876	4035
Rajasthan	2712	2943	3197	3487	3834	4261	4754

States / Union Territories	2000	2001	2002	2003	2004	2005	2006
Sikkim	12	12	13	15	17	20	22
Tamil Nadu	4611	5162	5658	8005	8575	9257	10054
Tripura	45	50	57	66	76	73	106
Uttarakhand	-	364	406	457	516	573	643
Uttar Pradesh	4627	4921	5171	5928	6460	7344	7989
West Bengal	$1690	$1690	$1690	2366	2548	2681	2872
Total States (A)	**44742**	**50639**	**54482**	**62073**	**67466**	**76218**	**83953**
Union Territories							
A & N Islands	*23	25	28	+28	+28	37	41
Chandigarh	** 386	** 386	** 386	562	586	617	647
D & N Haveli	* 13	* 13	* 13	31	35	40	45
Daman & Diu	34	37	41	44	48	51	55
Delhi	3424	3635	3699	3971	4237	4187	4487
Lakshadweep	4	4	5	5	5	5	6
Pondicherry	231	252	270	293	313	347	384
Total UTs (B)	**4115**	**4352**	**4442**	**4934**	**5252**	**5283**	**5665**
Grand Total (A+B)	**48857**	**54991**	**58924**	**67007**	**72718**	**81502**	**89618**

Source: Road Transport Year Book 2006-07, MoRTH

Note: Consequent on formation of three States (Chhattisgarh, Jharkhand and Uttarakhand), separate data is available only from 2000-01

* : Data relates to 1996-97 ** : Data relates to 1997-98 ^ :Data relates to 2002-03

$: Data relates to 1999-00 +: Data relates to 2001-02 P : Provisional

: Figures for Bihar only, excluding Jharkhand.

Summary of Action Plans for the 16 cities

Annexure-V

S. No	City	Action taken	Action proposed
1	Bangalore	Bharat stage-III vehicles , Task force constituted, augmentation in	Conversion of all three wheelers to LPG, Improve mass transport, anti

		infrastructure(Road & flyovers), better traffic management , LPG in autorickshaws, , ethanol blending in gasoline & computerized PUC centers	adulteration drives, cleaner fuels for industries.
2	Ahemdabad	B.S-III Vehicles, Task force constituted, anti adulteration drives, strengthened ambient as well as industrial monitoring, , green belt around industries, CREP implemented, CNG introduced as auto fuel	Phasing out of old commercial vehicles, better traffic management, ban 2-T oil, PUC auditing, strengthening AAQ network, implementation of clean fuels like CNG, LP, improvement in the infrastructure for traffic decongestion Intensify industrial monitoring, Air Pollution control instruments in various industries, CREP, ban on bio-mass burning.
3	Kolkata	Restriction in setting up of polluting industries , stricter emission standards for boilers, ceramic kilns, foundries and rolling mills of KMA & mandatory use of clean fuels, Ban on 2T oil & improvement in the fuel quality. Unleaded petrol. Upgradation of emission testing centers., Selling of pre-mixed 2-T oil., Sulphur content in petrol and diesel reduced to 150 & 350 ppm respectively& Benzene content in petrol reduced to 1 %., ethanol blending, in petrol.	Notified stricter emission particulate matter emission in small scale industries Future action plan under CREP. Emission norms for new diesel engines for genset application. Implementation of stricter emission norms & fuel quality accordingly, I&M system for all categories of in-use vehicles will be introduced, computerized PUC checking system, Augmentation of mass transport system , Stricter emission norms will be made applicable for inter-state buses and trucks., Switch over to CNG & LPG as auto fuels , Phasing out of older vehicles.
4	Hyderabad	Task Forces has been constituted., Augment in AAQM Stations , . Upgradation of PUC centers , supply of pre-mixed 2T Oil & Anti adulteration drives, LPG introduced as auto fuel, Multi Model Transport System introduced.	Stricter emission norms for new vehicles & improved fuel quality, Supply of pre-mixed 2-T oil, Conversion of two, three and four wheeled vehicles to LPG or dual mode would be encouraged.
5	Mumbai	The Hon'ble Bombay High Court directed for phasing out of old commercial vehicles unless they are converted to run on LPG /CNG. Mahanagar gas Limited is supplying CNG for vehicular application; LPG also has been approved as automotive fuel, stringent emission norms for both new & in-use vehicles, improved fuel quality, implemented Industrial location policy.	Increase CNG dispensing facilities, stricter emission norms & fuel quality, I&M system for all categories of in-use vehicles , Upgradation of PUC Centers, Augmentation of mass transport system Stricter emission norms for all Inter-state buses and trucks.
6	Kanpur	Stringent emission norms for both new & - In-use vehicles, anti- adulteration drive,	Stricter emission norms for vehicles & commensurate fuel quality, anti

		improved auto fuel, ethanol blended gasoline, older vehicles phased out, battery operated three wheelers, upgradation in PUC certification, Better traffic management options implemented, green belt developed, Regular industrial air quality monitoring / ambient air quality monitoring Inventory of all air polluting industries, Environment Management Plan for Kanpur city prepared by CPCB, registration of new industries is being done as per city master plan, as per revised master plan major by pass and MRTS system has been proposed, Four fly over have already been completed.	adulteration drives, improving I & M procedure, Traffic & road management, expansion of pre-mixed 2T oil outlets, phasing out older and grossly polluting vehicles in a time bound manner, restriction in movement of goods vehicles in urban and congested areas, higher road taxes on older vehicles, promotion of alternate cleaner fuels like CNG, LPG and battery operated vehicles. No new industry in residential and sensitive areas. , existing industries to be shifted in a phased manner, installation of air of pollution control devices etc. in industries Augmentation in traffic & road, Implementation of CNG as auto fuel, In accordance with orders of Honb'le Supreme court no time bound scheme for switching over to LPG mode has been proposed.
7	Varanasi	Task force constituted, Vehicular emission inventory done, implementation of vehicular emission norms & fuel quality as per road map notified by the Govt. of India. Upgradation in PUC testing, supply of pre-mixed 2-T oil, ethanol (5%) blended gasoline, Ban on re-registration of vehicles converted from petrol to diesel , anti- adulteration drives, Implemented beter traffic management options like restriction on plying of heavy vehicle during day time & bypassing of vehicles , Inventory of polluting industries ,Control of Industrial emissions and ensuring compliance to standards. Closure of clandestine industries, ban on open burning of garbage, Promotion of use of LPG as domestic fuel instead of burning coal wood etc.	Implementation vehicular emission norms& fuel quality in accordance with the road map laid by the Expert Committee on Auto Fuel Policy, Phasing out of old vehicles. Ban on registration of vehicles converted from petrol to diesel. Better traffic management options to be implemented like Bye passing of Inter state/inter city traffic, Wherever possible widening of roads and removal of encroachments Development & improvement in road & railway infra structure, Fiscal Measures like higher road tax for old vehicles, restructuring of parking fees & road tolls and fiscal incentives for alternate fuels. Inventorization of emissions from industrial sources. , Monitoring & closure of clandestine industrial operations, Vigilance of industries.
8	Lucknow	Stricter emission norms for new vehicles & fuel quality as per auto fuel policy road-map, Initial stage of implementation of CNG, Upgraded PUC certification, Supply	Vehicle emission norms & fuel quality as per auto fuel policy report, Introduction of clean fuels like CNG/LPG/Hybrid battery etc,

		of 2T pre- mixed fuel oil is , ban on supply of loose 2T oil, Fuel adulteration checks , Old Vikram tempos are banned on certain routes, Parking alternatives have been provided in Hazaratganj etc .improvement in public transport through system circular railways is already functional ethanol blended , banning of open garbage burning, Use of coal/ wood/ diesel for preparation of food items on commercial basis has been banned by Nagar Nigam and cooking gas (LPG) is the only allowed food for such activities	Augmentation of supply of CNG as auto fuel, Implementation of master plan for the Lucknow city, Augmentation & improvement in road infrastructure, Ban on supply of loose 2 T oil, Drive to check adulteration, Improvement of public transport system, Improvement of existing PUC system,. Organization of the inventories of the polluting industries, Inspection & monitoring of industries to ensure compliance , Identification and closure of unauthorized industrial operations, All commercial establishments having DG sets of capacity 7.5 KVA and above shall install wet scrubber and acoustic chamber. Notification for banning of open burning of garbage, Promotion of use of LPG as domestic fuel, Improved electricity supply in the city to discourage the use of DG sets.
9	Agra	Vehicle emission norms & fuel quality as per Auto fuel policy road map, Phasing out of grossly polluting , Diesel driven 7 seater tempos fitted with scrubber only are being issued registration , Restriction on plying diesel driven tempo-taxi and auto rickshaws and prohibition of all type of commercial vehicles within the radius of 500 meters of Taj Mahal . In zone I,II & III 114 industries are drawing natural gas for use in production processes, Strict vigil on compliance Supreme Court has directed for using coal or coke in identified industries, Few industrial units have connection for CNG by GAIL, All the brick kilns within the radius of 20 kms of significant monuments of Agra city have been closed, New Industries using coal and coke are not being allowed to set up in Agra Trapezium zone in Uttar Pradesh, Regular monitoring of ambient air quality in the Agra city. Currently four monitoring stations are there in the Agra city.	The city of Agra has been divided into five different zones & action plan has been proposed in a zone wise manner, Setting up of CNG/LPG retail outlets within Agra City for supplying CNG/LPG to the vehicles in a phased manner, Phasing out grossly polluting vehicles plying within the city in a phased manner. It is proposed to supply CNG as fuel for processing /production & it is also proposed to replace DG sets with Gas generators. It is proposed to implement the same in different zone, Restriction on supply and usage of coal. Coke, wood, rice husk, baggase to the industries situated in the city limit of Agra, D.G sets installed by Industries/ commercial establishments in no gas zones shall be fitted with wet scrubber 7 acoustic enclosures , Only small scale Service & Business related Enterprises (SSSBE) that are essentially required within the city, should be allowed in the designated commercial areas/ authorized markets/ authorized shopping plaza., Strict vigil on

			compliance of 292 industries that were directed by the Supreme Court not to use coal or coke, Petha Industries operating in the city shall be shifted to Kalindi Vihar site identified for this industry and shall operate by CNG/LPG only.
10	Jodhpur	Vehicle emission norms & Fuel quality as per auto fuel policy road map, Shifted Transport companies from busy city areas to Transport Nagar situated in Industrial area., Routing heavy vehicles through bye pass, Tempos have been removed from heavy traffic routes in the city and have been directed through alternate roads, Trucks are allowed to enter in main city area of Jodhpur after obtaining pass from additional Distt. Magistrate, Better traffic management system., Introduced of Pollution control certificates & effective checking rules, Road Infrastructure augmented , Ban on plying of vehicles which are more than 15 years old , Improvement and development of many other roads have been taken up under ADB project., Checking of vehicles emitting smoke with the help of smoke meters available with the traffic police, Removal of pressure horns from vehicles along with development of silence zones.	Emission norms & Fuel quality as per road map of auto fuel policy, Augmentation in the number of monitoring stations , Implementation of traffic master plan, Effective checking of vehicular emissions, Incorporation of environmental policy parameters in urban planning, Supply of premixed 2 T oil, Phasing out all grossly polluting vehicles, Development of green belt around the city, Master plan to shift various commercial activities located in densely populated areas to outside area to the outskirts of the city., Assessment of air pollution problems in the city.
11	Faridabad	Vehicle emission norms & fuel quality as per auto fuel policy roadmap, upgradation in PUC certification, Task Force constituted, Anti adulteration drives, colour codes to three wheelers depending upon the life of the vehicle,For the purpose of retail vending of CNG/PNG, M/s Indraprastha Gas Ltd, have engaged a technical consultant for preparation of detailed feasibility report for expansion of its supply of CNG/PNG in the adjoining towns of Delhi which includes the towns of Faridabad and Gurgaon., the State govt. has issued notification on 24.12.2003 vide which the age for the operation of various type of transport vehicles has been fixed. Almost all the industries covered under Air Pollution Act and using fuel other than oil and electricity have already installed	Introduction of vehicular emission norms & Fuel quality as per the road map proposed by the expert committee on Auto Fuel Policy, phasing out of 15 year old commercial vehicles and all diesel three wheelers, Upgradation of PUC system. , On-road inspection of vehicles by the representatives of F&S Deptt, Transport Authority and HSPCB, Improved centralized I&M programme to replace existing PUC system, Bye passing of Interstate/city vehicles and restriction of entry of non-destined commercial vehicles in the city, Stricter drive, to check the adulteration of fuel, Installation of pre-mix oil dispensers and ban on sale of loose 2T oil to be planned by IOC, Haryana State Government has decided to approve " Authorized testing Stations" for the grant /renewal of certificate of fitness to all type of motor vehicles

		the Air Pollution Control Devices.	registered/intended to be registered in Faridabad., Up gradation of Public Transportation Stricter & Regular inspection and monitoring of industries to ensure compliance, Closure of clandestine /unauthorized Industries, Fuels like CNG, LDO, HSD to be introduced in industries instead of rice husk, coal etc, Ultra low sulphur diesel to be used by industries for their generating sets ,Industries using rice husk as fuel to dump rice husk ash in a landfill outside Faridabad town, Thermal Power Plants in Faridabad and Badarpur should keep their ESP's functioning efficiently.
12	Pune	Emission norms & fuel quality as per Auto fuel policy, Inventory of emissions load from vehicles is done in Pune city, Banning on registration of all new diesel public vehicles, Ban on supply of loose 2 T oil, RTO has banned six seaters within Pune Municipal Corporation area, Only petrol driven rickshaws are permitted in PMC area, Switching over to cleaner fuels etc., Stricter PUC certification system, Augmentation in road infrastructure, Introduced synchronized traffic signals, Better traffic management through bicycle pathways, bye passing of inter city/inter state buses etc. Instruction to industries for controlling emissions generated from D.G. Sets. These conditions are specified for stack height commensurate with KVA installed and for barricading noise.	To review inventory of emission load from all categories of vehicles, Notify & Implement vehicular emission norms as per road map recommended by Expert committee on Auto Fuel Policy, Phasing out of grossly polluting vehicles , Ban on alteration of petroleum vehicles to diesel vehicles, Improvement & augmentation of Road & traffic infrastructure, Higher road tax for older vehicles. Fiscal incentives for alternate fuel and vehicles, Improvement in mass transportation system, Improvement of the existing PUC centers . Inventories of the polluting industries, Control of industrial emissions and ensuring compliance of the standards, Identification and closure of clandestine /unauthorized industrial operations or shifting, Compliance to standards in D.G sets,Implementation of industrial location policy for shifting of industries from non- confirming zones., Implementation of Common responsibility for environmental protection (CREP) for 17 categories of industries having more pollution potential. Notification for banning of open garbage burning, Promotion of use of LPG as domestic fuel instead of burning coal , wood & Cow dung etc.

			In accordance with orders of Honb'le Supreme court no time bound scheme for switching over to LPG mode has been proposed though plan for promotion of cleaner fuels have been proposed.
13	Solapur	Vehicle Emission Norms as per the auto fuel policy report, Inventory of emission load from vehicles in Solapur city reveals emission of 27 tonnes of pollutants per day, Ban on supply of loose 2-T oil, Checking of fuel adulteration., Banning on registration of all new diesel public vehicles like Six Seaters, Only petrol three seaters are running in the city, Stricter enforcement of PUC norms, Introduction of LPG is in advanced stage and SMC is required to modify the fleet of SMT to make it compatible with environmentally friendly fuels. The compliance is kept under observation through regular inspection & vigilance , implementing CREP for 17 categories of Industries , Adopted river regulation zone (RRZ) policy for sitting of , also adopted sitting criteria for stone crushers	Vehicle Emission Norms as per the auto fuel policy repor Performance checking for catalytic converters and conversion , Ban on supply of loose 2 T oil,Introduction of alternate fuels like CNG/LPG . IOC proposed to plan one RO to supply auto LPG, Improvement of public transport system , Improvement of existing PUC system., Phasing out of grossly polluting vehicles , Ban on conversion of petrol vehicles to diesel vehicles, Better traffic management to avoid congestions through introduction of synchronized signals with timers, bye passing of inter city interstate traffic, increased road length, augmentation of railway network and fiscal incentives, Organisation of inventories of polluting industries, Control of emissions and ensuring compliance of standards, Identification and closure of clandestine / unauthorized industrial operations , Compliance to standards in DG sets, Identification of areas where industries from non- confirming zones shall be shifted, Notification for banning of open burning of garbage, Promotion of LPG as domestic fuel instead of burning coal & wood.
14	Jharia	Vehicle Emission Norms as per the auto fuel policy report	Notification of vehicle emission norms in accordance with the road map proposed by the expert committee on Auto Fuel Policy, Introduction of clean-fueled vehicles like CNG/LPG/Hybrid Battery etc. Upgradation of PUC checking system, anti adulteration drives, improve in mass transport system, infrastructure development for traffic decongestion, implementation of better traffic management options like Regulation of

			traffic in peak hours at major traffic intersections& Restriction on movement of trucks and carrier vehicles in urban areas, Construction of ring road along the periphery of Jharia coalfield and link and feeder roads connecting the centers of activities to the ring road. The ring road shall be connected to NH-2 and NH-32 suitable link roads by 31.4.2004. Organization of the inventories , Control of industrial emissions ensuring compliance to standard., Identification and closure of clandestine/unauthorized operations, Compliance to standards in DG sets, Ambient Air Quality monitoring at critically polluted industrial areas in the town to be intensified, All the industrial plants to develop a green belt all along the periphery. Ensure reclamation of mined out areas, there are many abandoned mine out areas where mining is not being carried out for the long time. Such mines should be immediately declared abandoned and should start reclamation, dense tree plantation to be carried out on overburden, which left necked, Illegal open burning of coal to prepare soft coke. Development of collection, treatment and disposal of municipal solid waste & notification for banning of open burning of garbage
15	Patna		Vehicle Emission Norms as per the auto fuel policy report , Anti Adulteration drives, Stop removing silencers by tampering in vehicle, Upgradation in PUC certification system, Ban on supply of loose kerosene & loose 2 T oil at petrol pumps and introduction of pre-mixed fuel oil , Advance fuel testing laboratories are to be established at Patna.IOC has already established one laboratory in Patna which will be utilized for checking fuel adulteration on regular basis, Old buses and other commercial vehicles of 15 years to be

16	Chennai	Vehicle Emission Norms as per the auto fuel policy report, Periodic inspection of in use vehicles in Chennai is conducted by the officials of Transport Dept and Police Department, Supply of pre-mixed 2T oil , Entry of heavy vehicles restricted by the road in Chennai city during peak hrs, Ring roads have been constructed to avoid the entry of inter city vehicles in the city , Mass transport system (Metro rail) introduced at certain stretches, Fiscal measures like structuring parking fees and road tolls has been implemented, Clean fuels like LPG have been introduced , Encroachment on the roads being removed to reduce congestion. No new polluting units or new incinerators permitted within the city, Common facilities are set up outside the city for the incineration of bio-medical waste, Industries have been directed to develop a green belt of at least 25 % of the project area. Periodic inspection of industries and monitoring of ambient air quality and source emission is carried out for compliance, All stacks from industrial units are to be fitted with online stack monitor with computer recording arrangements.	Vehicle Emission Norms as per the auto fuel policy report, LPG as auto fuels (autorickshaws and taxis) in Chennai city, To check adulteration of fuel , Phasing out of grossly polluting vehicles, Improvement of Public Transport system, Upgradation of existing vehicle emission testing centers to computerized emission testing centers, Prohibition of movement of heavy goods vehicles except essential services in Chennai city 19 important roads, National Highways Authority of India under the MoRTH have undertaken the work of constructing a bye pass road to Chennai connecting NH45, NH4 & 5. The total length of the bye-pass road is 31.40 Km. phased out, LPG/CNG introduced, Regular monitoring at critically polluted areas of the city so that plan for providing the traffic management system can be developed, Removal of air pressure horns, Control of noise pollution due to playing of loud speakers, DG sets, crackers etc, Transport of building materials like sand, etc, garbage and other solid waste should only be done through properly covered vehicles., Better traffic management practices like Regulating traffic during peak Synchronized Traffic signals. Verification for compliance of specified norms by the industries , Ambient air quality monitoring at industrial area of the city to be intensified to pin point the source of pollution and take punitive action thereof, All the industrial units in the city to develop a green belt along their periphery, Verification of the compliance by industries with respect to Emission norms through surprise inspections, Strict implementation of prohibition of usage of carry bags To provide scrubbers to reduce emissions, to Shift the entire coal handling from Chennai port to Ennore Port , to shift the entire core handling from Chennai port to Ennore Port.
			having thickness less than 20 microns for any purpose or containers made of recycled plastics for storing, carrying, disposing or packing of food stuffs. Littering of municipal solid waste shall be prohibited in the city, Intensive awareness campaigns , Facility for storage of municipal solid waste transportation and processing , Proper landfill site shall be identified and developed, Proper management and handling of bio-medical waste generating units shall be ensured, Common disposal/incineration sites for the bio-medical waste, generated in the city, may be provided. Intensive awareness campaigns, workshops, seminars, etc. shall be conducted.