AUTO FUEL VISION AND POLICY 2025

REPORT OF THE EXPERT COMMITTEE

GOVERNMENT OF INDIA

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PREFACE

The Committee to prepare the Auto Fuel Vision & Policy 2025 was constituted in continuation to the previous Expert Committee chaired by Dr. R.A. Mashelkar in 2003 that had ushered in BS III and BS IV automotive fuels.

I have seen the task of this Expert Committee to first lay down a feasible roadmap for complete and rapid transition across the country to BS IV automotive fuels which with 50 ppm sulphur are able to support a level of after treatment devices that can ensure BS IV emission norms, which have much lower limits than BS III emission standards. Second, to lay down a feasible and early road map for a countrywide shift to BS V automotive fuels (10 ppm sulphur) and therefore to BS V emission norms, which will constitute a qualitative improvement on the present situation.

The primary reason for mandating stringent fuel and emission standards that imply huge investments in refineries on the one hand and in the automobile sector on the other, is the overwhelming concern for public health. It is true that deterioration in ambient air quality is not the sole source of stress on the lives and health of our citizens. Nor is vehicular tailpipe emissions the only source of air borne pollutants. However, vehicular emissions are indeed a large contributor to air borne pollution. And in seeking to shape public policy in a manner that protects human health from the multifarious hazards of modern life, it is vital to resolve these issues one by one, separately and eventually jointly.

The evidence on emission levels in the country shows that there has been a positive impact consequent to the various steps that have been taken in the past to limit emission of air pollutants. But these efforts are being offset by the increase in urban density, in associated road transportation and in consequence of vehicular tailpipe emissions. As the country grows, people will continue to move away from farming as the mainstay of livelihood, urbanisation will intensify, disposable incomes rise and with it will increase the needs of urban transportation.

Across the world over the last many decades, atmospheric air quality has been adversely impacted by emission from automobile tailpipe exhaust, industrial smoke stacks, thermal power plants, construction dust & debris and the other by-products of a crowded and modernised urban existence. Simultaneously the rising incidence of a range of health effects has been recorded and there is compelling evidence of a causative link from the former to the latter, some very direct, some somewhat direct and some in an associated sense along with other factors. That cleaning up the air will be good for citizens' well-being is thus not just a gut feeling, but clearly established in the research literature.

The World Health Organisation (WHO) has consistently red-lined the danger to human health from air pollutants. Findings from the latest systematic study have been published in the Global Burden of Disease (2010). This is the largest ever systematic effort to describe the global distribution and causes of a wide array of major diseases, injuries and health risk factors.

This new analysis identifies especially high risk levels in the developing countries of Asia where air pollution levels are the highest in the world. Overall GBD 2010 estimates that over 2 million premature deaths and 52 million years of healthy life were lost in 2010, due to ambient fine particle air pollution. Among other risk factors studied in the GBD, outdoor air pollution ranked fourth in mortality and health burden in East Asia where it contributed to 1.2 million deaths in 2010, and sixth in South Asia where it is said to have contributed to over 7 lakh deaths in 2010. The analysis found that reducing the burden of disease due to air pollution in Asia will require substantial decreases in the high levels of air pollution in those regions.

There have been attempts to place a monetary value on the health cost of outdoor air pollution. To my mind the evidence of a causative association between high levels of air pollution – both in the form of potentially toxic chemicals and fine particulate matter – and the large magnitude of the health impact is sufficiently compelling for public policy to seek quick reduction in the incidence of air pollution from specific activities, and especially where such reduction is clearly within the domain of technological possibility. Measuring the cost of human life and suffering most often translates into estimates of income foregone. One is acutely uncomfortable with this view of the value of human life and especially so in the public policy context.

Moreover, that there is harm caused to human health by outdoor air pollution and that automobile tailpipe exhaust is a major contributor is self-evident. Further, we know that the scale of urbanisation will increase and so will the number of automobiles on the road – and that too by a large factor. Reducing the unit emissions – that is per vehicle kilometre travelled – is obviously the only appropriate way to respond to this. Doubtless rolling out of urban mass transit like suburban rail/metro and/or electric buses will help further, but these initiatives will need to be implemented over and above reducing the emissions on per vehicle kilometre travelled.

Therefore, the Expert Committee took the view that the principal objective should be to ensure the nationwide rollout of BS IV emission norms as fast as possible and then the earliest possible rollout of BS V emission norms. That implied that BS IV grade automotive fuels should become available across the country as quickly as possible, followed by the earliest possible rollout of BS V grade fuels.

Accepting this as the paradigm within which the recommendations were to be framed, the next question was to ask how to ensure the most efficient manner of rollout given the technical constraints limiting the output of BS IV and BS V fuels.

It was noted that even at present, the penetration of BS IV motor spirit or gasoline in the domestic market was 24% and that for BS IV grade high speed diesel (HSD) was 16% – even four years after introduction of the BS IV regime in metropolitan cities. Indeed not much headway has been made since 2010-11. The reason for the lower penetration, especially in the case of diesel, was felt to be the fact that in the periphery of the designated BS IV cities, BS III vehicles could be registered; BS IV vehicles (especially heavy duty vehicles) were more expensive and BS III fuel was cheaper than the BS IV equivalent. Thus, the economics tended to subvert the desired course of the statutory mandate.

To address this problem it is recommended that the retail price of BS III fuel should be made equal to BS IV fuel. It has been separately recommended that the quality differential in price as between the two grades of fuel should be 75 paise per litre; therefore the excess collected by re-pricing of BS III fuel would also be 75 paise per litre. However, this amount should not go to the oil companies but accrue as a cess to the OIDB. The cess may be called "**high sulphur cess**", since that is what it is in fact; and in order to distinguish it from the "**fuel upgradation cess"** that is discussed subsequently. The amounts collected as "**high sulphur cess**" will rapidly decline as the three-phase rollout to complete BS IV standards is completed and will become in early 2017. Assuming it is made effective from July 2014, the total collections before full rollout of BS IV will be of the order of **Rs 10,000 crore**.

If BS IV fuel could be rolled out at one shot across the country within a year that would undoubtedly be the best solution. However, refineries even working to a very tight schedule would take much longer to switch over to complete BS IV output, therefore requiring the changeover to be a graduated process. There is also a problem where if BS IV vehicles are tanked up with BS III fuels, significant damage is possible to the engine and systems.

It was seen that if things move at the "**Business as Usual"** speed the changeover to BS IV will take many years and that to BS V would have taken even more and go up to 2025 or even beyond.

This was not felt to be acceptable. As stated earlier, the mission was seen to be the earliest possible roll out to first BS IV and then to BS V. Could we have leapfrogged nationwide to BS V straightaway without passing through the BS IV stage? Yes, but that would not be technically possible before 2020 and we would then have had to continue for 6 more years hoping that BS IV penetration increases beyond present levels. The course that this Committee has recommended will ensure major increases in BS IV penetration from 2015 onwards and 100% coverage by April 2017. The net benefit to be had would be enormous, even as the changeover to BS V remains on course to be rolled out countrywide between April 2019 and April 2020.

In view of the experience of the last few years, it was felt that the best course of action will be to lock up entire geographies, in stages to the BS IV standard. In this manner the phased transition identified several States at one go, often including neighbouring districts of other States to ensure the greatest integrity to the targeted transition. It would have been convenient had there been more BS IV fuel available in

2015 and 2016, but the plan in order to be feasible had to work within the constraints of the technically feasible space available.

In this way, the transition in the first phase scheduled for 1 April 2015 will cover the whole of North India – Jammu & Kashmir, Punjab, Himachal, Haryana, Uttarakhand, western Uttar Pradesh and several bordering districts of Rajasthan. In the next phase scheduled for 1 April 2016, Kerala, Karnataka, Telangana, Odisha, Goa, several Union Territories and parts of Maharashtra will be converted entirely to BS IV. Finally on 1 April 2017, the entire country will move to BS IV. Then on April 2019, the whole of North India and on April 2020 the rest of the country will switch to BS V automotive fuel and emission regime.

This was the best that could be done given the technical constraints. However, the roadmap that has been made out on the basis of what has been described in the report as the **Accelerated Transition Path** assumes that the financial constraints which operate in the **Business as Usual** scenario can be substantially relaxed. The oil companies and their refineries have been operating with stretched finances and therefore the financial constraints are operative. It is estimated that the capital costs in terms of new plant & equipment and some refurbishment of existing equipment which the refineries will have to incur in order to be able to switch to 100% BS V automotive fuel by 2019-2020 is of the order of **Rs 80,000 crore**.

It is proposed to levy a "**special fuel upgradation cess**" of 75 paise per litre on all gasoline and diesel sold in the country for seven years up to 2021. Assuming that this cess can be made effective from 1 July 2014, then over the course of the next seven years a total of **Rs 64,000 crore** would be collected assuming a modest rate of annual growth in domestic consumption. This cess will accrue to the OIDB which will make the funds available to the oil companies for investments which are necessary to achieve the upgrading of quality of fuel produced. After seven years, this cess will be discontinued.

The collections to the OIDB on account of both the "**special fuel upgradation cess**" and the "**high sulphur cess**" will thus be of the order of **Rs 74,000 crore**, which comes close to the estimate of Rs 80,000 crore referred to above required to meaningfully relax the financial constraints that can enable the refineries to proceed on the **accelerated transition path**. These funds will be extended for use to the refineries in terms of the OIDB's mandate and rules. The Committee has recommended that it is desirable, considering the financially stretched conditions of the oil companies and the statutory nature of the investment obligation, that the Ministry of Petroleum & Natural Gas make the funds available from OIDB on relatively easy terms, both in respect of interest cost and repayment period.

The retrofitting of catalytic after-treatment devices on the stock of older commercial vehicles has to be energetically pursued. Commercial vehicles come up for renewal of licences. Once an area is switched over entirely to BS IV, the existing stock of commercial vehicles, especially heavy duty diesel units, should be directed to compulsorily get after-treatment devices – that dramatically reduce particulate and NOx emissions – retro-fitted within two years, failing which their licence should not be renewed.

The point has repeatedly been made in the course of the deliberations of the Committee that the vexed issue of pollutant stress on air quality and health cannot be addressed solely through improving fuel quality and emission norms. This is entirely true. Long traffic jams and slow moving traffic are regular phenomena in our cities. In these conditions emissions will be higher than with smoothly flowing traffic. Urban mass transit reduces the passenger load on roads and is also a great convenience to the citizens of the country.

It is imperative that Government at all levels address itself ever more energetically to building by passes, over passes and expressways that can ease traffic flow.

There are several other constructive avenues that should be pursued with vigour. One is to put electric trolley buses on the roads – as in the case of many cities in the developed world. Another is to encourage hybrid personal cars. However, these tend to be expensive but there are cheaper hybrid options that have the further virtue of being able to be retrofitted to existing vehicles. At the overall level, policy must encourage the rapid development of mid-sized cities and large towns to ease the pressure on the metropolises as part of a broader strategy of urbanisation.

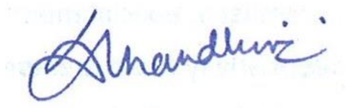
It is my sincere hope and I am sure all of my colleagues on the Committee, who have given so generously of their time and effort over the past two years, that the recommendations of this Expert Committee will lead the country on a rapid path of transition to lower emissions from road traffic and in consequence will help all of our fellow citizens to breathe easier.

I must thank the Ministry of Petroleum & Natural gas on the behalf of members of the Committee and on my own behalf for entrusting this very important task to us.

My thanks are due to all the members of the Committee, particularly to the Chairpersons of the various Working Groups that were constituted, who have given so generously of their time and effort to the deliberations and progress of this Committee. Special mention is due to S/Shri L N Gupta and R K Singh, who were sequentially the two member secretaries to this Committee; to Shri B.D. Ghosh, CHT and his team S/Shri R. Krishnamurthy and A. K. Agarwal in CHT for their massive effort in the finalisation of the work of this Committee; to Shri Rajkumar Ghosh, IOC; to Dr. S.C. Sharma in the Planning Commission for his unremitting patience and diligence; to Dr. B. Sengupta and Dr. Leena Srivastava who articulated the health and environmental concerns so well and helped lend depth to the quality of deliberations; to Prof Shantanu Roy who lent clarity to technical issues; to Shri Ashok Dhar, RIL who gave freely of his vast experience of the field; to S/Shri K.K. Gandhi and Atanu Ganguli of SIAM, Shri I.V. Rao, Maruti Suzuki who put in so much effort; Shri P. Harsha Sivaji, IOC and his colleagues for the huge job of working out the logistics detail which has made the rapid rollout of BS IV and BS V a possibility; to Shri Susobhan Sarkar, IOC and technical officers of the other oil companies who gave so generously to the workings of this Committee; to senior management of the two and three wheeler industry who gave freely of their time and effort in giving final shape to this report; to S/Shri B.K. Namdeo, K. Anand Rao and V. Ratanraj in HPCL and S/Shri Prasad Panicker, C.K. Soman, Thomas George and others in BPCL, Kochi and Shri P. P. Upadhya, MRPL who helped me better understand the contours of the challenges involved in accelerating the transition; to Shri C.F. Dias and his colleagues at Emitec Emission Control Technologies who helped me better understand how after treatment devices work. I am also indebted to S/Shri Alan Lloyd, Michael Walsh and A. Bandivadekar of the International Council of Clean Transportation (ICCT) who spent time and effort to interact with the Committee and some of the Working Groups. My thanks are also due to the two and three wheeler manufacturers who spent time with the Committee to explain their situation and took a constructive approach to problem resolution.

My personal staff needs a special word of appreciation, especially Shri Sanjay Vasnik who has bravely worked through completing this report on time, even if it has meant very late nights and foregone weekends.

Finally, I would like to place on record my deep sense of gratitude to Shri B.K. Chaturvedi, Member, Planning Commission, who is the best sounding board any person can ever hope for.



SAUMITRA CHAUDHURI
Member, Planning Commission and
Chairman, Auto Fuel Vision & Policy 2025

Dated: 2nd May 2014, New Delhi

List of Members/Participants

Sl No	Name	Organization	Role in the Committee
A.	**Government of India**		
1	Shri Saumitra Chaudhuri	Member, Planning Commission	Chairman
2	Shri R K Singh	Joint Secretary (Refineries), MoP&NG	Member Secretary
3	Shri L N Gupta	Secretary, Oil Industry Development Board	Initial Member Secretary
4	Shri S Bandopadhayaya	Joint Secretary, MoRTH	Member
5	Shri Ambuj Sharma	Formerly Jt Secy (now AS), Dept of Heavy Industry (DHI)	Member
6	Shri Niraj Kumar	Director, Department of Heavy Industry (DHI)	Representing DHI
7	Dr. Rashid Hasan	Advisor, MoE&F	Representing MoE&F
B.	**Experts from Academia**		
8	Dr. B Sengupta	Former Member Secretary, Central Pollution Control Board	Member
9	Prof. L M Das	Professor, IIT, Delhi	Member
10	Dr. Leena Srivastava	Executive Director, TERI	Member
11	Prof Shantanu Roy	Professor, IIT, Delhi	Member
C.	**Oil & Gas Companies**		
12	Shri Rajkumar Ghosh	Director (Refineries), IOC	Member
13	Shri B K Namdeo	Director (Refineries), HPCL	Member
14	Dr R K Malhotra	Director (R&D), IOC	Member
15	Shri Prabhat Singh	Director (Marketing), GAIL	Member
16	Shri B D Ghosh	Executive Director (CHT), IOC	Member
17	Shri Ashok Dhar	President (Industrial Marketing), Reliance Industries	Member
18	Shri Abhay Bakre	Executive Director, PCRA	Member
19	Shri B K Datta	Director (Refineries), BPCL	Invitee
20	Shri C. Manoharan	Director (Refinery) Essar Oil Ltd	Invitee
D.	**Automobile Industry**		
21	Shri K K Gandhi	Executive Director, SIAM	Member
22	Shri I V Rao	Executive Advisor, Maruti Suzuki Ltd	Member
23	Shri Shrikant Marathe	Director, Automotive Research Association of India (ARAI)	Member

Sl No	Name	Organization	Role in the Committee
E.	**Senior officials/executives who actively participated**		
24	Dr. Suresh C Sharma	OSD (Petroleum), Planning Commission	Participant
25	Shri K Balachandran	Chief of Operations (Jamnagar Refinery), RIL	Participant
26	Shri P. Raghavendran	President (Refinery Business), RIL	Participant
27	Shri Susobhan Sarkar	General Manager (Technical), IOC	Participant
28	Shri P. Harsha Sivaji	General Manager (S&D) IOC	Participant
29	Dr. A A Gupta	General Manager (Fuels), IOC	Participant
30	Shri Atanu Ganguli	Senior Director, SIAM	Participant
31	Shri Mohan Lal	Deputy Secretary, MoP&NG	Participant
32	Shri M R Karandikar	Executive Director (Supplies), IOC	Participant
33	Shri S K Handa	Executive Director, EIL	Participant
34	Shri R Ganesh	Chief Manager (Projects), BPCL	Participant
35	Shri E A Vimalnathan	General Manager (S&D), BPCL	Participant
36	Shri Vijay Mudgal	General Manager, GAIL	Participant
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40	Shri R Krishnamurthy	Director, CHT	Participant
41	Shri A K Agarwal	Advisor, CHT	Participant
42	Shri Anoop Bhat	General Manager, Maruti Suzuki	Participant
43	Shri Sunil Bahl	Director (Technical), PCRA	Participant
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47	Shri Sumit Arora	Chief Manager (S&D), IOC	Participant
48	Shri Rohit Dawar	Additional Director, PPAC	Participant
49	Shri Pramod Sisodia	Chief Distribution Manager, BPCL	Participant
50	Shri S Dhawale	Manager, Essar Oil	Participant
51	Shri K Srinivas	Deputy Director, ARAI	Participant
52	Shri Anurag Sharma	Sr. Manager, GAIL	Participant

LIST OF ABBREVIATIONS

AAQ	Ambient Air Quality
AFP	Auto Fuel Policy 2003
AFV&P	Auto Fuel Vision and Policy-2025
AIIMS	All India Institute of Medical Sciences
AKI	Anti-Knock Index
ALDS	Auto LPG Dispensing Station
APM	Administered Price Mechanism
ARAI	Automotive Research Association of India
ASTM	American Society of Testing and Materials
BCD	Basic Customs Duty
BENSAT	Benzene Saturation Unit
BEV	Battery Electric Vehicle
BIS	Bureau of Indian Standards
BLEVE	Boiling Liquid Expanding Vapour Explosion
BORL	Bharat Oman Refinery Limited
BPCL	Bharat Petroleum Corporation Limited
BS	Bharat Stage
CAD	Current Account Deficit
CARB	California Air Resources Board
CAT	Catalytic Converter
CCRU	Continuous Catalytic Regeneration Unit
CEN	European Committee for Standardisation
CGD	City Gas Distribution
CH_4	Methane
CHT	Centre for High Technology
CI	Compression Ignition
CMB	Chemical Mass Balance
CNG	Compressed Natural Gas
CO	Carbon Mono-oxide
CO_2	Carbon Dioxide
CONCAWE	Conservation of Clean Air and Water in Europe
CoP	Conformity of Production
COPD	Chronic Obstructive Pulmonary Disease
CPCB	Central Pollution Control Board
CPCL	Chennai Petroleum Corporation Limited
CPCL-CBR	CPCL-Cauveri Basin Refinery
CRU	Catalytic Reforming Unit
CSIO	Central Scientific Instruments Organisation
CSIR	Council of Scientific & Industrial Research
CST	Central Sales Tax
$DeNo_x$	De-nitrification (Reduction of NO_x)
DEP	Diesel Exhaust Particulate
DF	Deterioration Factor
DG	Diesel Generators
DHDS	Diesel Hydro De-sulphurisation Unit

DHDT	Diesel Hydro-Treating Unit
DHI	Department of Heavy Industry
DME	Di-Methyl Ether
DNA	Deoxyribonucleic Acid
DOC	Diesel Oxidation Catalyst
DPF	Diesel Particulate Filter
DTA	Domestic Tariff Area
E70, E100, E150	Volume Percentage of Fuel that Evaporates at 70°C, 100°C, 150°C
EBP	Ethanol Blended Petrol
EC	Elemental Carbon
ECE	Economic Commission for Europe
ECU	Electronic Control Unit
ED	Executive Director
EGR	Exhaust Gas Recirculation
EIL	Engineers India Limited
EOU	Export Oriented Unit
EPA	Environmental Protection Agency, US Government
EPPR	Environmental and Propulsion Performance Requirements
ER-EV	Extended-Range Electric Vehicle
ESC	European Stationary Cycle
ETC	European Transient Cycle
EU	European Union
FBP	Final Boiling Point
FCC GDS	FCC Gasoline Desulphurisation Unit
FCCU	Fluidised Catalytic Cracking Unit
FIE	Fuel Injection Equipment
FO	Furnace Oil
GAIL	GAIL (India) Limited
GBD	Global Burden of Disease
GDP	Gross Domestic Product
GDS	Gateway Digital Switch
GHG	Green House Gas
GIFT	Green Initiatives for Future Transport
GIP	Green Initiative for Power Generation
GRDP	Greening of Regional Development Programme
GRPE	Report of the Working Party on Pollution and Energy
GST	Goods and Services Tax
GTR-2	Global Technical Regulation No. 2
GVW	Gross Vehicle Weight
H_2	Hydrogen
HC	Hydrocarbon
HCU	Hydro-cracking Unit
HCV	Heavy Commercial Vehicle
HEI	Health Effects Institute
HEV	Hybrid Electric Vehicle
HFRR	High Frequency Reciprocating Rig
HIV/AIDS	Human Immuno-deficiency Virus/Acquired Immuno-deficiency Syndrome
HMEL	HPCL–Mittal Energy Limited

HPCL	Hindustan Petroleum Corporation Limited
I&M	Inspection & Maintenance
ICB	International Competitive Bidding
ICE	Internal Combustion Engine
IDC	Indian Driving Cycle
IgE	Immunoglobulin E
IHS	U.S. based organization which does market forecasts and analysis for automotive OEMs
IIP	Indian Institute of Petroleum
IIT	Indian Institute of Technology
INOVEV	France based automotive data analysis organization
IOC (M)	Indian Oil Corporation Ltd. (Marketing)
IOCL	Indian Oil Corporation Ltd.
IPP	Import Parity Price
IREP	Integrated Refinery Expansion Project
ISO	International Organisation for Standardisation
ISOM	Isomerisation Unit
ITRC	Industrial Toxicology Research Centre
JAMA	Japan Automobile Manufacturers Association
JNNURM	Jawaharlal Nehru National Urban Renewal Mission
KV	Kinematic Viscosity
LCV	Light Commercial Vehicle
LDO	Light Diesel Oil
LNT	Lean NO_x Traps
LPG/LP Gas	Liquefied Petroleum Gas
LSHS	Low Sulphur Heavy Stock
MIL	Malfunction Indicator Lamp
MMBTU	Million Metric British Thermal Units
MMSCMD	Million Metric Standard Cubic Meter Per Day
MMT	Million Metric Tonnes
MMTPA	Million Metric Tonnes Per Annum ($\simeq$ Twenty Thousand Barrels Per Day)
MNRE	Ministry of New and Renewable Energy
MoE&F	Ministry of Environment & Forests
MON	Motor Octane Number
MoP&NG	Ministry of Petroleum & Natural Gas
MoRT&H	Ministry of Road Transport & Highways
MoST	Ministry of Surface Transport
MRPL	Mangalore Refinery and Petrochemicals Limited
MS	Motor Spirit
MSAT	Mobile Source Air Toxics
MTBE	Methyl Tertiary Butyl Ether
MUV	Multi Utility Vehicle
NAAQS	National Ambient Air Quality Standards
NBEM	National Board for Electric Mobility
NCEM	National Council for Electric Mobility
NCR	National Capital Region
NA	Not Applicable
NE	North East

NEDC	New European Drive Cycle
NEERI	National Environmental Engineering Research Institute
NEMMP	National Electric Mobility Mission Plan
NG	Natural Gas
NHEB	National Hydrogen Energy Board
NHT	Naphtha Hydro-treating Unit
NMEM	National Mission for Electric Mobility
NMHC	Non-Methane Hydrocarbon
NO_2	Nitrogen Dioxide
NO_x	Nitrogen Oxides
NPL	National Physical Laboratory
NRL	Numaligarh Refinery Limited
O_2	Oxygen
O_3	Ozone
OBD	On-Board Diagnostics
OC	Organic Carbon
OECD	Organisation for Economic Co-operation and Development
OEM	Original Equipment Manufacturer
OHCU/HCU	Once-Through Hydro-Cracker Unit/Hydro-Cracker Unit
OIDB	Oil Industry Development Board
OIL	Oil India Limited
OMC	Oil Marketing Companies
ONGC	Oil and Natural Gas Corporation
PAH	Polycyclic Aromatic Hydrocarbon
Pb	Lead
PCRA	Petroleum Conservation Research Association
PDRP	Paradip Refinery Project
PHEV	Plug-in Hybrid Electric Vehicle
PI	Positive Ignition
PM	Particulate Matter
PM_{10}	Particulate Matter of 10 Microns or smaller in diameter
$PM_{2.5}$	Particulate Matter of 2.5 microns or smaller in diameter
PN	Number of Particles
POL	Petroleum, Oil and Lubricants
PPAC	Petroleum Planning and Analysis Cell
PPM	Parts Per Million
PTW	Powered Two Wheelers
PUC	Pollution Under Control
PV	Passenger Vehicle
R&D	Research & Development
R/P	Reserve/Production
RC	Registration Certificate
RHC	Reactive Hydrocarbon
RIL	Reliance Industries Limited
RLNG	Re-gassified Liquefied Natural Gas
RON	Research Octane Number
RSPM	Respirable Suspended Particulate Matter
RTA	Regional Transport Authority

RVP	Reid Vapour Pressure
RW	Reference Weight
SCOE	Standing Committee on Emissions
SCR	Selective Catalytic Reduction
SCV	Small Commercial Vehicles
SEZ	Special Economic Zone
SI	Spark Ignition
SIAM	Society of Indian Automobile Manufacturers
SKO	Superior Kerosene Oil
SO_2	Sulphur Dioxide
SPCBs	State Pollution Control Boards
SPM	Suspended Particulate Matter
T_{85}	Temperature at which 85% vol. of the fuel evaporates
T_{90}	Temperature at which 90% vol. of the fuel evaporates
T_{95}	Temperature at which 95% vol. of the fuel evaporates
TAME	Tertiary Amyl Methyl Ether
TAMP	Tariff Authority for Major Ports
TAP	Type Approval Procedure
TERI	The Energy Research Institute
THC	Total Hydrocarbon
TMT	Thousand Metric Tonnes
TPP	Tariff Parity Price
TSP	Total Suspended Particulate
UFP	Ultra Fine Particles
ULSD	Ultra Low Sulphur Diesel
ULSFs	Ultra Low Sulphur Fuels
UNECE	United Nations Economic Commission for Europe
USA	United States of America
VAT	Value Added Tax
VGO	Vacuum Gas Oil
VLCC	Very Large Crude Carriers
VLGC	Very Large Gas Carriers
VLI	Vapour Lock Index
V_{max}	Maximum Speed
VOC	Volatile Organic Compounds
WHO	World Health Organisation
WHSC	World Harmonised Stationary Cycle
WHTC	World Harmonised Transient Cycle
WMTC	Worldwide Motorcycle Test Cycle
WOO	World Oil Outlook
WP.29	World Forum for Harmonisation of Vehicle Regulations
WSD	Wear Scar Diameter
XEVs	Full Range of Hybrid and Electric Vehicles

CHAPTER 1

INTRODUCTION

1.1 THE BACKGROUND

Air quality is an issue of social concern worldwide in the backdrop of rising industrial and vehicular air pollution. While pollution does arise from many different sources, vehicular exhaust is an important source of pollution of ambient air and there is an urgent need to check the extent of vehicular pollution, especially since there has and is likely to continue to be a large increase in the stock of road vehicle traffic in the country.

Though considerable work had been done in the past to improve the auto fuel quality, India did not have a comprehensive Auto Fuel Policy before 2001, prior to the establishment of the first Expert Committee set up under the chairmanship of Dr. R.A. Mashelkar.

Liquid fuels namely, gasoline and diesel are the most common automobile fuels everywhere as also in India. Personal vehicles include two wheelers and motor cars. Two wheelers run only on gasoline, while personal cars mostly use gasoline but some use diesel. Three wheelers and cars operating as commercial vehicles run on gasoline, diesel and CNG. Some private cars have also switched to CNG use. Public/commercial transport such as buses, trucks and other light and heavy duty vehicles run mainly on diesel. Though CNG and LPG have been in use in India as alternative auto fuels for more than a decade, their share is low. CNG is presently being used in about fifty cities and towns, including Delhi and Mumbai metropolitan regions.

The quality of automotive fuels is governed by extant vehicular emission norms and vehicle technology. Management of air quality within acceptable limits is the principal objective of regulating vehicle emission regimes and also forms the underlying control factor for regulating fuel quality. Overall vehicle emissions are determined by combinations of vehicle technology, automotive fuel quality, vehicle maintenance, driving patterns and various other factors.

Another public policy objective is continuous improvement in fuel efficiency which operates in conjunction with the emission oriented outcomes that fuel standards and emission norms are expected to generate.

It is the tailpipe emissions and not the fuel *per se* that determine the impact on ambient air quality. Therefore, the technology solution space comprise of the combination of engine technology and fuel quality which meet the prescribed vehicular emission norms. This is the approach taken worldwide.

In India, automotive fuels are produced in petroleum refineries as per BIS standards. These standards are amended from time to time to meet environmental as well as other quality aspects and are mandatory.

Vehicular emission norms in India was first introduced in 1991 and tightened thereafter in 1996, when most vehicle manufacturers had to incorporate technology up-gradation such as catalytic converter to reduce exhaust emission. This necessitated the use of lead free and low sulphur fuels. Initially, refineries were enjoined to supply lead free gasoline to NCR and major cities and subsequently in the rest of the country.

Fuel specifications based on environmental consideration were for the first time notified in the country by the Ministry of Environment & Forests in April 1996 for achievement by 2000. These norms were incorporated in the BIS 2000 standards.

Further, based on the Supreme Court order of April 1999, Ministry of Surface Transport (MoST) notified Bharat Stage-I (BIS 2000) and Bharat Stage-II vehicle emission norms broadly equivalent to Euro I and Euro II for introduction in entire India and NCR respectively.

In line with the **Auto Fuel Policy (2003)**, starting from 2005, fuel conforming to BS III norms was introduced in 13 major cities, while BS II fuel was made available elsewhere in the country and BS I quality fuel phased out. From April 2010, BS IV fuel was implemented in 13 major cities and BS III fuel made available in the rest of the country from September 2010.

In order to comply with the increasingly stringent auto fuel specifications, oil companies have made major investments for technological up-gradation and other changes in the manufacture of gasoline and diesel and in their transportation over the past decade.

1.2 AUTO FUEL POLICY 2003

The Ministry of Petroleum & Natural Gas, Government of India notified the constitution of an Expert Committee, under the Chairmanship of Dr. R.A. Mashelkar, then Director General, Council of Scientific & Industrial Research (CSIR) on 13th September 2001 to recommend an Auto Fuel Policy for the country including major cities; to devise a road map for its implementation; to recommend suitable auto fuels and their specifications considering the availability and logistics of fuel supplies, the processing economics of automotive fuels, and the possibilities of multi-fuel use in different categories of vehicles; to recommend attributes of automobile technologies, fiscal measures for ensuring minimisation of social cost of meeting a given level of environmental quality and institutional mechanisms for certification of vehicles and fuels, as also the monitoring and enforcement measures.

The Expert Committee submitted their report to the Government of India in August 2002, which included their recommendations for achieving the desired objectives. Based on these recommendations, MoP&NG released the "Auto Fuel Policy" as approved by the Government in October 2003, which contained the recommendations for implementation, along-with the time frame, wherever applicable.

The Auto Fuel Policy (2003) addressed measures to cover various areas in which action was required *viz.* vehicular emission norms, fuel quality and standard of CNG/LPG kits, measures to reduce emissions from in-use vehicles, vehicle technology, air quality data and Research & Development. It also covered air quality data and health effects of air pollution.

1.2.1 Key Recommendations of Auto Fuel Policy 2003

Vehicular Fuel/Emission Norms

- Road map for fuel standards/emission norms for 4/more wheeled new vehicles.

  ENTIRE COUNTRY

  - Bharat Stage-II fuel/emission norms from 1st April 2005.
  - Euro III equivalent fuel/emission norms from 1st April 2010.

  In 11 major cities – Delhi/NCR, Mumbai, Kolkata, Chennai, Bangalore, Hyderabad, Ahmedabad, Pune, Surat, Kanpur and Agra

  - Euro III equivalent fuel/emission norms for all private vehicles, city public service vehicles and city commercial vehicles from 1st April 2005.
  - Euro IV equivalent fuel/emission norms for all private vehicles, city public service vehicles and city commercial vehicles from 1st April 2010.

- Road map for emission norms for new 2 and 3 wheelers.

  ENTIRE COUNTRY

  - Bharat Stage-II emission norms from 1st April 2005.
  - Euro III equivalent emission norms preferably from 1st April 2008 but not later than 1st April 2010 in any case.

1.2.2 Other Recommendations

- Use of CNG/LPG in cities that are affected by higher vehicular population.
- Comprehensive programme for encouraging zero emission vehicles to accelerate development of alternative fuel vehicles (battery powered, hydrogen and fuel cell).
- Technologies for producing ethanol/bio-fuels from renewable energy sources and vehicles to utilise these bio fuels.

- Replacement of the existing PUC system to a more reliable computerised system.
- Inspection & Maintenance (I&M) system in 11 major cities and further extension throughout the country.
- On-Board Diagnostics (OBD) system for new vehicles in lieu of I&M system.
- Performance checking of catalytic converters and conversion kits.
- Promoting public transport to improve urban road traffic.
- Linking of vehicle insurance with Inspection and Certification.
- Retrofitting old vehicles with new engines or emission control devices. Developing incentives for replacement of old polluting vehicles.
- System to check emission warranty of new vehicles.
- Random checking of CNG/LPG kits, any other emission control devices or retrofit engines for emission performance.
- Levying higher motor vehicle tax on old vehicles.
- Extending tank lorry locking system for movement of products.
- Setting up of consumer pumps by transport companies operating public transport.
- Use of markers on commercial basis to detect and prevent adulteration.
- Making oil companies responsible and accountable for quality of fuels dispensed from their retail outlets.
- Reporting of conversion of vehicles to CNG/LPG to registering authority.

CHAPTER 2

COMMITTEE FOR AUTO FUEL VISION & POLICY 2025

2.1 Objectives and Expectation of this Expert Committee

The Government of India's **Auto Fuel Policy (2003)** had envisaged that the Policy undergo periodic revisions. Technological and other changes which take place over time must be incorporated in the policy framework. In this backdrop, it was felt necessary to initiate a process to give form to an **Auto Fuel Vision & Policy** for the country which would lay a clear roadmap to the year 2025. Accordingly, the Ministry of Petroleum & Natural Gas vide Office Memorandum dated 19 December 2012 constituted an Expert Committee under the Chairmanship of Shri Saumitra Chaudhuri, Member, Planning Commission, Government of India to prepare a **"Draft Auto Fuel Vision & Policy 2025"**.

2.2 Terms of Reference

1. Recommend a road-map for auto fuel quality till 2025 for the country, taking into account the achievement under the last **Auto Fuel Policy**, emission reduction of in-use vehicles, growth of vehicles and the supply and availability of fuels.

2. Recommend suitable mix of automotive fuels including natural gas and its specifications, considering the following:

    a) Availability of infrastructure and logistics of fuel supplies,

    b) The processing economics of auto fuels, and

    c) Improvement in the quality of fuel *vis-à-vis* improvement in vehicle engine technology.

3. Recommend vehicular emission norms for various categories of vehicles and roadmap for their implementation.

4. Recommend use of alternate fuels to minimise impact on environment.

5. Recommend fiscal measures for funding requisite up-gradation of Oil Refineries, logistics and removal of inter-fuel pricing distortions.

2.3 MEMBERS OF THE EXPERT COMMITTEE

The composition of the committee was as given below.

	Name	Organisation	
1.	Shri Saumitra Chaudhuri	Member, Planning Commission	Chairman
2.	Prof. L.M. Das	Centre for Energy Studies, IIT Delhi	Member
3.	Prof. Shantanu Roy	Dept. of Chemical Engineering, IIT Delhi	Member
4.	Dr. R.K. Malhotra	Director (R&D), IOC	Member
5.	Shri Shrikant R. Marathe	Director, ARAI, Pune	Member
6.	Dr. B. Sengupta	Former Member Secretary, Central Pollution Control Board	Member
7.	Dr. Leena Srivastava	ED, TERI	Member
8.	Shri Ashok Dhar	President, Industrial Marketing, RIL	Member
9.	Shri I. V. Rao	Executive Advisor, Maruti Suzuki India Limited	Member
10.	Shri K.K. Gandhi	Executive Director (Tech), SIAM	Member
11.	Shri B.D. Ghosh	Executive Director, CHT (for Technical & Secretarial support)	Member
12.	Shri L.N. Gupta/ Shri R.K. Singh	Joint Secretary (R), MoP&NG	Member Secretary

1. Originally, Shri S. Sundareshan, former Secretary, MoP&NG and later Department of Heavy Industry, was nominated as a Member. However, Shri Sundareshan was unable to take it up on account of other responsibilities that were given to him. Shri L.N. Gupta moved as Secretary, Oil Industry Development Board. Shri R.K. Singh, who

succeeded Shri L.N. Gupta as Joint Secretary (R) in MoP&NG became the Member Secretary of the Committee. Shri L.N. Gupta was subsequently involved in the working of the Committee as Special Invitee.

2. Representatives from the following Ministries/Departments not below the rank of Joint Secretary will be Ex-Officio members of the Committee:

    i. Ministry of Environment & Forests
    ii. Department of Heavy Industry
    iii. Ministry of Road Transport & Highways
    iv. Department of Health and Family Welfare
    v. Department of Consumer Affairs

3. The Committee may hold formal consultations with different stake holders and co-opt any Expert for technical assistance in their deliberations.

4. Technical and Secretarial assistance to the Committee will be provided by the Centre for High Technology (CHT).

5. Subsequently, Chairman, Director (R) and Director (M) IOC, Director (M) GAIL, Director (R) HPCL and ED, PCRA were also included as Members to the Expert Committee for preparing the Draft Auto Fuel Vision & Policy 2025.

CHAPTER 3

APPROACH AND METHODOLOGY ADOPTED

3.1 MISSION STATEMENT

The Mission Statement for this Committee may be stated as:

"To develop an auto-fuel vision, road-map and an enabling policy framework, going forward to the year 2025 that aims to minimise the contribution of vehicular use to (primarily) urban air pollution in the shortest possible time frame and to do so in a financially sustainable manner. In doing this, due consideration will be given to the adverse environmental and health impacts of a deteriorating air quality and the associated socio-economic costs, while acknowledging that vehicular use is just one of the contributors to ambient air pollution the significance of which carries across geographies".

3.2 CONSULTATION AND DISCUSSION

The Expert Committee reviewed the initiatives taken by the Government/Oil Industry for upgrading Auto Fuel Quality and the status of the various recommendations of the previous Expert Committee on Auto Fuel Policy.

Discussions were focussed on learning from previous auto fuel policy initiatives, India centric emission standards and fuel quality specifications. It explored the prospects of using add-on emission control devices or after treatment devices to reduce emissions and harmonisation of fuel quality and its impact on the Indian refined petroleum product industry. It also looked at the impact of DG set emissions on Ambient Air Quality.

The Source-wise analysis of emissions was studied through Source Apportionment Studies carried out in six Indian cities by the CPCB, the findings of which were released in February 2011.

3.3 CONSTITUTION OF FOUR WORKING GROUPS

The Committee *inter alia* constituted following four Working Groups to deliberate on the above and recommend roadmap for fuel quality and its implementation:

i. "Air Quality & Vehicular Emission Norms for all Types of Vehicles, Vehicle Technology and Fuel Quality"; Convenor: Dr. R.K. Malhotra, Director (R&D), IOC.

ii. "Automobile Exhaust on Ambient Air Quality & Public Health, Emission reduction programme, fuel economy, warranty of in-use vehicles"; Convenor: Dr. B. Sengupta, Ex-Member Secretary, CPCB.

iii. "Refinery Up-gradation, Technology and Logistics, Funding & Fiscal Measures"; Convenor: Shri R. K. Ghosh, Director (R), IOC.

iv. "Suitable Mix of Auto Fuels Including Gas, Logistics, Road Transport"; Convenor: Shri Prabhat Singh, Director (M), GAIL (India) Ltd.

The details on the membership of these four Working Groups are at **Annexure 1**. The minutes of the meetings of the Working Groups have been compiled and are available as part of the proceedings of the Committee.

3.4 INTERACTION AND CONSULTATION

In the course of the Committee's tenure, broad based consultation was encouraged with research agencies, policy groups and others. Several presentations were made before the working groups and some also to the Chairman of the Committee.

Groups and bodies forming the eco-system of the fuel-automobile-emission project, including those involved in production of fuel, vehicle and emission control devices, met with and interacted with the Committee. The Chairman separately met with the automotive industry, manufacturers of after treatment devices and professionals engaged in research and dissemination on the linkage between emissions and human health**.**

These wide-ranging interactions played an important role in shaping the recommendations and the time frame for implementation that has eventually emerged.

3.5 TWO DIMENSIONS – FUEL ECONOMY AND HUMAN HEALTH

There are two outcomes that in the view of the Committee were germane to the context. First, was to encourage the trend towards greater fuel economy (or lower GHG emissions) and the other was to create conditions whereby vehicular emissions would be contained so as to limit the adverse impact on human health.

The controlling factor on emissions *per se* is the combination and interaction of three factors, namely:

- Advanced Engine Design
- Ultra Low Sulphur[1] in the fuel.
- Advanced Emission Controls

[1] The effort in the first decade of this century was to lower sulphur from >3,000 ppm to 500 ppm and lower. Ultra Low Sulphur (ULS) is broadly understood to be at the lower end of the scale and would in most developing countries be identified as ≤ 50 ppm. Since 2006, in the USA by law ULS is defined to be fuels containing up to 15 ppm of sulphur. In the EU presently ULS is regarded by convention to be fuels containing up to 10 ppm of sulphur, EU V.

3.5.1 Fuel Economy/GHG Emissions

Green House Gas (GHG) emissions are more-or-less another way to express fuel use efficiency. The better the fuel economy of a vehicle – the lower would be the CO_2 emissions, which is the principal component of GHG. For the most part this is an outcome of improvement in design of the engine and the rest of the power train, design of the body (reduction of aerodynamic drag) and kerb weight management. Hybrid technologies of course can further enhance fuel economy.

Superior engines also require supporting fuel manufactured to appropriate standards. Fuel efficiency can be defined in terms of kilometres travelled per litre of fuel or in terms of CO_2 emissions per kilometre travelled. For greater familiarity here fuel efficiency is being presented in terms of kilometres per litre, although statutory requirements are in terms of CO_2 emissions which are further compounded by the allowable kerb weight of vehicles in the formula notified.

Driven by concerns about the need to economise on energy use and more recently climate change, countries around the world have adopted or proposed vehicle fuel economy or greenhouse gas (GHG) emission standards. Europe, the United States, China, Japan, South Korea, and Canada have all been leaders in this area.

India, too, has recently started a process to set national fuel consumption standards. With over 75% import dependence for liquid petroleum fuels, and with the rapidly growing transportation sector being the large contributor to greater petroleum product demand, India has even greater incentive to tighten fuel economy.

Indian consumers are very sensitive to fuel efficiency and the industry has been acutely sensitive to this. Purchase decision in the country largely depends on the fuel efficiency performance of the vehicles. Therefore, the consumer pressure has always dictated the need for improvement of fuel efficiency performance of vehicles.

Significant improvement has been done by the automobile industry to improve fuel efficiency over the years, as preliminary estimates indicate that the overall average fuel efficiency of Indian passenger vehicles was around 14.5 km/l in the year 2000. The industry data of the year 2010 indicates that the average fuel efficiency of passenger vehicles sold in India improved to about 16.5 km/l. This improvement between 2000 and 2010 of by 14%, on an annualised basis was 1.3%. The expectations in regard of fuel efficiency as recently prescribed by Government (Gazette Notification, 30 January 2014) requires a formulaic improvement which broadly is equivalent to that average fleet fuel efficiency improving to 18.2 km/l by 2016-17 and further to 21 km/l by 2021-22. These targets imply annualised improvement of 1.7% and 3.0% respectively going forward.

3.5.2 Emissions and Human Health

The human health dimension mostly comes from some of the components of tailpipe emissions – nitrogen oxides (NO_x), benzene and other un-combusted hydrocarbons, combustion products of sulphur and particulate matter, especially of finer sizes.

These emission products in high concentrations can cause respiratory illness and in extreme cases contribute to creating conducive conditions for carcinogenic action.

Better engine design, superior automobiles and standardised fuels can and does decrease the incidence of hydrocarbons and particulate matter in the emissions. However, there is, in the final analysis, a trade-off between fuel economy and NO_x emission. The leaner the fuel mixture (high oxygen to fuel ratio) the better will be the fuel economy, but the greater will be the generation of NO_x and unburnt particulate carbon and *vice versa*.

The installation of after treatment devices permit the NO_x to be scrubbed out and the particulate matter trapped in filters. Thus, one can maximise fuel economy with leaner fuel mixtures while keeping NO_x and particulate emission down with the use of after treatment devices.

However, after treatment devices use catalysts which get immobilised by sulphur. Reduction of sulphur content in fuel to 50 ppm and less permit the economic application of such after-treatment devices. The lower the sulphur content, the longer is the life of the catalyst. Hence, in that sense fuels with sulphur of 10 ppm and less is preferable to 50 ppm and less, provided there is availability.

The Working Group No. 2 ("Automobile Exhaust on Ambient Air Quality & Public Health, Emission reduction programme, fuel economy, warranty of in-use vehicles") has highlighted the human health dimension very well. It has noted that in 83 cities PM_{10} and $PM_{2.5}$ are in excess of the extant regulatory standard. That benzene/PAH are also above the limits and NO_x is also becoming a matter of concern.

Particulate matter is especially high in the northern region, including Delhi (several times higher than the prescribed limit), while NO_x is particularly high in larger cities such as Delhi, Kolkata and Pune.

Automobile exhaust is certainly not the only contributing factor to the presence of particulates, NO_x and other harmful matter in the ambient air. Industrial and construction activity play a large part. The peculiar air flow characteristic in North India also contributes.

3.5.3 Objectives of the Committee

However, having said that, there is little merit in investing energy to exactly define what contribution was from automobile tailpipe exhaust and what from other sources. In any case there is an excellent source apportionment study that has been conducted and which is discussed subsequently.

The key issue as far as the Committee was concerned, was that the human health dimension has to be kept at the highest priority. If that was tackled successfully, at least whatever may be the exact contribution of tailpipe emissions to the public health problem, this contribution would be contained to the least afforded under the available technology; and feasible within the constraints of fuel manufacturing capacity.

Hence the proximate objective must be to roll out BS IV fuels with 50 ppm and less sulphur at the earliest possible date and set a challenging timeline for migration to BS V fuels with 10 ppm and less sulphur.

3.6 ISSUES EXAMINED

The Committee went into many issues in the course of its deliberations. The process was driven by the objective of making the transition to the higher standards of fuel in as short a time as possible and in a manner that stretched, but did not deem impractical, the capability of the oil refineries and logistics involved of taking the product from the refinery to retail outlet. A summary of the several issues that were gone into is given below:

- Review of initiatives taken by the Government and the Oil Industry for upgrading Auto Fuel Quality.
- Learning from the experience of implementation of the previous auto fuel policy initiatives and the status of various recommendations of the previous Expert Committee on Auto Fuel Policy.
- Health related issues of emissions and review of outcome of the Source Apportionment Studies in six Indian cities carried out by CPCB, February 2011.
- Global experience and developments on Auto Fuel standards.
- Review of current fuel specifications, including investigating possibility of further tightening of the existing BS IV fuel specification in respect of sulphur content.
- Review of auto fuel quality parameters in Europe, USA, Japan, Republic of Korea & China *vis-à-vis* India.
- Simplifications in diesel specification.
- Major differences between BS IV and Euro V & VI fuel standards.

- Bottlenecks in North East India in meeting future fuel quality.
- Review of refineries capability of producing superior fuels *viz.* BS IV and BS V gasoline and diesel.
- Change in refinery configuration/complexity needed to meet BS IV and Euro V similar BS V fuels, including limitations if any, capital expenditure requirement, timeline etc.
- Euro V equivalent BS V fuels specifications.
- Fuel supply logistics.
- Roll out plan for BS IV gasoline and diesel nationwide.
- Public policy: Fuel prices, taxes, standards and regulatory regime in the context of broader energy policy.
- Fuel standards and roadmap for BS V & BS VI to 2025.

CHAPTER 4

REVIEW OF THE EXPERIENCE

4.1 REVIEW OF INITIATIVES TO IMPROVE FUEL QUALITY & EMISSIONS

Vehicular emission norms in India was first introduced in 1991 and tightened in 1996, when most of the vehicle manufacturers had to incorporate technology up-gradation like catalytic converter to reduce exhaust emission. This required lead free and low sulphur fuels. It required the refineries to initially supply lead free gasoline to NCR and major cities and subsequently in the entire country.

Fuel specifications based on environmental consideration were notified for the first time in the country by MoE&F in April 1996 to be done by 2000. These norms were incorporated in BIS 2000 standards. Further, based on the Supreme Court order of April 1999, MoST notified in April 1999 Bharat Stage-I (BIS 2000) and Bharat Stage II vehicle emission norms broadly equivalent to Euro I and Euro II respectively for introduction in rest of the India and NCR and other Metros respectively.

There was substantive improvement in fuel quality when “BIS 2000” vehicle emission norms came into effect in phases starting with the year 2000. In line with the Auto Fuel Policy (2003) the BS III and BS II auto fuel quality norms came into existence from April 2005 for 13 major cities and in the rest of the country respectively. Likewise, BS IV and BS III auto fuel quality norms came into effect from April 2010 in 13 major cities and in the rest of the country respectively.

Auto fuel specifications were gradually made stringent to improve the ambient air quality. Oil companies have implemented major programmes for up-gradation of auto fuels (gasoline and diesel) quality in the past few years.

Automotive fuels are governed by vehicular emission norms and vehicle technology. Air quality is the main issue for vehicle emission regulations and the same is also the controlling factor for changing the quality of fuel. In other words, vehicle emissions are determined by combinations of vehicle technology, auto fuel quality, vehicle maintenance, driving patterns and various other factors.

It may be mentioned that it is the tailpipe emissions and not the fuel per se that affect the ambient air quality. Therefore, any combination of engine technology and fuel meeting the prescribed vehicular emission norms is acceptable throughout the world, giving choice to the manufacturers, owners and operators to choose the vehicle type and the fuel.

In India, auto fuels are produced in refineries as per BIS standards. These standards are amended from time to time to meet environmental as well as other quality aspects and are mandatory.

In keeping with the worldwide trend and notification issued by MoE&F, Petroleum sector embarked upon a major quality improvement programme for supplying desired quality of gasoline and diesel in phased manner.

The first step in this direction was lowering of lead in gasoline and production of unleaded gasoline by 1 April 2000 in the entire country, incorporation of benzene limit, reduction of sulphur and increase in octane number. In case of diesel, major improvements were in respect of sulphur, distillation recovery, density and Cetane number by the year 2000.

Introduction of Bharat Stage II emission norms for new cars in Delhi in the year 2000 and subsequent expansion of norms to Mumbai, Kolkata and Chennai in 2001 followed by another 7 major cities *viz.* Bangalore, Hyderabad, Ahmedabad, Pune, Surat, Kanpur and Agra in phases by 1st April 2003 was another step.

As per the Auto Fuel Policy (2003), Bharat Stage III fuels *viz.* gasoline and diesel were introduced in 13 major cities (Delhi/NCR, Mumbai, Kolkata, Chennai, Bangalore, Hyderabad, Ahmedabad, Pune, Surat, Kanpur and Agra including Lucknow and Sholapur, which were later, added to the list) and Bharat Stage II fuels in rest of the country with effect from October 2005.

Likewise, BS IV auto fuels were implemented in 13 major cities including NCR with effect from 1 April 2010 and BS III fuels in rest of the country by September 2010. Besides this, MoP&NG has decided to expand BS IV auto fuels to 50 more cities by March 2015.

Of this, BS IV auto fuels have already been expanded to 26 more cities in addition to 13 cities where this was already implemented in 2010.

Major improvements from BS I to BS II, III & IV gasoline, covered octane number, sulphur and benzene as well as introduction of criterion to limit aromatics and olefins in BS III.

As far as diesel is concerned, major changes from BS I to BS II, III & IV were made in respect of density, Cetane number, sulphur, distillation recovery including criterion for limiting Polycyclic Aromatic Hydrocarbon (PAH).

4.1.1 Gasoline Quality Improvement

Phasing out of Lead

Health effects associated with the use of lead alkyl additive in gasoline have led to elimination of leaded gasoline in several countries.

Lead content in gasoline in India was removed in 6 years in phases and only unleaded gasoline is being produced and sold from 01.02.2000. Initial lead limit of 0.56 g/litre for leaded gasoline was reduced to 0.15 g/litre for low lead gasoline and then to 0.013 g/litre for unleaded gasoline.

In order to phase out the lead from gasoline, Catalytic Reforming Units (CRU)/Continuous Catalytic Regeneration Unit (CCRU) and Methyl Tertiary

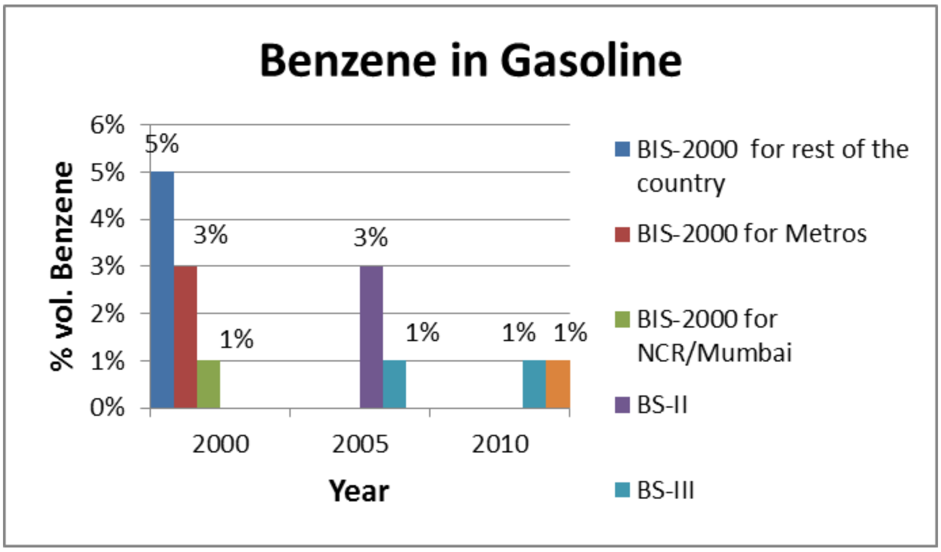
Butyl Ether (MTBE)/Tertiary Amyl Methyl Ether (TAME) units were put up at the refineries.

Reduction of Benzene Content

Benzene is a natural constituent of crude oil besides its production during catalytic reforming operation for making high octane gasoline component. It is known to be a human carcinogen. An effective way to reduce human exposure to benzene is to control benzene in gasoline.

There was no benzene specification in gasoline in India till MoE&F notified a benzene limit of 3% vol. max for 4 Metros and 5% vol. max for rest of the country from the year 2000.

Benzene in gasoline supplied to NCR of Delhi and Mumbai was further reduced to 1.0% vol. max since Oct/Nov, 2000. This is at par with Euro III/IV norms and best of the world.



Refineries had made necessary operational changes like feed cut point adjustment, severity of operation, blending pattern and installed facilities like Benzene Saturation (BENSAT) Unit and Isomerisation (ISOM) units, pre & post reformate and FCC gasoline splitters to meet the above benzene limit for entire country.

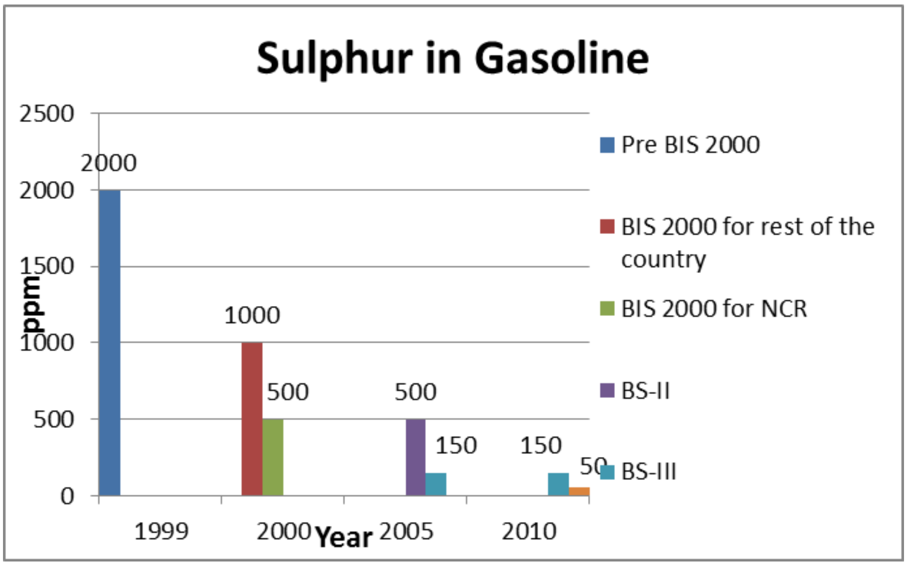
Reduction of Sulphur Content

Reduced sulphur in gasoline results in reduced emissions from all catalyst equipped vehicles. Sulphur adversely affects exhaust gas sensors besides affecting efficiency of catalyst used in the after treatment devices.

For BIS 2000 specification, sulphur in gasoline was reduced by 50% from 0.2% to 0.1% wt max from the year 2000. Further, in line with the MoST Gazette notification, sulphur in gasoline was further reduced to 0.05% wt. max to meet Euro II equivalent Bharat Stage-II emission norms in NCR from April, 2000 and expanded to 11 cities by 1st April 2003.

Sulphur content in gasoline was further reduced to 150 and 50 ppm respectively for BS III and BS IV gasoline supplied in the country and major cities as per Auto Fuel Policy.

Refineries had installed FCC Gasoline Desulphurisation unit to manage sulphur content in gasoline.



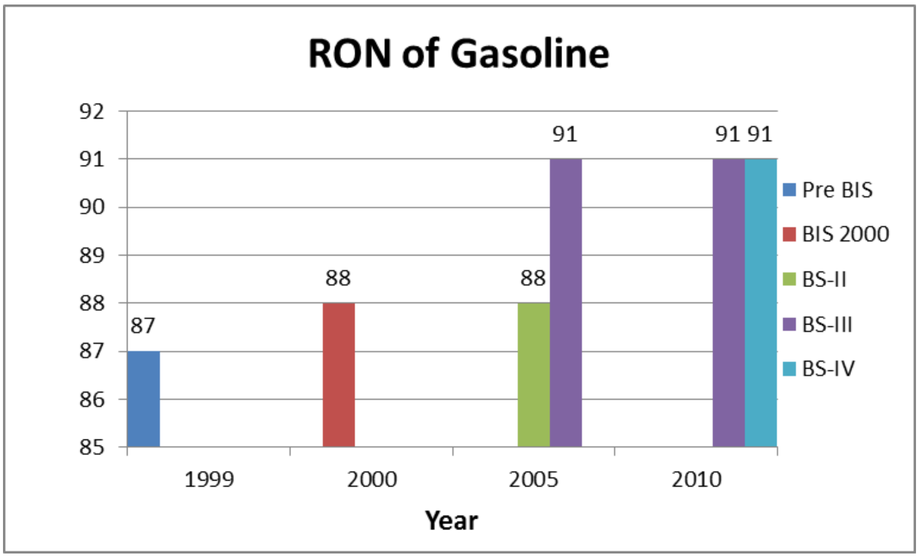
Octane Number Enhancement

Octane number of gasoline signifies the improved performance of engine. Loss in octane number due to phasing out of lead was made up by installing new facilities in the refinery and changes in refinery operation. RON (Research Octane Number) of gasoline for BIS 2000 spec was increased to 88

(93 for premium grade gasoline supplied in major cities). Anti-Knock Index (AKI) was added as the new criterion for BIS 2000 as 84 (88 for premium grade gasoline supplied in major cities).

RON was further increased to 91 for regular grade gasoline meeting BS III & IV specification respectively.

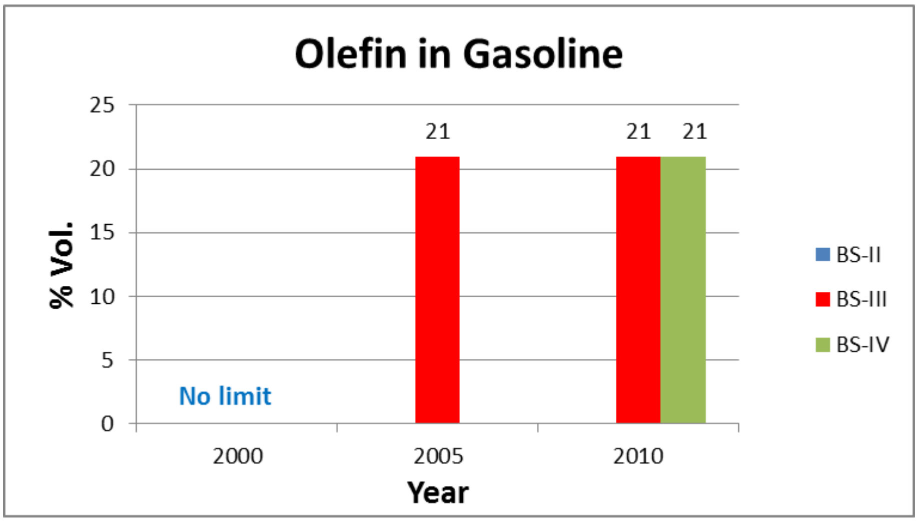
Refineries had put up Catalytic Reforming Units (CRU/CCRU) as well as Alkylation units to increase RON of gasoline.

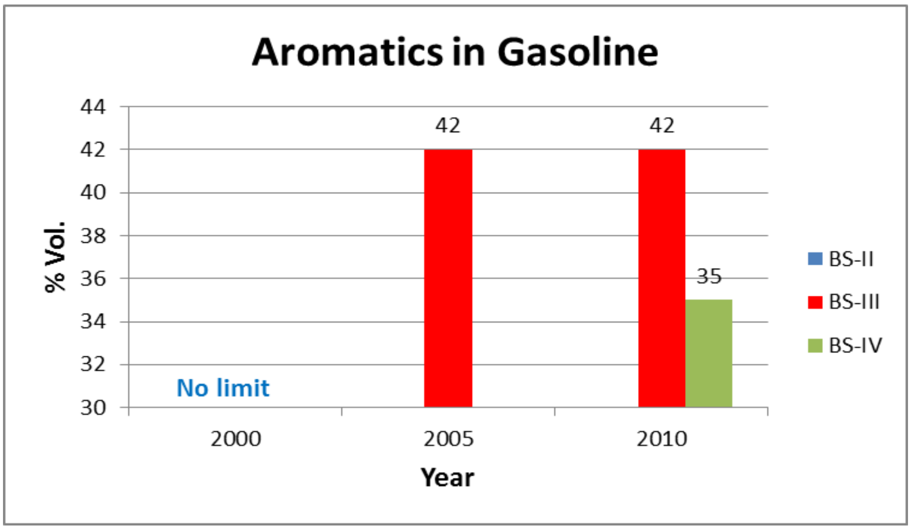


Limiting Olefin and Aromatics Content

Olefin and aromatic content limit was for the first time introduced in BS III gasoline specification as 21% and 42% vol. max respectively (18% and 42% vol. max for premium gasoline). Aromatics were further brought down from 42% to 35% vol. in BS IV gasoline. This was done with the objective to reduce deposit formation and reduced tailpipe emission of reactive hydrocarbons, undesirable compounds and CO_2.

Olefins in gasoline were managed by either hydro-treating FCC feed *i.e.* VGO or treating unsaturated FCC gasoline in FCC gasoline Desulphurisation unit or both.





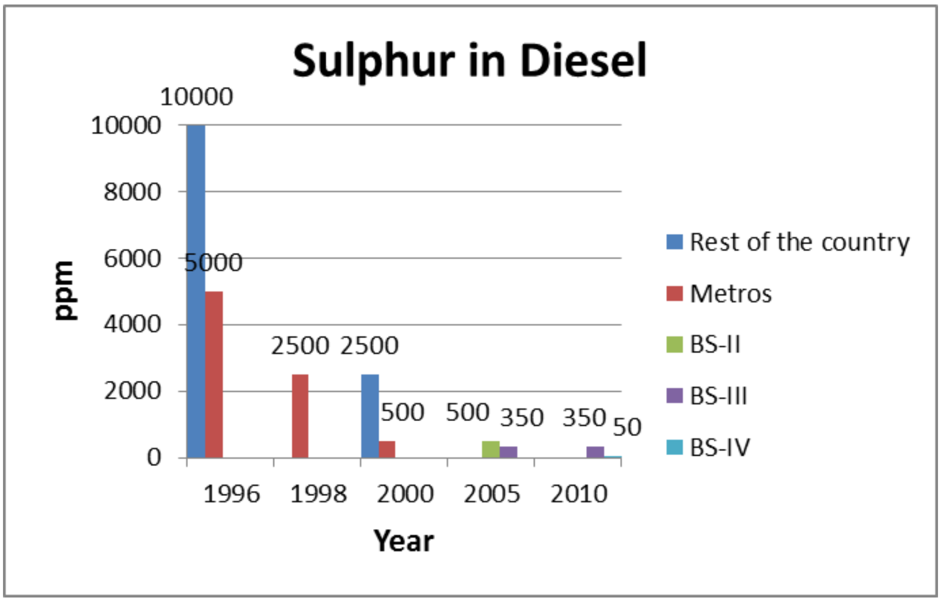
4.1.2 Diesel Quality Improvement

Reduction of Sulphur Content

Sulphur in diesel fuel contributes to fine Particulate Matter (PM) emissions through the formation of sulphates both in exhaust and in the atmosphere. It can also lead to corrosion and wear of engine. Efficiency of some of the after treatment devices is severely affected at higher sulphur levels and these work well only with fuel having 50 ppm or less sulphur.

Sulphur in diesel was reduced from 1% max to 0.5% max by weight from April 1996 in 4 metros and Taj Trapezium, and then to 0.25% max from September 1996 for Taj Trapezium. Supply of diesel having 0.25% max sulphur was started in entire Delhi, Mumbai, Kolkata and Chennai w.e.f. April 1998. The same in the entire country was started from January 2000. Supply of extra low sulphur diesel with 500 ppm sulphur was started from NCR in April 2000 and then gradually extended to other metros. Sulphur in diesel was reduced in phases from 2500 ppm for BS I to 500, 350 and 50 ppm respectively for BS II, III and IV diesel supplied in the country and major cities as per Auto Fuel Policy.

Refineries had put up Diesel Hydro-desulphurisation (DHDS), Diesel Hydro-treating (DHDT) and Hydro-cracking units (HCU) to meet the sulphur specification of diesel.

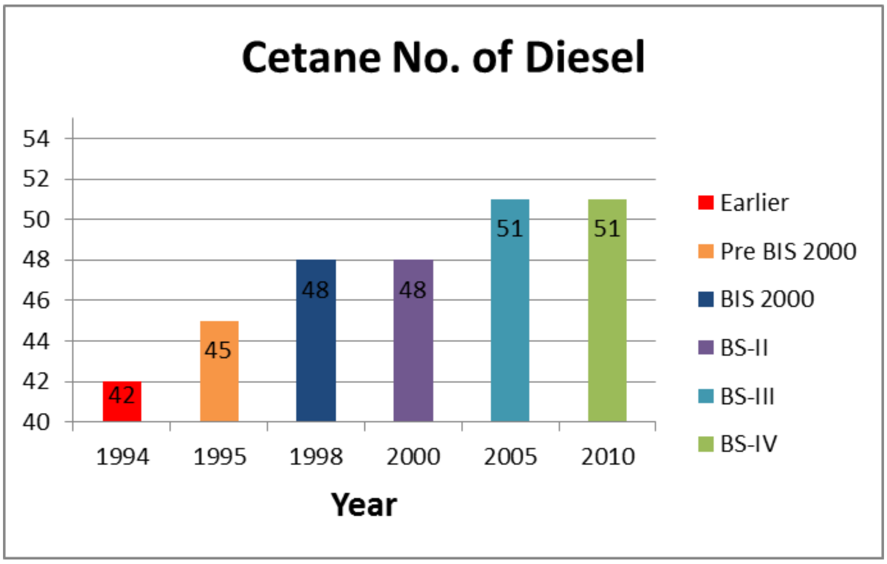


Increasing Cetane Number

The Cetane number is a measure of compression ignition quality of diesel fuel and influences cold start-ability, exhaust emissions and combustion noise. Some increase in smoke is generally seen at Cetane number at levels of below 45. However, little improvement in performance is seen at Cetane number above levels of 50.

Cetane number was increased from 42 to 45 in 1995 and further increased to 48 by the end of December 1998 as per MoE&F Gazette notification and BIS 2000 specification. Relaxation of Cetane number to 45 was given for diesel produced by the refineries processing Assam crude as diesel produced from Assam Crude has low Cetane.

The Cetane number was increased further from 48 to 51 for diesel in order to comply with BS III and BS IV specifications. The refineries were able to meet the specification after installation of DHDT and hydrocracker units, as per requirement. The lower limit for refineries processing Assam Crude was also raised to 48.

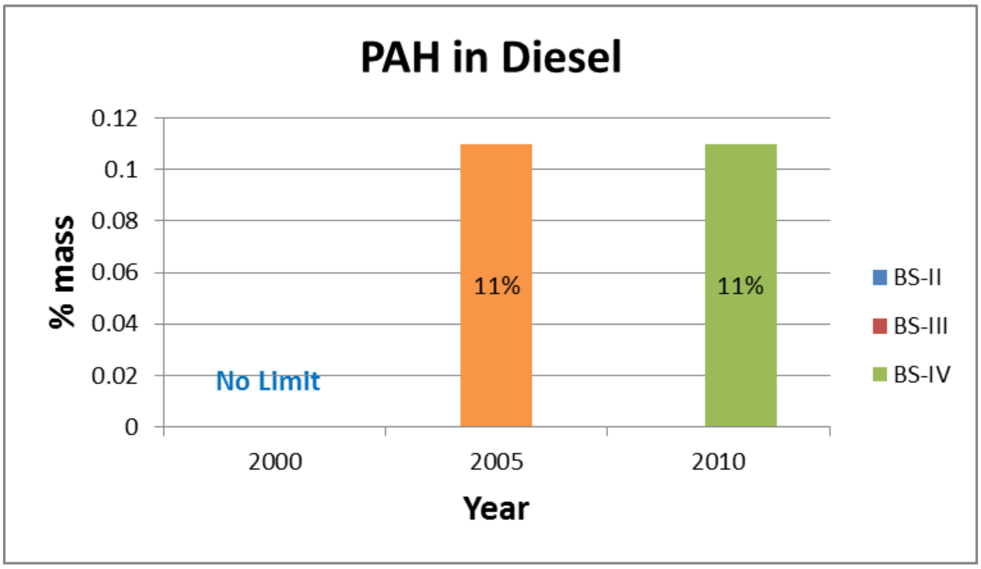


Changes in Distillation Recovery and Density

Changes in distillation recovery were to improve performance and life of diesel engines and reduced emission. As per MoE&F Gazette notification, distillation recovery spec for BS I & II diesel was changed to 85% vol. (min) (T_{85}) and 95% vol. (min) (T_{95}) at 350°C and 370°C respectively against 90% vol. (min) (T_{90}) at 366°C earlier. Subsequently, distillation recovery for BS III & IV diesel was further changed to 360°C max for 95% vol. recovery. Density range for BS I & II diesel was reduced to 820–860 kg/m^3 as against 820–880 kg/m^3 earlier. Density range of BS III & IV diesel was further reduced to 820–845 kg/m3. The altered specifications for recovery and density were achieved with feed cut point management and installation of DHDT. However, some of these changes have been subjected to a review here.

Limiting Polycyclic Aromatic Hydrocarbon (PAH) Content

Polycyclic Aromatic Hydrocarbons (PAH) are harmful to human beings. One of the reasons for presence of PAH in the air is due to burning and incomplete combustion of diesel or gasoline. Bulk of PAH in the air is of respirable size *i.e.* below 7 µm.



Criterion for limiting PAH was for the first time introduced for BS III diesel as 11% wt. max., since PAH are believed to be responsible for particulates emission, its limit was introduced.

Refineries could meet the PAH criterion with the installation of DHDT and hydrocracker units.

4.2 SOME LEARNINGS OF THE PAST DECADE

The first comprehensive **Auto Fuel Policy (2003)** for the country had given a clear-cut road map for changes in vehicular technology and corresponding fuel quality for the whole country. It also proposed measures to reduce emissions from in-use vehicles.

In line with the Auto Fuel Policy, BS IV auto fuels in 13 major cities were introduced with effect from 1 April 2010 and BS III fuels in the rest of the country from September 2010.

MoP&NG had decided to expand coverage of BS IV auto fuels to 50 more cities by March 2015, thus expanding BS IV coverage to a total of 63 cities. Of this, BS IV has since been expanded to cover 26 cities, in addition to the first batch of 13 cities in which BS IV was implemented in 2010.

In order to meet the fuel quality in line with the Auto Fuel Policy, the oil refineries had to upgrade technology and invest in additional facilities. The oil refineries have invested over Rs 35,000 crore in upgrading facilities in refineries and installation of additional facilities in order to be able to gear up for production of stipulated quality of auto fuels.

4.3 STATUS OF COMPLIANCE OF AUTO FUELS AND AUTOMOBILES

Euro III equivalent Bharat Stage III fuels *viz.* gasoline and diesel fuels were introduced in 13 major cities (including Lucknow and Sholapur which were subsequently added) and Bharat Stage-II fuels in rest of the country from October 2005.

BS III and BS II emission norms for select cities and the rest of the country respectively have already been complied with by the vehicle manufacturers for new vehicles (with the exception of 2 and 3 wheelers which moved to BS II emission norms across the country) as per Auto Fuel Policy from the year 2005. They have also complied with BS IV and BS III emission norms for select cities and rest of the country respectively from year 2010 in line with the Auto Fuel policy.

4.4 STATUS OF RECOMMENDATIONS OF THE AUTO FUEL POLICY (2003)

While several of the recommendations of the Auto Fuel Policy (2003) have been implemented, some have not and some are in the process of being implemented. A tabular presentation of the status is given at **Table 4.1**.

Table 4.1

Summary of Status of Recommendations of the Auto Fuel Policy (2003)

Table 4.1: Summary of Status of Recommendations of the Auto Fuel Policy (2003)

Sl. No.	Recommendations	Status
1	BS III/BS IV Auto Fuels	Coverage achieved is greater than recommended
2	Use of CNG/LPG in cities affected by high vehicular population	CNG extended to 60 cities; Auto LPG expanded to ~ 350 cities having ~ 900 dispensing stations
3	Comprehensive programme for zero emission vehicles to accelerate development of alternative fuel vehicles (battery powered, hydrogen and fuel cell)	Initiatives have been taken by MNRE, with limited progress, while some initiatives have also been taken by Department of Heavy Industry
4	Technologies for producing ethanol/bio fuels from renewable energy sources and vehicles to utilise these bio fuels	Minimum 5% ethanol blending has been made mandatory, subject to availability of ethanol
5	Replacement of existing PUC system to more reliable computerised system	Computerized system may not have been widely introduced across the country
6	Inspection & Maintenance (I&M) system in 11 major cities and further extension throughout the country	- MoRT&H and ARAI is looking into issues of PUC and I&M - I&M model Centres to come on PPP mode - End of life for vehicles is being worked out
7	OBD system for new vehicles in lieu of I&M system	OBD-II implemented in BS IV vehicles from April 2013

Sl. No.	Recommendations	Status
8	Performance checking of catalytic converters and conversion kits	Not given effect to
9	Promoting public transport to improve urban road traffic	Some progress
10	Linking of vehicle insurance with Inspection and Certification	Not in place
11	Retrofitting old vehicles with new engines or emission control devices. Developing incentives for replacement of old polluting vehicle	Irregular
12	System to check emission warranty of new vehicles	Not ensured
13	Random checking of CNG/LPG kits, any other emission control devices or retrofit engines for emission performance	Irregular
14	Notification of Fuel Economy Standards	CO_2 emission, fuel economy yet to be implemented
15	Levying higher motor vehicle tax on old vehicles	Not in place
16	Extending tank lorry locking system for movement of products	Has been fully implemented
17	Setting up of consumer pumps by transport companies operating public transport	Limited implementation through oil companies
18	Use of markers on commercial basis to detect and prevent adulteration	Implemented but discontinued due to circumvention. New markers under development
19	Making oil companies accountable for quality of fuels dispensed from their retail outlets	Implemented
20	Reporting of conversion of vehicles to CNG/LPG to registering authority	Not ensured

4.5 EXTENSION OF BS IV AUTO FUELS COVERAGE TO 50 CITIES

The transition to first BS III from BS II fuels and then to BS IV fuels in select metropolitan centres and to BS III fuels across the country was based on certain premises. First, there was recognition of the need to move in phases, given the order of changes that were required at the refinery end and in terms of vehicle production. Second, given the link of fuel standards to emission outcomes, it was perceived that priority should be accorded to where the scarcer BS IV quality fuels would be first launched: in the metropolitan centres where vehicle density and emission standards are the highest. The benefit from BS IV fuel used in metropolitan centres that have higher emission loads was viewed to be proportionately higher than in the rest of the country where the emission load was less severe.

MoP&NG decided to go beyond the recommendations of the **Auto Fuel Policy (2003)** and expand BS IV auto fuels to 50 more cities (in addition to the 13 cities covered) by 2015 with preference to most polluted cities, state capitals and cities with ≥ 1 million population subject to logistics constraints.

As per Census 2001, there were 35 cities and Urban Agglomerates with population of ≥ 1 million. This number rose to 51 in Census 2011. The largest city is Greater Mumbai in Maharashtra with population of 18.4 million followed by Delhi (16.3 million) and Kolkata (14.1 million). The Committee constituted by MOPN&G had identified 32 polluted cities. Out of these, 26 cities have already been covered with BS IV fuel.[2] Another 4 cities[3] will be covered by end 2014. The remaining extension will be on hold as the three-stage conversion of the entire country to BS IV is to be carried out between 1 April 2015 and 1 April 2017.

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[2] Medak, Mehboobnagar and Nizamabad in Andhra Pradesh; Vapi, Jamnagar, Ankleshwar and Valsad in Gujarat; Hissar, Karnal, Yamuna Nagar and Kurukshetra in Haryana; Bharatpur, Hindon City and Dholpur in Rajasthan, Puducherry an UT; Mahabaleshwar and Ahmednagar in Maharashtra, Mathura, Aligarh, Rae Bareli, Unnao, Kosi Kalan and Vrindavan in Uttar Pradesh; Silvasa, Daman & Diu.

[3] Kochi, Trivandrum, Vishakapatnam and Lakshadweep

4.6 KEY ISSUES REGARDING BS IV QUALITY AUTO FUELS

BS IV fuels have sulphur content restricted to a maximum of 50 parts per million (ppm), at which level sophisticated after treatment devices for containing both NO_x and particulate emission become practical. Sulphur tends to poison the catalysts that are used in after treatment devices. BS III fuels which contain up to 350 ppm of sulphur cannot be practically used in conjunction with after treatment devices.

BS IV fuels cost a bit more than BS III fuels. Motor vehicles equipped with after treatment devices also cost more than ones without. The more rigorous the treatment to reduce carbon particulate and NO_x emission, the more expensive becomes the vehicle. Private vehicles – both cars and utility vehicles – purchased in metropolitan centres are for the most part registered there and are therefore BS IV compliant. Thus, the emission outcomes – that is, improvement – which were expected from the switch to BS IV fuel and emission norms did materialise.

However, commercial vehicles have been a different story. The economics are hugely influenced by the capital cost of the vehicle and the cost of fuel. These vehicles are diesel vehicles. Commercial vehicles therefore have tended to get registered where BS III fuel/vehicles are permitted and travel into metropolitan centres where otherwise BS IV is mandated. Hence, the expected outcomes on emissions for commercial vehicles have to an extent been subverted. As a matter of fact almost all light, medium and heavy trucks sold in the country since 2011 continue to be BS III compliant.

The quantity and composition of vehicle and fuel mix as between BS III and BS IV over the past few years is presented at **Table 4.2** and **Table 4.3** respectively. The difference in the experience as between motor spirit/gasoline and high speed diesel is quite marked. In the case of diesel fuel sales it is only 16% in 2013-14 (9 months) and that for Medium & Heavy Commercial vehicles it is 12% and for Light Commercial Vehicles it is 24% in 2013-14 (9 months).

Table 4.2

Number of Vehicles of Different Classes Sold in the Domestic Market Compliant with BS III and BS IV Fuel & Emission Norms

	2010-11	2011-12	2012-13	2013-14*
Vehicles Sold in BS III Regions in '000				
2 & 3 Wheelers	8,810	12,086	12,372	9,815
Pass. Cars incl. MUV	1,463	1,805	2,069	1,418
LCV †	312	227	361	223
M & HCV †	276	312	237	127
Vehicles Sold in BS IV Regions in '000				
2 & 3 Wheelers ‡	1,658	1,695	1,853	1,419
Pas. Cars incl. MUV	276	312	237	127
LCV †	1,463	1,805	2,069	1,417
M & HCV †	312	227	361	222
Share of Vehicles Sold in BS IV Region of Total				
2 & 3 Wheelers ‡	15.8%	12.3%	13.0%	12.6%
Pass. Cars incl. MUV	29.0%	22.7%	23.0%	22.5%
LCV †	17.0%	23.8%	24.2%	24.3%
M & HCV †	13.3%	12.0%	11.8%	12.3%

Note: ‡ For 2 & 3-wheelers applicable emission norms has been conforming to BS III even when sold in areas where BS IV norms are applicable to 4-wheelers.
* For the period April-December 2013-14
† Including goods and passenger carriers.

Table 4.3

Automotive Fuels Sold in the Domestic Market Conforming to BS III and BS IV Fuel Standards All Oil Marketing Companies

	2009-10	2010-11	2011-12	2012-13	2013-14*
BS III Fuel – MMT					
Motor Spirit/Gasoline	1.35 †	10.50	11.19	11.84	9.75
High Speed Diesel	0.10 †	50.30	53.54	57.02	42.30
BS IV Fuel – MMT					
Motor Spirit/Gasoline	nil	3.70	3.80	3.90	3.13
High Speed Diesel	nil	9.57	10.27	11.09	8.29
Share of BS IV Fuel of Total					
Motor Spirit/Gasoline	nil	26.1%	25.3%	24.8%	24.3%
High Speed Diesel	nil	15.9%	15.9%	16.0%	16.2%

Note: * For the period April-December 2013-14
† Most of the fuel sold in 2009-10 conformed to BS II specifications

4.7 LESSONS FOR GEOGRAPHICAL FUEL STANDARD INTEGRITY

The experience with commercial vehicles however, has been different when compared with personal vehicles. For commercial vehicles financial logic has a much more powerful influence in shaping choices within the regulatory framework. Personal vehicles cover less distance over any length of time and owners prefer to register the vehicles in the place of their residence for purpose of convenience, resale and the like. However, for commercial vehicles the distances travelled are much longer and the cost of fuel is an overriding element. Moreover, the cost of the vehicle *per se* is more expensive in the case of BS IV compliant units, relative to BS III compliant ones. For commercial vehicles that operate under national, multi-State and even State wide permits, registering the vehicle in a BS III regulatory regime and operating it across BS III and BS IV geographies is not a challenge. Neither is there the issue of inconvenience faced as between a notional place of residence and place of registration.

In consequence, unless commercial vehicles are required for other reasons to register in BS IV cities – as is the case with city buses for instance – they have registered in BS III centres and continue to ply in all areas capturing the economic benefit involved. The significantly lower share of BS IV diesel as compared to BS IV gasoline (see **Table 4.3**) testifies to this. Even in the case of gasoline an element of stagnation in terms of penetration seems to have set in, which in part owes to the continuation of BS III norms for two wheelers. It also suggests that after the initial coverage of the first set of 13 metropolitan cities the impact of further expansion to other centres has not had the desired impact.

One clear lesson to be drawn from this is that insofar as diesel is concerned the coverage must seek to extend across substantial geographies so that fuel/region-hopping is disabled. It also underscores that whenever two standards of fuels are available, the cheaper option will tend to dominate both in terms of operating and capital servicing cost. Therefore, as long as two alternative standards (which do not differ significantly on fuel economy) of fuel are available in adjacent geographies, care must be taken to ensure that the desired outcomes in terms of emissions are achieved by seeking to insulate large swathes of area so as to try and ensure geographical integrity as far as fuel standard is concerned.

It also raises the question whether keeping BS III fuel at a price cheaper than BS IV fuel – on the basis of private cost differentials that are oriented exactly opposite to public costs – is appropriate or whether the public cost point of view should be allowed to prevail or a meaningful hybrid is adopted. That is, reimburse the BS IV fuel on cost basis, but either maintain BS III fuel at the same level or at a higher price based on the higher public costs involved.

4.8 REVIEW OF INITIATIVES TAKEN TO UPGRADE QUALITY OF AUTOMOTIVE FUELS

Oil companies have invested huge sums in the up-gradation of their refineries from BS II to BS III and BS IV. The total investment of the public sector companies in this regard has amounted to about Rs 35,000 crore. The switchover to BS IV in select metropolitan centres and to BS III in the rest of the country also involved a massive logistics exercise. This was a continuation of the implementation of the previous upgrading of fuel standards.

Thus, the intensification of improvement in fuel quality in order to permit improvement in emissions has been a continuing effort involving a large and steady flow of investments. The automobile companies have also kept up their side of bargain by upgrading vehicle technology including after treatment devices.

However, the oil companies feel that their investments have faced a particularly steep uphill journey as the official pricing regime continues to operate financially in a sub-optimal fashion.

The automobile companies on the other hand, are unhappy with the pace with which the transition to higher quality fuels has happened and would have liked to see the roll out of 10/15 ppm sulphur fuels in the near future, rather than the medium term.

The opinion of professionals who look at the impact of emissions on ambient air quality and on to the health of the citizens tend to reflect the same impatience to see 10/15 ppm sulphur fuels rolled out shortly.

4.9 FUEL EFFICIENCY OF INDIA'S ROAD TRANSPORTATION VEHICLES

There has been a sizeable improvement in the fuel efficiency of both personal and commercial vehicles in India over the past decade and half for which reasonable data is available. SIAM has manufacturer wise data on fuel efficiency (expressed in terms of CO_2) which can readily be converted to litres of fuel per kilometres – the more popularly understood measure in the Indian context. This data is more comprehensive for the last few years but sufficiently detailed to afford comparison starting 2000.

For the better part, fuel efficiency is an outcome of improvement in design of the engine and the rest of the power train, design of the body (reduction of aerodynamic drag) and kerb weight management. Hybrid technologies of course can further enhance fuel economy. Superior engines require supporting fuel manufactured to appropriate standards. India is in the process of setting national fuel consumption standards. With over 75% import dependence for liquid petroleum fuels, and with the rapidly growing transportation sector being the large contributor to greater petroleum product demand, India has even greater incentive to tighten fuel economy norms.

Indian consumers are very sensitive to fuel efficiency and the industry has been acutely conscious of this. Purchase decision in the country largely depends on the fuel efficiency performance of the vehicles. Therefore, the consumer pressure has always dictated the need for improvement of fuel efficiency performance of vehicles.

Significant improvements have been carried out by the automobile industry to improve fuel efficiency over the years, as preliminary estimates indicate that the overall average fuel efficiency of Indian passenger vehicles was around 14.5 km/l in the year 2000.

Industry data for 2010 indicates that average fuel efficiency of passenger vehicles sold in India improved to about 16.5 km/l. This improvement between 2000 and 2010 by 14%, on annualised basis was 1.3%. The expectations in regard of fuel efficiency as recently prescribed by Government (Gazette Notification, 30 January 2014) requires a formulaic improvement which is broadly equivalent to average fleet fuel efficiency improving to 18.2 km/l by 2016-17 and further to 21 km/l by 2021-22. These targets imply annualised improvement of 1.7% and 3.0% respectively.

Heavy Duty Vehicles (HDVs) have a relatively short history of fuel consumption regulations. Establishing fuel efficiency norms for HDVs is significantly more challenging due to their diversity in terms of vehicle size, configurations and usage patterns.

Japan was the first country to introduce fuel efficiency norms for HDVs in 2005, giving a roadmap for improvement up to 2015. US have finalised HDVs fuel efficiency standards in 2011, which begin with model year 2014, and increase in stringency through 2018. Canada has aligned its GHG emission standards with the US HDV fuel efficiency standards. Europe and China are in the process of designing HDV efficiency standards. With increasing focus on the fuel efficiency/GHG emissions of medium and heavy commercial vehicles across the globe, a number of countries are expected to introduce regulatory norms in the coming years.

PCRA in India has also embarked upon the process of preparation of Fuel Efficiency programme for diesel trucks & buses in India by engagement of ICRA Management Consulting Services Limited (IMaCS) to prepare a Status Report based on market survey leading to fuel consumption norms for diesel trucks & buses in India.

CHAPTER 5

HEALTH RELATED ISSUES OF EMISSIONS AND THE SOURCE APPORTIONMENT STUDIES BY CENTRAL POLLUTION CONTROL BOARD IN SIX CITIES

5.1 HUMAN HEALTH, SOURCE APPORTIONMENT AND CONTINUOUS MONITORING

This chapter has three sections. In the first, the issue of how harmful components that are present in vehicular emissions adversely impact human health is discussed. This is largely a summary of the report of **Working Group 1 & 2** that examined the subject of vehicular emission, public health and the environment. In the second section, the source apportionment studies that were conducted by the CPCB, its principal findings and some narration of the city wise picture are presented. Finally, the issue of how to set up a system that enable an ongoing and regular monitoring of ambient air quality in our cities, source apportionment and analysis is proposed.

5.2 HUMAN HEALTH AND VEHICULAR EMISSIONS

As has been stated previously, the primary policy objective of improving fuel standards is to enable vehicle technology that can permit sharp reduction in the harmful matter contained in vehicular emissions. There is additionally a need to enforce standards and compliance. While the first step taken in the West in regard of mandating norms for automobiles may have been motivated to improve fuel economy, the principal theme in the discourse since then has been the issue of the hazard that deterioration of ambient air quality poses to human health. It has been no different in India. It is the desire to ensure improved ambient air quality and protect our citizens from hazardous levels of air pollutants that has motivated the legislative and rule making agenda of government – one in which all stakeholders including research institutions and civil society have played a valuable role.

This Committee is keenly aware that it is the consideration for better ambient air quality and protection of human health that drives the process of upgrading fuel quality and vehicle technology – a process that consumes large resources – both human energy and financial. In the first part of this chapter is a small summary of some of the major concerns in this regard and in the second part is a summary of the source apportionment study conducted in six major Indian cities by CPCB.

5.2.1 Principal Harmful Components in Vehicular Emission

The eight items that are classified as being "critical pollutants" contained in vehicular emissions are:

1. Lead (Pb)
2. Nitrogen Oxides (NO_x)
3. Particulate Matter (PM) – PM_{10} and more so $PM_{2.5}$
4. Sulphur Oxides (SO_x)
5. Ozone (O_3) and
6. Carbon Monoxide (CO)
7. Benzene
8. Poly Aromatic Hydrocarbons (PAH)

Historically, vehicles powered by internal combustion engines have had emissions with all of these ingredients, although over the years each vehicle is now a relatively much lower emitter of lead (Pb), SO_x, benzene and PAH and CO, with the phasing out of leaded gasoline, lower sulphur, benzene and PAH in fuel and improved engine systems. However, PM and NO_x continue to be candidates of serious concern. While PM and NO_x are emitted directly from the tailpipe of vehicles, ozone (O_3) is a secondary pollutant formed by the combination of emissions of NO_x and unburnt hydrocarbons.

Of all the pollutants emitted by vehicles, PM, especially the finer $PM_{2.5}$ is arguably the most harmful, having the ability to penetrate deep inside the lungs and it remain suspended in air for longer periods than coarser particles. While ambient PM_{10} may sometimes seem to be a bigger problem because larger, heavier particles lead to a higher ambient mass concentration, reducing the $PM_{2.5}$ fraction will actually have a deeper and more profound positive impact on public health.

5.3 HARMFUL EMISSIONS FROM MOTOR VEHICLES

Motor vehicles emit large quantities of carbon dioxide, carbon monoxide, hydrocarbons, nitrogen oxides, particulate matter and substances known as mobile source air toxics (MSATs) such as benzene, formaldehyde, acetaldehyde, 1,3-butadiene and lead (at least until unleaded gasoline replaced leaded gasoline). Each of these items, along with secondary by-products such as ozone and secondary aerosols (*e.g.* nitrates and inorganic and organic acids), can cause adverse effects on health and the environment. Pollutants from vehicle emissions are related to vehicle type (*e.g.* light or heavy duty vehicles) and age, operating and maintenance conditions, exhaust treatment, type and quality of fuel, wear of parts (*e.g.* tyres and brakes) and engine lubricants used.[4]

Re-suspended road dust, tyre wear and brake wear are sources of non-combustion PM emissions from motor vehicles, which contains chemical compounds, such as trace metals. However, current estimates of these emissions are uncertain. Thus, although they are not regulated in the way exhaust emissions are, non-combustion emissions may need to be considered more closely in future assessments of the impact of motor vehicles on health.

Actual measurement of motor vehicle emissions is critically important for validating emission models. Studies that have sampled the exhaust of moving vehicles in real world situations (specifically in tunnels) and on roadways have contributed useful information about the emission rates of the extant

[4] Report of the Working Groups 1 & 2.

motor vehicle fleet and have also allowed the evaluation of the impact of new emission control technologies and fuels on emissions.

5.4 IMPACT OF SPECIFIC POLLUTANTS ON HUMAN HEALTH

Many studies have been conducted over the years by leading Indian institutions such as Patel Chest Institute, AIIMS, Chittaranjan Cancer Institute, PG Medical College and Ramachandra Medical College of serious medical conditions that were attributable to a variety of toxins present in the ambient air, an important component of which is vehicular emissions.

5.4.1 World Health Organisation (WHO)

The linkage that pollutants in the ambient air, including that arising from vehicular emissions, have with adverse health consequences on the human population have been documented over the years. The WHO in its most recent factsheet on the "10 leading causes of death in the world, 2000 and 2011" lists ischemic heart disease at No.1, stroke at No.2, lower respiratory infections at No. 3, COPD at No. 4 and diarrheal diseases at No. 5. However, apart from global figures, the WHO also separately reports for Low Income Countries, where lower respiratory infections have been the No. 1 killer, followed by HIV/AIDS, diarrheal disease, stroke and ischemic heart disease.

On outdoor air pollution, the WHO says:

> "Outdoor air pollution is large and increasing as a consequence of the inefficient combustion of fuels for transport, power generation and other human activities like home heating and cooking. Combustion processes produce a complex mixture of pollutants that comprises of both primary emissions, such as diesel soot particles and lead, and the products of atmospheric transformation, such as ozone and sulphate particles.
>
> Urban outdoor air pollution is estimated to cause 1.3 million deaths worldwide per year. Children are particularly at risk due to the immaturity of their respiratory organ systems. Those living in middle-income countries disproportionately experience this burden. 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”.[5]

WHO World Map of Exposure to Particulate Matter

A global map prepared by the WHO on the presence of particulate matter in the ambient air for the period 2003-2010 is presented at **Chart 5.1**. It may be observed that the concentration of particulate matter in developing countries like India is higher than for the industrialised and developed world, notwithstanding lower levels of energy use and lower vehicular populations.

5.4.2 Global Burden of Disease (GBD) Study

The first GBD 1990 study quantified the health effects of over 100 diseases and injuries for 8 regions of the world in 1990. As the WHO says:

> “A consistent and comparative description of the burden of diseases and injuries and the risk factors that cause them is an important input to health decision-making and planning processes. Information that is available on mortality and health in populations in all regions of the world is fragmentary and sometimes inconsistent. Thus, a framework for integrating, validating, analysing and disseminating such information is needed to assess the comparative importance of diseases, injuries and risk factors in causing premature death, loss of health and disability in different populations. Countries can combine this type of evidence along with information about policies and their costs to decide how to set their health agenda”.

More recently, the WHO has been collaborating with the Institute for Health Metrics and Evaluation and other academic partners in bringing out the Global Burden of Disease 2010 (GBD 2010). This is the largest ever systematic effort to describe the global distribution and causes of a wide array of major diseases, injuries, and health risk factors and which the **Lancet** journal decided to publish in a special issue.

It applies consistent methods to the largest global database ever assembled to estimate risks of premature mortality and contributions to global health

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[5] WHO Webpage: http://www.who.int/ceh/risks/cehair/en/)

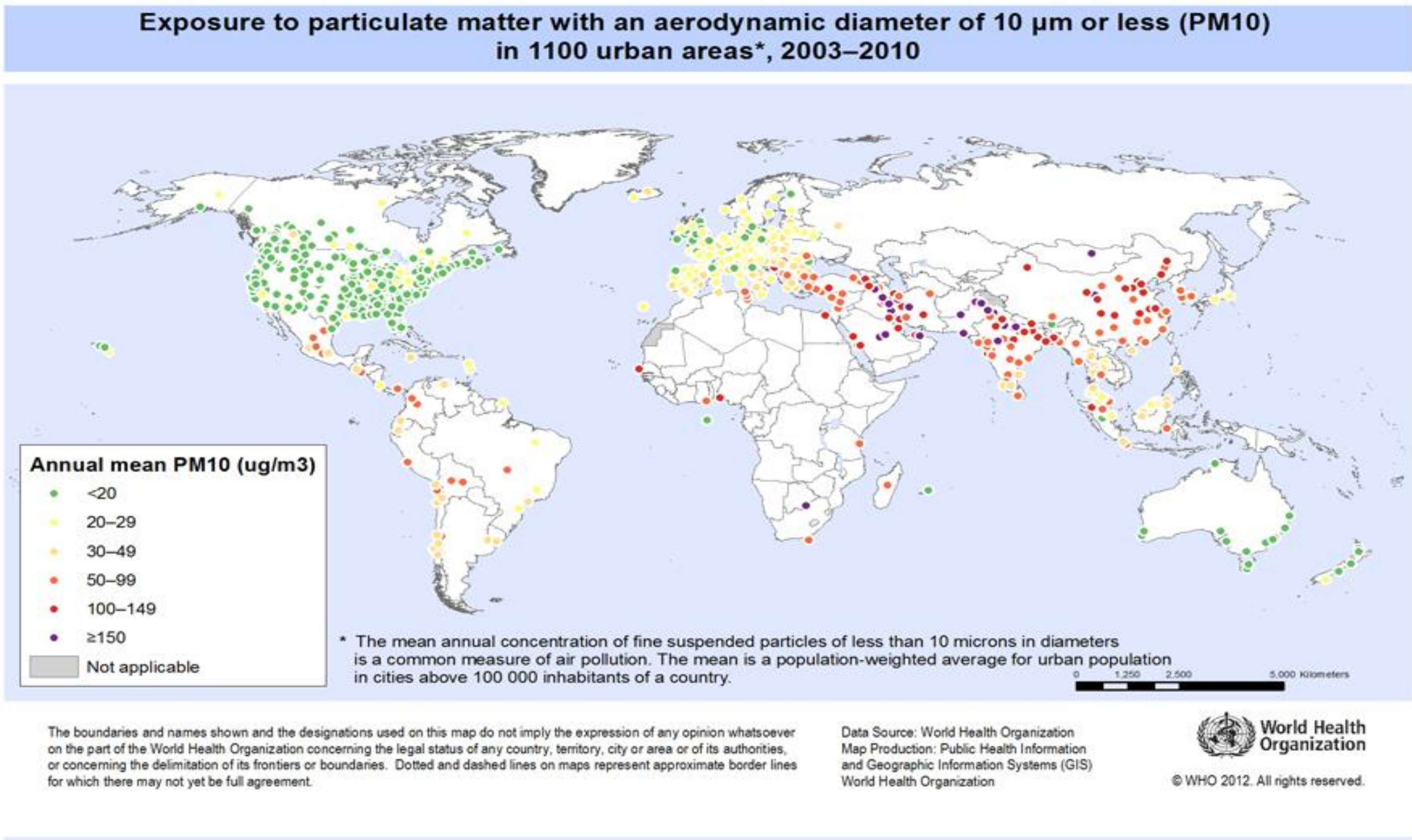
burden from a wide variety of risks: smoking, diet, alcohol, HIV/AIDS, household and outdoor air pollution, and many more. For the first time it places outdoor air pollution among the top 10 risks worldwide and among the top five or six risks in the developing countries of Asia. It documents as well that household air pollution from the burning of solid fuels is responsible for a substantial burden of disease in low and middle income countries.

This new analysis identifies especially high risk levels in the developing countries of Asia where air pollution levels are the highest in the world. Overall GBD 2010 estimates over 2 million premature deaths and 52 million years of healthy life lost in 2010 due to ambient fine particle air pollution, fully two thirds of the burden worldwide. Among other risk factors studied in the GBD, outdoor air pollution ranked 4th in mortality and health burden in East Asia (China and North Korea) where it contributed to 1.2 million deaths in 2010, and 6th in South Asia (including India, Pakistan, Bangladesh and Sri Lanka) where it contributed to 712,000 deaths in 2010. The analysis found that reducing the burden of disease due to air pollution in Asia will require substantial decreases in the high levels of air pollution in those regions.

5.5 CAUSAL LINKAGES BETWEEN VEHICULAR POLLUTION AND HUMAN HEALTH

As the evidence has mounted linking exposure to traffic emissions with adverse human health conditions, increasingly the focus has been to identify the more virulent elements in traffic pollution – even as one, namely lead has been removed – and increasingly strict restrictions placed on emissions and fuel quality. There has also been a shift away from mere correlation and towards developing causal linkages.

Chart 5.1
WHO World Map of Exposure to Particulate Matter



5.5.1 The Panel Report of the Health Effects Institute

The Health Effects Institute (HEI) is a Boston, Massachusetts based research organisation focused on examining the impact on health of among other things, outdoor air pollution and had been a partner in the GBD (2010) research effort. The HEI had constituted an international panel of experts to review the research done in the area of human health and likely causation from traffic emissions and this was published in 2010. The discussion that follows largely follows the way the matter was organised in the HEI report which in content is similar to reports of other agencies that have gone into the matter.

Mortality and Traffic Emissions

There have been very few studies that examine the evidence of association of mortality from all causes or of cardiovascular mortality with long-term exposure to traffic related emission. In consequence, the conclusions or inferences that have been developed are classified as "suggestive but not sufficient" insofar as a clear causal association goes. The four studies of all-cause mortality associated with short-term exposure, which met the Panel's criteria, were also classified as "suggestive but not sufficient".

In respect of short-term exposure to traffic related emissions, only four time-series studies of all-cause mortality met the Panel's criteria. Hence, these were classified as "suggestive but not sufficient," largely on the strength of one well-done study.

Many of the issues that applied to studies of all-cause mortality also applied to studies of cardiovascular mortality associated with long-term exposure and led, similarly, to a classification of "suggestive but not sufficient". Only two time-series studies of cardiovascular mortality met the inclusion criteria, and although they both show positive associations, the Panel concluded that, given the overall paucity of studies, the evidence for effects of short-term exposure was "inadequate and insufficient".

Cardiovascular Morbidity

Studies that documented changes in cardiac physiology after short-term exposure to traffic related pollution provided strong evidence for a causal association with exposure. However, failure of some studies to consider stress and noise as potential confounders led the Panel to classify them as "suggestive but not sufficient" in regard to a casual association. Collectively, the studies made a very strong case for an association between exposure to traffic related pollutants and atherosclerosis. However, because of the small number of studies, the Panel classified them as "suggestive but not sufficient" to infer a causal association.

There have been a few toxicology studies that examined the cardiovascular effects of traffic emissions specifically. However, the Panel concluded that the recent toxicology literature provides suggestive evidence that exposure to pollutants that are components of traffic emissions, including ambient and laboratory-generated PM and exhaust from diesel and gasoline-fuelled engines, alters cardiovascular function. There is also evidence, albeit inconsistent, for acute effects on vascular homeostasis and suggestive evidence in animal models that repeated exposures to ambient PM in general enhance the development of atherosclerosis. Some studies support the involvement of oxidative stress. Although the evidence from toxicology studies in isolation is not sufficient in terms of a causal association between traffic emissions and the incidence or progression of cardiovascular disease, when viewed together with the epidemiologic evidence, a stronger case could be made for a potential causal role for traffic-related pollutants in cardiovascular-disease morbidity and mortality. The extent to which these associations apply to individuals without underlying cardiovascular disease cannot be determined from the evidence available at this time.

Asthma and Respiratory Health Problems, Particularly in Children

Asthma is an inflammatory disease of the lung air ways characterised by episodic obstruction, which can lead to chronic obstructive lung disease. The most prevalent form of asthma in children and young adults is allergic asthma. This develops as immune response to inhaled allergens. Individuals with asthma and other allergic conditions who have an increased tendency to develop immediate and localised reactions to allergens (*e.g.* pollens) that are mediated by immunoglobulin E (IgE) are referred to as “atopic”.

Extracting from a number of studies, the Panel concluded that living close to busy roads appears to be an independent risk factor for the onset of childhood asthma. The Panel considered the evidence for a causal relation to be in a gray zone between “sufficient” and “suggestive but not sufficient”. The results found across the studies followed a pattern that would be expected under the plausible assumption that the pollutants really are causally associated with asthma development, if only among a subset of children with some accompanying pattern of endogenous or exogenous susceptibility factors. The conditions that underlie an increased risk for asthma development among children exposed to traffic-related pollutants are not known.

Although most of the studies reviewed were not restricted to children with asthma, all these symptoms were more prevalent among those with asthma, and it is very likely that there was an exacerbation of asthma. The Panel concluded that the evidence is “sufficient” to infer a causal association between traffic exposure and exacerbations of asthma but that it is “inadequate and insufficient” to infer a causal association between exposure and respiratory symptoms in children without asthma.

In the case of adults, the few human studies in which subjects were exposed to realistic traffic conditions (a road tunnel or busy street) were found to be supportive of the possibility that persons with asthma may be more susceptible to adverse health effects. The Panel’s evaluation of the toxicological data on the respiratory system regarding effects of traffic related air pollution was that such exposures result in mild acute inflammatory responses in healthy individuals and enhanced allergic responses in allergic asthmatics and animal models.

Lung Function and Chronic Obstructive Pulmonary Disease (COPD)

The studies reviewed were heterogeneous in their design, approach to exposure assessment, and lung-function measures. Given their limited comparability, the Panel concluded that the evidence is “suggestive but not sufficient” to infer a causal association between short- and long-term exposure to traffic-related pollution and decrements in lung function.

However, in the case of long term exposure, there was some coherence in the data, suggesting that (a) long-term exposure is associated with changes in lung function in adolescents and young adults; (b) lung-function measures are lower in people who live in more polluted areas; and (c) changing residence to a less-polluted area in one study is associated with improvements in lung function.

The first and second points are consistent with long-lasting effects on lung structure and/or function. The third point can be interpreted to indicate that some component of the apparent effects on lung function is reversible or is more the result of short-term exposure.

Because only two of the COPD studies fulfilled the criteria for inclusion in the review and their results were not consistent, the Panel concluded that there is “inadequate and insufficient” evidence for fixing a causal association between exposure to traffic pollution and COPD.

Allergy

The toxicology data provided strong mechanistic evidence in respect of the diesel particle component of traffic-generated pollution and IgE-mediated allergic reactions and some evidence for NO_2 and late-phase response to allergen. However, the epidemiology studies were not entirely consistent.

The Panel concluded that there is "inadequate and insufficient" evidence to infer a causal association, or even a non-causal association, between exposure to traffic-related pollution and IgE-mediated allergies.

Birth outcome

Although there is a considerable body of data from around the world which have identified a consistent association between exposure to ambient air pollution in general and various birth outcome measures (low birth weight, small for gestational age, and peri-natal mortality), there have been only four studies that met the reviewing criteria for examining the impact of traffic-related pollution to birth outcome. The small number of studies and their limited geographic coverage led the Panel to conclude that there is "inadequate and insufficient" evidence to infer causality.

Cancer

The toxicological research summarised included in vitro mutagenicity studies of exposure of cells to PM from traffic pollution, diesel or biodiesel exhaust, and organic components of some of these mixtures, as well as animal carcinogenicity studies after exposure to exhaust from diesel and gasoline-fuelled engines. Although studies in cells demonstrating the capacity of DEP to induce DNA-strand breaks, base oxidation, and mutagenicity provide a possible mechanism for the induction of carcinogenicity by traffic-related pollution, the applicability of *in vitro* mutagenicity studies to human risk assessment has been questioned. Animal studies have demonstrated the ability of high concentrations of exhaust components in both diesel and gasoline-fuelled engines to cause tumours in animals. However, caution needs to be exercised in extrapolating these data to the situation where people are exposed to much lower concentrations of pollutants, as seen in the epidemiology studies. Therefore, the Panel concluded that any statement that tries to relate the toxicological to the epidemiological data would be premature at this point in time.

Overall the Panel concluded that the evidence was “inadequate and insufficient” to make inferences for causality between exposure to traffic pollution and onset or development of cancer.

5.5.2 Overall Comments on Public Health Impact

Surrogates for traffic-related exposure have played, and are likely to continue to play, a preeminent role in exposure assessments in epidemiology studies. The optimal selection of relevant surrogates (especially surrogates that are single chemicals) depends on accurate knowledge of the degree to which they represent the chemical and physical properties of the actual primary traffic-pollution mixtures to which humans are exposed, which, in turn, depends on accurate knowledge of motor-vehicle–emissions composition and near-source transformation and dispersion. The Panel concluded that none of the pollutant surrogates (CO, NO_2, UFP, EC, and benzene) is unique to emissions from motor vehicles. Among the surrogates based on traffic-exposure models, the question remains as to the extent to which the proximity model (*i.e.* the simple distance-to-road measures) should be employed in future epidemiology studies because it is particularly prone to yielding measures potentially containing extraneous information that can lead to the confounding of associations between health effects and exposure. In the Panel’s view, the hybrid model is the current optimal method of assigning exposures to primary traffic related pollution.

Many aspects of the epidemiologic and toxicological evidence relating adverse human health effects to exposure to primary traffic-generated air pollution remain incomplete. However, the Panel concluded that the evidence is sufficient to support a causal relationship between exposure to traffic-related air pollution and exacerbation of asthma. It also found suggestive evidence of a causal relationship with onset of childhood asthma, non-asthma respiratory symptoms, impaired lung function, total and cardiovascular mortality, and cardiovascular morbidity, although the data are not sufficient to fully support causality. For a number of other health outcomes, there was limited evidence of associations, but the data were either inadequate or insufficient to draw firmer conclusions. The Panel's conclusions have to be considered in the context of the progress made to reduce emissions from motor vehicles. Since the epidemiology studies are based on past estimates of exposure from older vehicles, they may not provide an accurate guide to estimating health associations in the future.

In the light of the large number of people residing close to major roads, the Panel concludes that the sufficient and suggestive evidence for these health outcomes indicates that exposures to traffic-related pollution are likely to be of public health concern and deserve public attention. Although policy recommendations based on these conclusions are beyond the scope of this report, the Panel has tried to organise, summarise, and discuss the primary evidence in ways that will facilitate its usefulness to policy makers in the years ahead. The review conducted clearly show that traffic-related emissions impact ambient air quality on a wide range of spatial scales, from the local road side and to the over-arching urban scale to broadly regional background scales. Based on a synthesis of the best available evidence, it was identified that an exposure zone within a range of up to 300 to 500 metres from a major road, to be the area most highly impacted by traffic emissions. The range reflects the variable influence of background pollution concentrations, meteorological conditions, and season.

5.6 SOURCE APPORTIONMENT STUDY

The previous Expert Committee had recognised the fact that the existing air quality data was insufficient and required major expansion and augmentation of the existing network of air quality monitoring and supervision, with necessary funding. It recommended that surveys and studies on the sources of pollution and their apportionment to different sources should be initiated in the most polluted cities and the National Capital Territory.

5.6.1 Air Pollution Coming From Different Sources

Source apportionment or similar studies have been carried out elsewhere in the world – especially in the US and European Union. Air pollution, specifically oxides of sulphur and nitrogen, *i.e.* SO_x and NO_x, and particulate matter (PM) as well as others are generated by a variety of activities and vehicular traffic exhaust emissions are one of the principal elements amongst them. The impact of air pollution or rather its severity on human health varies with geography and season, as well as the time of day. Inland urban centres are in general more vulnerable than coastal locations and some seasons are much worse than others on account of varying meteorology. At times of day of peak economic activity and traffic, pollution conditions worsen. Within a city there is considerable variation depending on the location – background, residential, commercial, industrial or kerbside.

In order to manage the ambient air quality it is necessary to identify which source contributes how much to the total inventory of emissions. Only then can policy/regulatory intervention hope to be successful. The shift from leaded to unleaded gasoline has resulted in a massive decline in atmospheric lead pollution in urban centres across the world – a case of clear cut successful achievement of end outcomes.

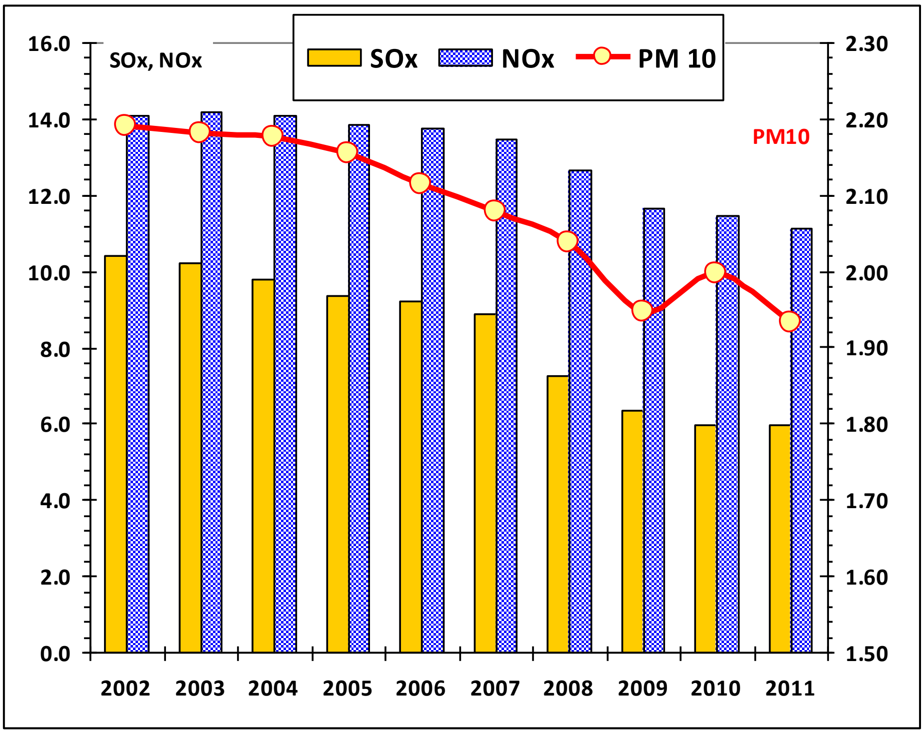
5.6.2 Sources of Air Pollution in Europe

The aggregate air pollution inventory in the EU is reported at the national aggregative level and is available in considerable detail. A perusal of the data shows (**Chart 5.2**) that there has been a decline in measured air pollution at the national level, particularly in the case of sulphur (SO_x).

Chart 5.2

Generation of Air Pollutants in Europe in Recent Years

Unit: Million metric tonnes per annum



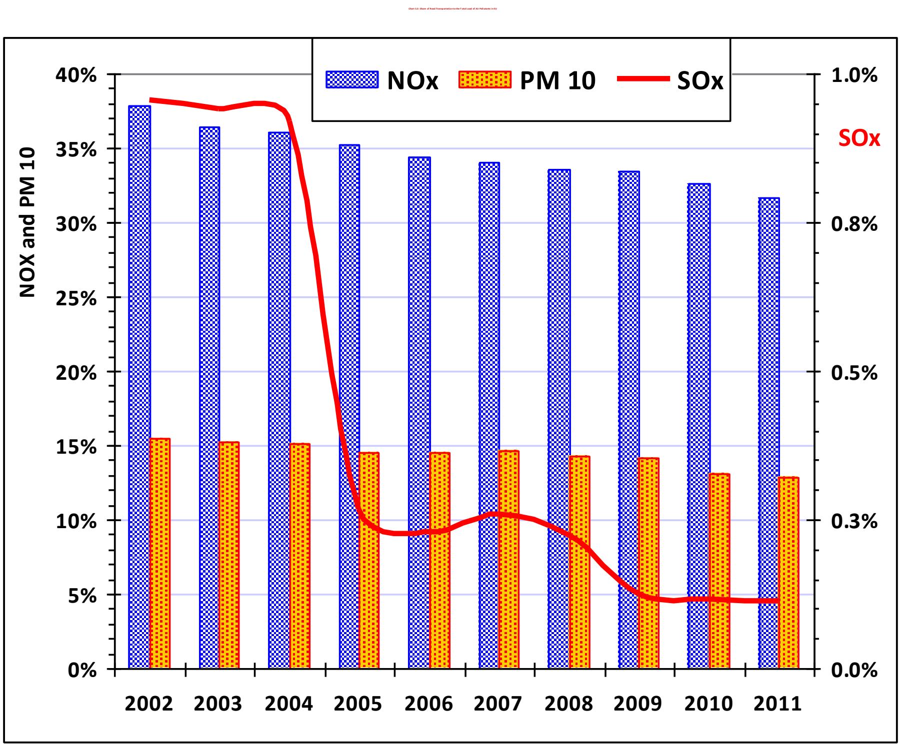
Source: Air Pollution Database, European Environmental Agency

The contribution of vehicular exhaust and non-exhaust emissions to the total generation of air pollutants is less than 1% for SO_x, about one third for NO_x and 10–15% for PM. Even in these ratios, there has been a significant decline in the contribution of road transportation activities to the total load of emissions as can be seen from **Chart 5.3**.

It has been estimated that in the EU, road transport exhaust contributes 33% to total NO_x loading at the aggregate level, while road transport non-exhaust sources add another 4%. Including railways, shipping and aviation the aggregate contribution to NO_x emission from transportation was found to be 58%, with the balance 42% coming from non-transport activities. In the case of PM_{10}, road transport is estimated to have contributed 22% to the total loading, with road transport exhaust accounting for 7% and road transport non-exhaust adding 6%.

Chart 5.3

Share of Road Transportation to the Total Load of Air Pollutants in EU



Source: Air Pollution Database, European Environmental Agency

However, if the estimation is carried out for urban areas separately than for rural areas – at the national level what we get is an aggregation across urban and rural areas – the contribution of road transport exhaust and non-exhaust is higher. The contribution in urban areas of vehicular traffic to PM_{10} is estimated to be 34%, with the figure likely to be higher for $PM_{2.5}$ and that for NO_x estimated at 64%.[6]

Other studies that have examined nature and likely source wise contribution of particulate matter have shown that in European cities, there is a sizeable step up in the presence of particulate matter – both PM_{10} and $PM_{2.5}$ – as between regional background, urban background and road or kerbside.

[6] Contribution of Transport to Air Quality, Alfredo Sanchez Vicente, European Environment Agency (2013)

Further that much of this step up in particulate matter generation is on account of vehicular traffic and that is even truer for $PM_{2.5}$.

Studies in several German cities show that first there is about one third higher concentration of particulate matter in the kerbside compared to the urban background and that over 60% of this – both PM_{10} and $PM_{2.5}$ – is on account of vehicular traffic. In the UK, studies showed that the elevation of particulate matter at the kerbside over the background was much higher at 53% for PM_{10} and 44% for $PM_{2.5}$. The contribution of vehicular traffic via higher elemental carbon was 43% for PM_{10} and 76% for $PM_{2.5}$.[7]

5.6.3 Sources of Air Pollution in USA

Source apportionment studies have been extensively carried out in the USA as well. Secondary sulphate/coal (from coal combustion) was identified as the largest or one of the largest sources in studies carried out on particulate source apportionment.[8] Secondary organic matter/mobile sources (from road traffic), was also identified major source in nearly all the sites. Nitrate (ammonium nitrate and also sulphate) was also found to be a large contributor and the source activity was agricultural activity. Biomass burning, industrial and other activities were also flagged as sources.

The source apportionment study carried out for 8 sites in the USA for $PM_{2.5}$ showed that coal combustion (mostly in coal fired power plants) contributed a median value of 38% of total $PM_{2.5}$, while mobile sources (traffic) contributed a median value of 23%. Ammonium nitrate made up for 15%. In the capital, Washington DC, mobile sources (traffic) accounted for 28% and coal combustion for 46%.[9]

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7 Second Position Paper on Particulate Matter, CAFÉ, European Environment Agency, Dec 2004.

8 Compilation of Existing Studies on Source Apportionment for PM2.5, Second Draft Technical Report, prepared for US EPA, August 2003.

9 Final Report, Eight Site Source Apportionment of PM2.5 Speciation Trends Data, prepared for US EPA, Sept 2003.

In the USA, the trend over time indicates that there has been a reduction in the degree of air pollution. The EPA notes that:

> "Since 1990, nationwide air quality has improved significantly for the six common air pollutants . . . (namely) . . . ground level ozone, particle pollution ($PM_{2.5}$, PM_{10}), lead, nitrogen dioxide, carbon monoxide and sulphur dioxide".[10]

The EPA document notes that the order of decline in air pollution has been significant: 45% for annual levels of nitrogen dioxide, 75% for sulphur dioxide, 24% for $PM_{2.5}$. It however points out that nearly 40% of the population resided in districts where the national standards were regularly exceeded in respect of one or more parameters.

In the national emissions inventory for 2008,[11] it is estimated that the contribution of on road vehicles to air pollution is highest in the case of carbon monoxide (58%), nitrogen oxides (40%) and volatile carbon compounds (23%). The share of on-road vehicles towards sulphur oxides is a mere 1% and that to $PM_{2.5}$ is surprisingly low at 6.7%. However, if the focus is shifted from the national inventory to urban locales, the share of on-road vehicles to $PM_{2.5}$ may be substantially higher.

5.7 BACKGROUND OF SOURCE APPORTIONMENT STUDY 2010

The petroleum industry initiated the Air Quality Monitoring, Emission Inventory, Source Apportionment Studies and Emission Factor Determination Projects at an estimated cost of Rs 13.50 crore in August 2003. IOCL, HPCL, BPCL and RIL began this project in collaboration with leading research institutes, *viz.* National Environmental Engineering Research Institute (NEERI), Nagpur; The Energy & Resources Institute (TERI), New Delhi and Automotive

[10] Our Nation's Air: Status and Trends Through 2012", US EPA-454/R-12-001, Feb 2012,

[11] 2008 Report on National Emissions Inventory: Review, Analysis and Highlights, US EPA, May 2013.

Research Association of India (ARAI), Pune. The Air Quality Monitoring (AQM) and source apportionment studies were undertaken as indicated below:

Delhi	-	NEERI
Bangalore	-	TERI
Pune	-	ARAI
Mumbai	-	NEERI
Chennai	-	IIT Madras
Kanpur	-	IIT Kanpur

In addition to air quality monitoring, ARAI was also assigned the responsibility for development of Emission Factors for Vehicles. The IIT, Mumbai was identified to take up source profiling for non-vehicular sources, while ARAI was to take up source profiling for vehicles.

MoE&F is the regulator and enforcement agency for environmental standards and was requested by the oil industry to lead the AQM projects thus initiated. MoE&F took ownership of these studies in October 2005. It constituted a Steering & Technical Committees with representatives from MoP&NG, MoRT&H, MoE&F, CPCB, SPCBs, NEERI, ARAI, TERI, SIAM and Oil Companies. The Steering Committee under the Chair of Secretary, MoE&F monitored progress of the programme. The Technical Committee chaired by Chairman, CPCB, provided technical guidance and support.

In order to ensure that the studies produce consistent and comparable results, CPCB reviewed the scope of work and methodology and made some modifications. Some of these were as under:

a) Besides PM_{10}, monitoring/source apportionment of $PM_{2.5}$ was included.

b) The survey and preparation of detailed emission inventory for zone of influence (2x2 km^2area) around each Ambient Air Quality (AAQ) monitoring location was incorporated.

c) Two new studies on developing profiles for vehicular and other sources (construction activities, roadside dust, DG sets, combustion etc.) were included in the scope.

5.8 SCOPE OF THE STUDY

1) Building of emission inventories;
2) Monitoring of ambient air quality for various pollutants *viz.* SPM, PM_{10}, $PM_{2.5}$, SO_2, NO_x, CO, O_3, Benzene etc.
3) Chemical speciation of ambient PM_{10} & $PM_{2.5}$ and that of source emissions for applying dispersion;
4) Future projections and evaluation of various control options to develop cost effective action plans.

5.9 SOME FINDINGS FROM THE STUDY

The final report on Source Apportionment Study undertaken at 6 cities *viz.* Delhi, Mumbai, Chennai, Bangalore, Pune and Kanpur was brought out by CPCB in February 2011.[12] Some of the findings of the report are discussed here to highlight the emerging trends. Along with this, select observations on air quality over a longer time period is reproduced here to give a sense of the direction of the change and of its principal components.

5.9.1 Change in Air Quality in Delhi Over Time

Some of the findings of the report are discussed here to highlight the pattern of development. The air quality in Delhi has been of particular concern, both on account of the intensity of generation of pollutants from diverse factors, including vehicular exhaust and the meteorological characteristics of this inland locations that results in "inversion" in the winter months resulting in particular severe deterioration of ambient air quality. The data is also available for Delhi over a slightly longer time period.

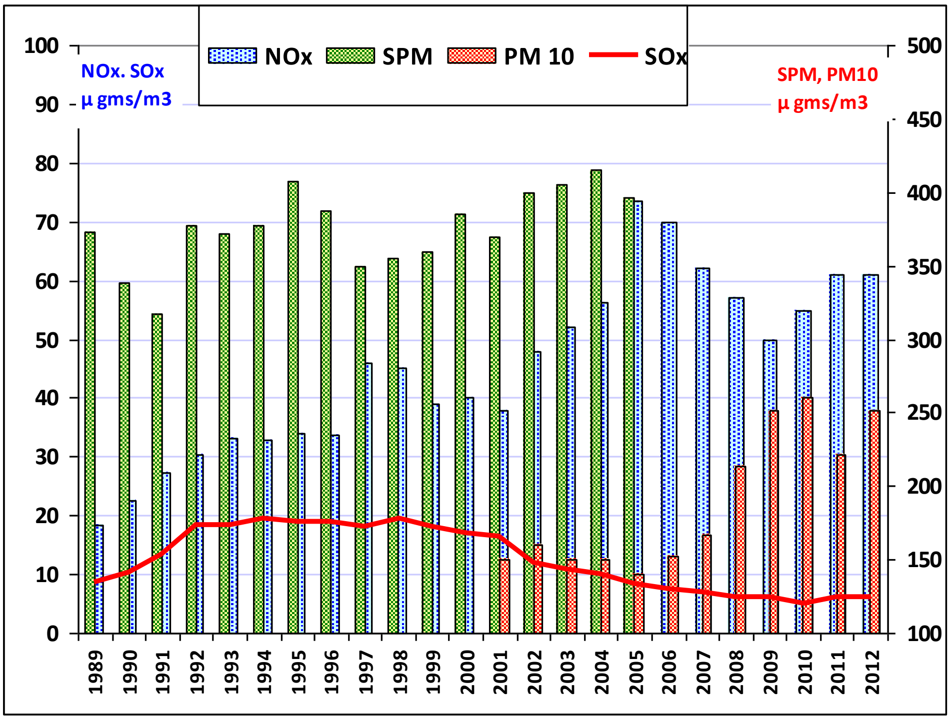
There are several specifics that are notable in **Chart 5.4**. First, the sharp reduction in sulphur oxides (SO_x) content which increased rapidly from 8.9 micrograms (µ gms) per cubic metre (m3) in 1989 to over 19 in the nineties,

12 Air quality monitoring, emission inventory and source apportionment study for Indian cities, Dec 2010, CPCB

before declining in the course of the 2010s to 6.0 µ gms/m3 in 2012. The reduction in sulphur content in automotive fuel perhaps played a part in this, as must have the relocation of industries away from the capital city.

Chart 5.4

Levels (annual average) of Critical Air Pollutants in Delhi over the Past 23 Years



Source: Compiled from White Paper on Pollution in Delhi, Dr B Sengupta's presentation (2011), "Towards Cleaner Air", Delhi Pollution Control Board and data directly from CPCB.

Second is the steady pick-up in nitrogen oxides after a few dips in the early years of 2000s and then again in 2008 and 2009. As we have seen in USA and Europe a large share of the contribution to NO_x comes from vehicular tailpipe exhaust.

Third, is the fairly steady level of PM_{10} concentrations up to 2005, which may be contrasted with the pick up in $PM_{2.5}$ concentrations from the middle of the decade of the 2000's. Again the global data referred previously tends to suggest that in urban locales, the pick up of $PM_{2.5}$ is most often from the increase in elemental and organic carbon that can be sources to the tailpipe exhaust of internal combustion engines – both on road and stationary. That is, in the Indian and particularly Delhi context to motor vehicle tailpipe and diesel generating set exhaust.

5.9.2 Comparison of Air Pollution – Levels & Trends – in Some Indian Cities

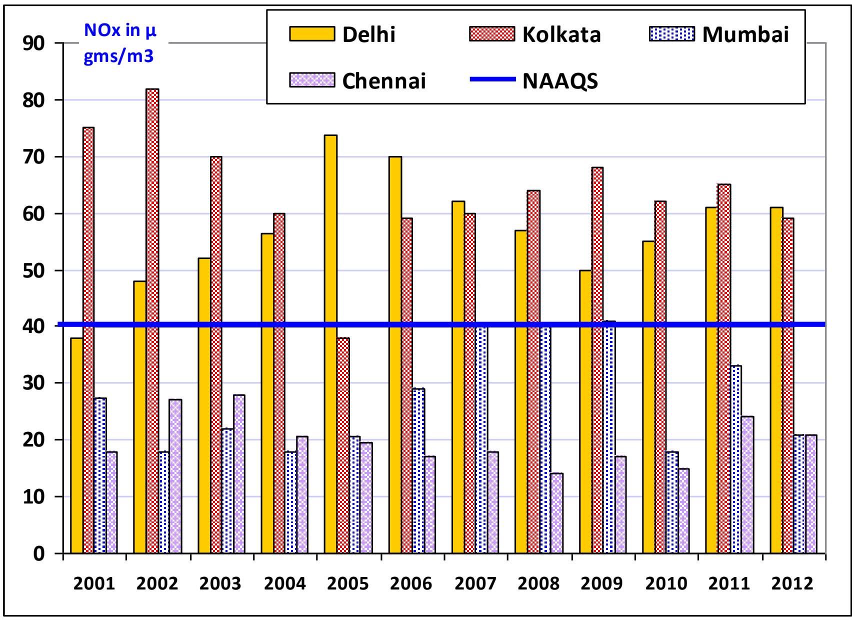
There are significant differences between first the level of air pollution in the different cities of India and even amongst the metropolitan cities and in the manner in which they have changed over the course of the years. In **Charts 5.5 and 5.6**, the principal air pollutants (annual average) have been plotted for the years 2001 to 2012. What stands out is the big difference between the higher levels of air pollution in Delhi and Kolkata, compared to Mumbai and Chennai. This is true both for nitrogen oxides and for particulate matter (PM_{10}).

Second, in Delhi, while NO_2 levels seems to have not increased significantly over time, that of PM_{10} has increased quite sharply in recent years. On the other hand in Kolkata, NO_2 seems to have abated a bit, as also PM_{10}. However, in both cities, the levels are much above the National Ambient Air Quality Standard (NAAQS) over the entire time period.

Third, in Mumbai and Chennai, the NO_2 levels have and continue to remain within the NAAQS, although since 2007 the PM_{10} in Mumbai is staying well above the NAAQS. Not so Chennai which remains compliant.

Chart 5.5

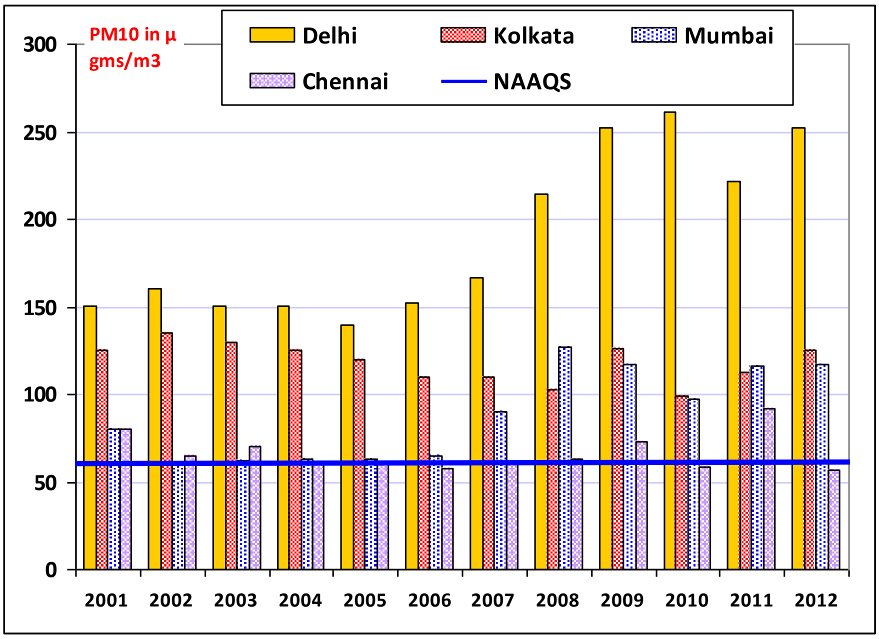
Concentrations (annual average) of Nitrogen Oxides in Four Metropolitan Cities National Ambient Air Quality Standard: 40 µ gms per cubic metre



Source: Compiled from data from Central Pollution Control Board

Chart 5.6

Concentrations (annual average) of PM_{10} in Four Metropolitan Cities National Ambient Air Quality Standard: 60 µ gms per cubic metre



Source: Compiled from data from Central Pollution Control Board

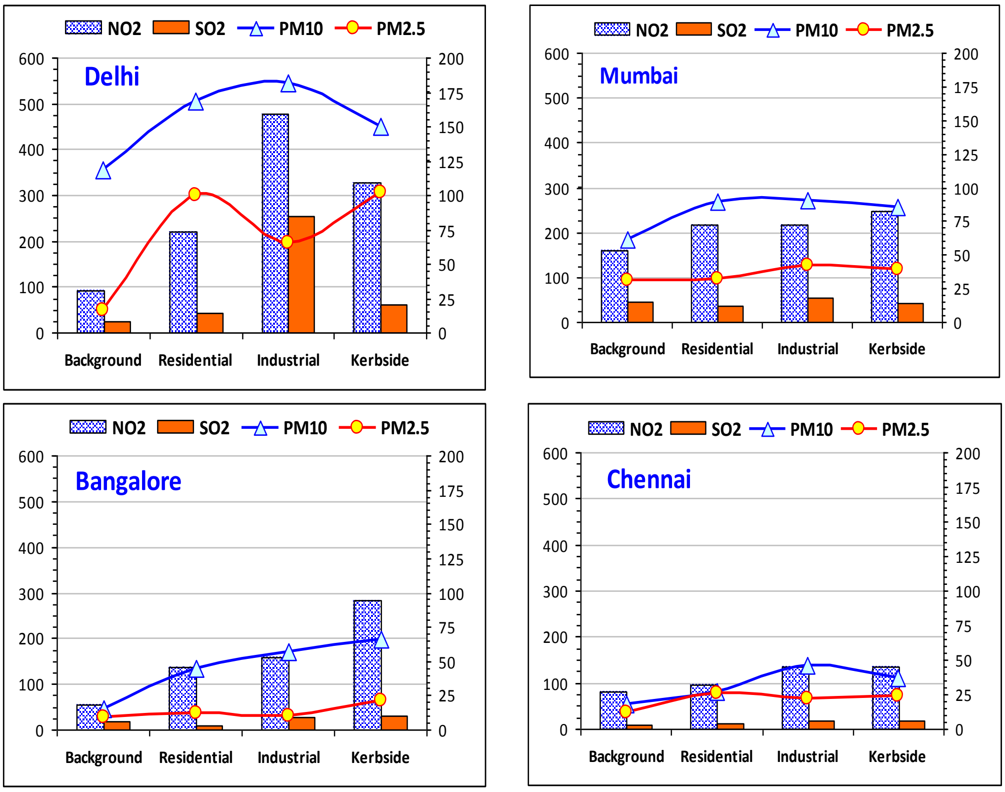
At **Chart 5.7**, the levels of NO_2, SO_2, PM_{10} and $PM_{2.5}$ in four cities separated in terms of principal economic activity – namely, background, residential, industrial and kerbside has been presented for the **Winter** season 2008-09. In all of these cities, the seasonal air pollution in winter is much above that in Summer and the Post-Monsoon. In order to bring out the wide difference in levels the scale on the two vertical axes has been kept constant, which brings out the massive difference in pollution levels between Delhi and Mumbai, and that between these two cities *vis-à-vis* Bangalore and Chennai.

Chart 5.7

Comparison of Air Pollution in Four Indian Metropolitan Cities in Winter Season (2008-2009)

PM_{10} & $PM_{2.5}$ on LHS Axis and NO_2 & SO_2 on RHS Axis

Unit: µ grams per cubic metre



Source: Compiled from data in Air Quality Monitoring, Emission Inventory and Source Apportionment Study for Indian Cities, National Summary Report, CPCB, Dec 2010, Table 3.2, pp 24–25

The other element of note is that air pollution levels in industrial and kerbside are of similar import and in the case of Delhi, the levels in the industrial areas are higher than that for the kerbside NO_2, SO_2 and PM_{10}, though not for $PM_{2.5}$. This actually reflects the high proportion of non-vehicular contribution to the air pollution inventory in Delhi and other cities.

Trend of air quality with respect to SO_2, NO_2 and PM_{10} in 50 major Indian metropolitan cities during the last five years (2008 to 2012) is tabulated in **Annexure 2**.

5.9.3 Source-wise Contribution to Air Pollution Inventory – Indian Cities

Expectedly the contribution to air pollution in the six cities studied was seen to be coming from a variety of source – both stationary and mobile. Stationary sources included on the one hand dust from paved and unpaved roads, dust from construction activities and on the other thermal power plants, industrial activity, domestic combustion of LPG, kerosene and solid fuels, bakeries, garbage burning, crematoria and diesel generating (DG) sets. Mobile sources primarily encompassed on road vehicle exhaust, but also diesel locomotives and marine transport the two of which were significant sources in Mumbai. The city wise and pollutant wise variation is depicted at **Chart 5.8**.

In four of the six cities, nitrogen oxides were found to be coming mostly from on road vehicular traffic. In two – Delhi and Mumbai – the most important source was found to be coal thermal power stations. In Bangalore, DG sets was seen to be the second most important sources of NO_x and in Mumbai it was diesel locomotives. The primary source of sulphur dioxide was found to be thermal power plants (in Delhi and Mumbai) and industry (in Mumbai, Kanpur, Bangalore and Pune). Only in Chennai was vehicular exhaust seen to be a significantly large source (48%).

Source contribution in particulate matter varied as between PM_{10} and $PM_{2.5}$. The coarser and broader PM_{10} particles were seen to originate primarily from road dust (73% in Chennai, 61% in Pune and 53% in Delhi) and industry (32%

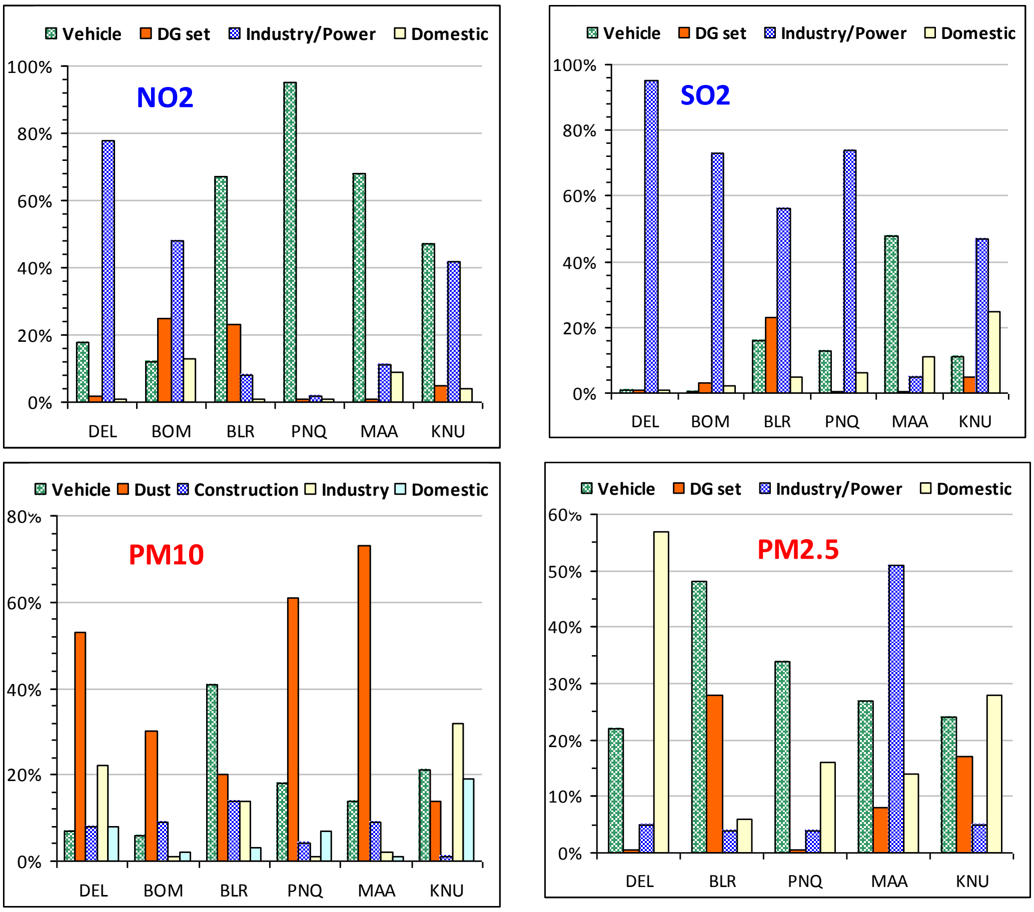
in Kanpur and 22% in Delhi). Vehicular exhaust was found to be a major source only in Bangalore (41%).

In the case of $PM_{2.5}$, there was a more varied picture with vehicular exhaust seen to be a bigger contributor to $PM_{2.5}$ than to PM_{10}. However, only in Bangalore was vehicular exhaust the principal contributor (48%), followed by DG sets (28%). In Delhi the lead was taken by domestic kitchen fuels (57%), followed by vehicular exhaust (22%). In Chennai vehicular exhaust (27%), coal burning (27%) and road dust (24%) were the leading contributors. In Kanpur domestic fuels (28%), vehicular exhaust (24%) and DG sets (18%) were the leading contributors.

Chart 5.8

Source Wise Contribution to Air Pollution in Six Indian Metropolitan Cities

Unit: per cent of total



Note: DEL=Delhi; BOM=Mumbai; BLR=Bangalore; PNQ=Pune; MAA-Chennai; KNU=Kanpur

Source: Compiled from data in Air Quality Monitoring, Emission Inventory and Source Apportionment Study for Indian Cities, National Summary Report, CPCB, Dec 2010, pp 62–66

5.10 SUMMARY OF SOURCE APPORTIONMENT STUDY FINDINGS

The major findings of the Source Apportionment Study described above for Delhi, Mumbai, Chennai, Bangalore, Pune and Kanpur were:

i. Annual RSPM average exceeded norms in all cities in all years except for Chennai.

ii. Generally NO_2 levels are within standard, but it is an emerging pollutant.

iii. The SO_2 levels are within standard and the decreasing trend is largely attributed to sulphur reduction in diesel (from BS II levels). Sulphur is emitted from tailpipes as sulphate or sulphur oxides, which are major contributors to the most dangerous pollutant for human health, ultra-fine particles (*i.e.* $PM_{2.5}$)

iv. RSPM is the most important pollution parameter in urban areas. PM pollution problem is severe.

v. Levels of PM_{10} and $PM_{2.5}$ in ambient air are significantly high irrespective of the type of locations.

vi. The presence of SPM, PM_{10}, $PM_{2.5}$ exceeded norms at almost all locations and in all seasons in Delhi and Kanpur.

vii. Even background locations indicate considerable levels of particulates, which could be occurring naturally and/or due to transport of finer dust.

viii. PM pollution problem is severe and NO_2 is the emerging pollutant.

ix. Concentration of pollutants is relatively higher at kerbside/roadside due to density of vehicular movement. Morning and evening peaks in CO levels correspond to intensity of vehicular movement.

x. Significant sources of particulate pollution arise from soil and road dust and this contributes to coarser fraction of PM_{10}.

xi. Re-suspension of road dust and combustion sources including vehicles, refuse burning & DG sets emerge as prominent sources of PM in all cities.

xii. Combustion sources including vehicles, DG sets, refuse burning etc. emit particles in the finer size ($< PM_{2.5}$).

xiii. Benzene levels are higher at Bangalore, Pune and Kanpur, while formaldehyde is a matter of concern in Mumbai, Pune and Bangalore.

xiv. Within the transport sector, PM_{10} contribution in terms of emission load is mainly from heavy duty diesel vehicles in almost all cities. In case of Kanpur, contribution from 3-wheelers is the highest. Heavy duty vehicles are the major contributor of NO_x emission.

xv. Elemental carbon (EC) and Organic carbon (OC) contribution to $PM_{2.5}$ is more than what it is to PM_{10}. It signifies that $PM_{2.5}$ is more toxic than PM_{10} that mostly come from combustion sources like vehicles, coal, biomass, garbage combustion and others.

5.11 Steps Required for Improving Air Quality

Based on the findings of the study, the steps that were identified for improving the air quality in urban areas were as under:

i. Better maintenance of roads, paving of unpaved roads, footpaths or low-elevation concreting of unpaved surfaces along major roads with high traffic.

ii. Preparation of guidelines by agencies responsible for road construction and maintenance for reducing silt load on roads.

iii. Progressive tightening of emission regulations.

iv. Universal use of BS IV norms throughout the country and subsequently introduction of BS V regulations, taking into account environmental and economic factors.

v. Ensuring nation-wide same quality of fuel.

vi. Restricting entry of polluting trucks and heavy duty goods vehicles and banning of old commercial vehicles in the cities.

vii. Need for comprehensive vehicle scrapping policy.

viii. Mandatory periodical inspection and maintenance in place of existing PUC system.

ix. Synchronising traffic signals, staggering business hours, restricting vehicular movements in certain areas with high pollution levels, fiscal incentives/disincentives, banning of odd/even vehicles on major roads.

x. Development of mass rapid transport system.

xi. Financial incentives for non-polluting vehicles – electric, hybrid etc.

xii. Identification of highly polluting areas as low emission zone.

xiii. Banning of garbage/refuse burning.

xiv. Reduction in use of DG sets by ensuring adequate power supply.

Besides the introduction of CNG for city transport few years back, BS IV fuels in 13 major cities and BS III fuels in rest of the country were introduced in 2010 in line with the **Auto Fuel Policy (2003)**. Although there have been significant improvements in air quality after introduction of cleaner fuels, gains to some extent, are getting neutralised due to increase in vehicular population and construction activities. Further, there have not been any significant scientific studies after the Source Apportionment Study mentioned above in India to assess the impact of improvement in air quality after introduction of cleaner fuels.

5.12 TOWARDS BETTER UNDERSTANDING OF THE EMISSION INVENTORY

Aside for the extensive work presented in the CPCB (2010) Report, recent years has seen numerous publications appearing in the scientific and technical literature on air quality in Indian cities. Most of these studies have been conducted by educational and research institutions in India, through Government funded projects; but not necessarily in a coordinated effort. Thus, there is a large diversity in the methods employed, parameters studied, and in some cases, the way in which the conclusions are deduced. Clearly, studies conducted by medical doctors seem to have very specific medical and toxicological perspective, while those from engineering institutions seem to be focussed mainly on receptor modelling and source apportionment. However, it is a rich body of literature and it is pertinent for the workings of this Committee, in as much as these complement the findings of the 2010 Source Apportionment Study. This may also form the basis for commissioning of future studies.

5.12.1 Problems in the Existing Research

India is a large and diverse country, and not surprisingly studies have drawn widely differing conclusions. Even within individual Indian cities, different authors have come to widely varying conclusions over source attribution and apportionment, and this may to some extent be a result of using different sampling locations and seasons. Most of the reported studies have identified vehicle emissions and soil/road dust as a major contribution to the fine and coarse fractions respectively, but differentiation of these from industrial emissions and other sources such as construction activity has not been very clearly achieved. The studies conducted to date seem to produce, *in toto*, a confused picture from a quantitative perspective even though a clear qualitative picture seems to be evolving.

The efforts which led to the CPCB (2010) report set a benchmark for this kind of work in India. Also, it produced valuable data of the kind that had not been done in the past, even though some scientific critique of that work has been reported by several experts [summarised for example, by Pant & Harrison (2012)]. However, this must be followed up by more studies of this kind, and perhaps involving the numerous experts around the country whose expertise should be tapped for this national effort. It is also important that the results be peer-reviewed and discussed, perhaps amongst these experts and also internationally, probably through publications in peer-reviewed journals. The latter is happening a lot, as seen from the vast body of work being reported, but the authors of these high quality pieces do not seem to be part of a coordinated umbrella effort.

Some other points need to be recorded for further discussion. First, most of studies have used multivariate statistical methods which have yielded factors represented by combinations of elemental and ionic constituents which cannot be unequivocally attributed to any specific source. Faced with factors associating often strange combinations of chemical components, authors feel obliged to attribute a source, but in many cases these are under question. The possible reasons are many and include genuine co-linearity of sources, or more likely an inadequate number of samples relative to the number of species analysed leading to instability in the statistical model.

Most of the studies used well under 100 samples. It is imperative that studies using multivariate statistical methods collect many more samples (100 is hardly a statistically significant number for this kind of work), and this must be done on a regular basis and also through various seasonal and local meteorological events. Such an exercise under the pressure of time in a short term time-bound project is unlikely to yield results. Long-term and sustained effort is therefore a requisite for a better understanding of the facts.

5.12.2 Improvements Required in the Research

The other major reason for a mixed picture is inadequate data to discriminate the background, both regional and local. The failure has been in most cases the inability to distinguish vehicle exhaust from non-exhaust vehicle emissions, particularly re-suspension of road dust, and/or inability to differentiate regional crustal sources (*e.g.* desert dust), from local wind-blown soils and from re-suspended road dust.

Making a distinction between road dust and local soils can be difficult under any circumstances if the soils are polluted by vehicle emissions or the road dusts contain a significant soil contribution.

However, separating these sources, and in particular quantifying the vehicle exhaust contribution alone, and differentiating regional crustal sources from local soils and road dust is crucial, as the policy response depends heavily upon these insights. In this light, there is also the need to develop multi-site studies Wherever these exist, they tend to use multiple sites within a city (*e.g.* CPCB report of 2010) rather than using urban/rural contrasts to elucidate the importance of emissions within the city relative to the regional background.

The above two points would ensure (or definitely improve) the issues related to mass closure in the different source apportionment studies. As mentioned clearly in the CPCB (2010) report, mass closure has been a challenge.

Equally important is to develop, through actual experimentation and modelling, better emission factors for non-vehicular sources. The ARAI effort in putting together emission factors for vehicular emission is of high quality, but unfortunately that is not matched with the same for non-vehicular sources. Thus, the final source apportionment gets plagued by this limitation. Indeed, this has been a criticism of the CPCB (2010) effort as well, as reported by various authors.

Though there are some studies reported on secondary pollutants, most studies pay little attention to them. Sulphate, which in developed countries is almost exclusively secondary, tends to be attributed to local primary sources and regional transport processes are largely ignored. Similarly, nitrate receives little attention despite its complex atmospheric chemistry and frequent association with regional processes in developed countries (Abdalmogith and Harrison, 2005). Secondary organic aerosol may be an important contributor to PM mass in India as the conditions exist to facilitate its formation from both anthropogenic and biogenic precursors, but the literature as well as past reports, ignore it.

There has been insufficient use of size fractionation of particulate matter. Most studies have focused upon TSP or PM_{10}, therefore not benefiting from the additional insights to be gained from separating coarse from fine particles, and in doing so achieving a crude separation of crustal/soil/road dust/construction sources from those associated with high temperature processes (fuel combustion, metallurgical industries, etc.) and gas-to-particle conversion to form secondary pollutants.

While the CPCB report (2010) as well as literature seems to recognise that the $PM_{2.5}$ is coming mainly from vehicular sources, measurements thus far have been few. Clearly as we move forward, a better assessment of the policy decisions on the crucial $PM_{2.5}$ fraction is imperative to have.

There has, to date, been insufficient use of organic molecular markers. While these alone will not answer all source apportionment questions, they are an important tool in the development of receptor modelling and could help to sharpen up both CMB and multivariate model studies.

5.13 Need for a Monitoring & Analysis System on Continuous Basis

There is a clear need to have an integrated, co-ordinated and standardised system that monitors and analyses the ambient air conditions in the major cities of India and does source apportionment on a continuous basis. This system should produce an annual status report and have a programme to cover the major cities on a rotation basis with greater frequency for the large metropolitan centres.

5.13.1 Recommendation for Further Technical Investigations and Studies During Rollout of AFV&P 2025 and Beyond

Past experience with the previous Auto Fuel Policy and other such policies have demonstrated the critical importance of continuously monitoring its progress, both the policy implementation as well as the expected outcomes for which it was defined, to ensure its success. For this to happen at a national scale, it is imperative to create the required monitoring and evaluation protocols, supported as necessary by on-going research, and involve a number of institutional and civil society partners to assist the process. In the case of the AFV&P 2025, substantial investments would be made by the petroleum and automobile sectors to upgrade their fuel quality and vehicular technology to ensure better ambient air qualities in India's cities and to minimise the adverse health impacts of ambient air pollution.

These investments would need to be supported by appropriate incentive/penal mechanisms, adequate awareness generation on 'right' practices as well as policies that would address other non-automotive sources of pollution. As such, the monitoring and evaluation studies that would need to be undertaken would have a multi-dimensional character and would necessarily have to be built on adequate quantifiable baseline datasets for proper impact assessment. Further, such studies will likely shape the course of future policy interventions, as well as direct mid-term course corrections of the implemented policies, as required.

5.13.2 Type of Studies/Activities

The kind of studies that will be required to be carried out can be broadly classified into three categories:

- Technology related, such as those relating to fuel quality, the refinery and fuel processing technology leading to a certain quality of fuel, modifications in engine technology, standardising driving cycles, developments in after-treatment devices and their operation in Indian context, use of alternative fuels, etc. Additionally, this set of activities should also ensure that the equipment and tools used for measuring and monitoring are standardised, calibrated and that the human capacities needed to interpret results are more uniformly endowed across the country.
- Environmental impact, health impact and toxicology related, such as periodic source apportionment studies in various cities and regions, assessment of background pollution, studying effect of certain kinds of pollution amongst various cohort groups, developing and implementing statistical tools for analysis and mining of such data, etc.
- Economics, policy and market related, such as demand analyses and pricing of various fuel types, adequacy of Institutional mechanisms for effective implementation of AFV&P, behavioural responses to energy and related policies having an impact on urban ambient air pollution, economic valuation of health impacts, etc.

5.13.3 Monitoring and Assessment

It is recommended to establish an Empowered Monitoring & Evaluation Committee with the Secretariat being provided by CPCB and with members drawn from all the stakeholders as well as independent experts knowledgeable in the various aspects (including technical, financial, health, social, environmental and institutional), to define the studies and analyses that would be undertaken for effective implementation of the AFV&P. Such a Standing Committee, resourced adequately, should meet several times a year and review new project proposals (against specific calls), oversee implementation of on-going projects in a time-bound manner, review final project reports, and most importantly, be empowered to make specific recommendations for policy interventions by distilling the key findings from various studies. The committee should also be empowered to consult various subject matter experts based in India and elsewhere for review of project proposals and reports so as to ensure the high quality of work through high level peer-review.

The process of project funding and implementation should be clearly laid out. It is recommended that the projects may be funded based on specific "needs" identified by the committee and awarded to qualified research groups around the country, or through an open "call for proposals" for major initiatives, or smaller-budget projects to be awarded in an ongoing manner. In all cases, key markers for implementation should be high technical merit (determined by a peer-review process) and the ability to extract key findings to shape future policy making in broad areas on interest (listed above).

5.13.4 Typical Studies/Activities

Based on the AFV&P 2025 report and deliberations over the past few months, it is clear that some of the topics that require further investigation would be as follows.

Technological

- Process innovations that may be required for reaching ULSD levels in diesel, over and beyond existing "brute-force" methods. Alternate protocols for reaching the ULSD levels in petroleum derivatives should be encouraged.
- Assessment of impact of increasing octane number on fuel efficiency of gasoline vehicles and financial/operational impact on refineries.
- Assess the effect of enhancing T_{95} point of diesel fuel on emissions of vehicles. There is considerable debate in literature over this, however it is worth assessing this impact since if the emissions are controllable, then this can add considerably to the diesel pool in the country.

- Assessment of performance of vehicular after-treatment devices with partially adulterated fuel, which may be realistic in Indian circumstances but never tested when many of these devices are developed in foreign countries.
- Assessment of "on-road performance" of the after-treatment devices (which is known to be distinct from testing on-chassis in well-defined laboratory conditions).
- Process innovations in after-treatment devices, such as partial filter DPFs, lean NO_x traps etc. However, such projects should be undertaken in association with interested automobile industry partners.
- Auditing of inspection and maintenance facilities including calibration of the analysers used.
- Development of calibration protocol for $PM_{10}/PM_{2.5}$ sampler.
- Accreditation of suppliers of $PM_{10}/PM_{2.5}$ sampler by national institute like NEERI/CPCB/CSIO/NPL etc.

Science/Process

- Following up on the MoE&F CPCB 2010 Source Apportionment Study by repeating the study in the six cities of that report, and extending the scope to other cities. Periodicity of such studies should be established (such as once in 3 to 5 years in the most polluted cities, once in 5 years in the next class of pollution cities, etc.). Air quality management and source apportionment studies to be carried out on continuous basis and shall be part of periodic review for policy and measures.
- Standardisation of measurement procedures should be upgraded and made at par with international standards, and the same should be communicated to all participating organisation and institutes. It is noteworthy that standardising the measurement of ultra-low concentrations, such as very small mass fraction of $PM_{2.5}$, or fine sulphate concentrations, is in itself a non-trivial research objective and should be taken up as a separate study from the source apportionment studies.
- Development of calibration protocol for continuous ambient air quality analysers (SO_2, NO_x, Hydrocarbon, Benzene, Ozone, $PM_{2.5}$ etc.).
- Conducting regularly chemical characterisation of $PM_{2.5}$ samples for OC, EC, Sulphate, Nitrate, Toxic and heavy metals etc.
- Black carbon measurement in ambient air using remote sensing techniques as well as manual sampler.

- Posting of source apportionment study findings in websites of CPCB/MoE&F.
- Development of air quality index and display of index in website as well as in various prominent location in cities.
- Development of suitable methodology for studying the effect of vehicular air pollution on health and applying the same in sample cities.

Market/Policy

- Defining regulatory strategies to ensure effective I&M of vehicles.
- Comparative studies on mobility demand patterns across cities with different modal mixes.
- Effectiveness of Institutional frameworks at state/city levels for ensuring clean air to its citizens.
- Aligning fiscal strategies with reduced urban air pollution.
- Cost-benefit analyses of auto-fuel policy interventions on the environment and health of urban populations.

Capacity Building

- All the above activities would need careful, well-thought out capacity building to take place in various agencies/institutions. A full programme would need to be drawn up for the purpose and funded separately.

CHAPTER 6

GLOBAL EXPERIENCE AND DEVELOPMENTS ON AUTO FUEL STANDARDS

6.1 DIRECTION OF THINKING ON EMISSION STANDARDS WORLDWIDE

As mentioned previously the first step at regulating vehicle performance was in the area of fuel efficiency in response to the oil shocks of the seventies. However, thereafter there was a shift focusing on mitigating the impact on deteriorating ambient air quality from vehicular emissions. This has had many elements to it including changes in engine technology, vehicle design, automotive fuel quality, incorporation of after treatment devices for tailpipe emissions and in petroleum refining to enable production of appropriate fuels, amongst others.

These changes were driven by regulatory initiatives, and enjoyed broad public support. Significant improvement in processes and technologies in both oil refining and automotive technology helped the process to bear fruit. While the broader move was to lower emissions of toxic products of fuel combustion, the emphasis primarily was on lowering NO_x and particulate emissions, combined with other co-objectives such as reduction in benzene and other aromatics. In the process of seeking to achieve these outcomes, reduction of sulphur in automotive fuel became the proximate target, for without drastic lowering of sulphur none of the other emission related objectives could be attained.

At the very high sulphur levels historically in use (3,000 to 5,000 ppm), sulphur oxides participated with other emission products to generate harmful mists and hazes. This was particularly true of diesel. As the sulphur levels were lowered to 500 ppm and below, the issue became one of matching after-treatment devices to limit the emission of harmful NO_x and carbon particulate matter, which for viability of the catalysts involved, required fuel of sulphur content of 50 ppm and lower. To the extent sulphur content could be lowered towards 10 ppm, economics of the catalyst use improved by lengthening its life; the economics and efficiency of after treatment devices improve, correspondingly leading to much better tailpipe emission regime.

6.2 FACTORS DRIVING ACHIEVEMENT OF BETTER AIR QUALITY

In the Auto Fuel Policy (2003) India had broadly aligned with the Euro norms on both fuel quality and tail pipe emissions. It may be mentioned that some of the particulars of the context for raising the ambient air quality standards in advanced countries were somewhat different than was the case with India.

- **EU**: In part to comply with the Kyoto protocol and pushing for CO_2 emission reduction
- **USA**: Ground level Ozone and CO in some cities
- **Japan**: Trade-off between particulates and NO_x in diesel engines and cost benefit approach
- **India**: Considerations of concentration of particulate matter (PM_{10} & $PM_{2.5}$).

It may be noted from the above that the key drivers for better air quality in India are more in line with Japan than other countries, even as we have implemented auto fuel quality standards conforming to that of Europe. Base levels of Particulate matters (PM_{10} & $PM_{2.5}$) are high in India owing to road dust and other local issues.

India also gets a large part of its vehicle technology from Japan and Korea. Hence there is a case for examining a broader menu of options and keeping the needs of India in the forefront when it comes to aligning or “similarising” fuel quality standards.

6.3 TRENDS IN GLOBAL AUTO FUEL STANDARDS

The rising number of passenger cars and commercial vehicles, the increasing number of diesel fuelled vehicles and an aging car fleet, all contribute to the increase in vehicle emissions from the transportation sector. To reduce the effect of these air pollutants, European countries have regulated vehicle emissions. In 1980, The EU developed an integrated policy to reduce the impact of transportation on air quality. European institutions have set a number of directives since the 1980's relating to emissions of gases and particulates from either light duty passenger cars or heavy duty buses and trucks. EU standards are commonly referred to as Euro standards. Tightening of emission norms was adopted at about the same time by all developed countries.

As of now, most developing countries that have followed the EU standards framework have implemented Euro III equivalent fuel specification having sulphur content of 150 ppm for gasoline and 350 ppm for diesel. Some of these developing countries have also introduced Euro IV equivalent fuels with 50 ppm sulphur in both gasoline and diesel, either nationally or in select hot spot cities. India is amongst the latter group.

Most developed countries have moved to lower sulphur content of 10–20 ppm. Euro V requires maximum of 10 ppm sulphur and that is also the case with the extant Japanese standards. In the USA the limit is 15 ppm for diesel and varying for gasoline. The situation in major countries has been summarised for developed (OECD) and non-OECD countries separately. While the emphasis in the summary is on the prescribed maxima for sulphur in diesel, there are considerable differences as between countries in respect of other components of fuel standards as well – such as benzene content, aromatics content, research octane number for gasoline, Cetane for diesel and in other properties.

OECD Countries

European Union (27)

The European Union (27 countries) have introduced 10 ppm sulphur Euro V gasoline and diesel fuels since 2008-09 and has moved to Euro VI fuels – which also limit sulphur to 10 ppm in 2014.

USA

Sulphur content in diesel across USA is limited to 15 ppm. There are varying limits for sulphur in gasoline. It is 80 ppm for the country with the exception of California, where different grades of ultra-low sulphur gasoline are in use with limits of 15, 20 and 30 ppm. However, for the country (except California) refiners are constrained within an annual average of 30 ppm sulphur in gasoline. The (annual) average limit for benzene in gasoline from July 2012 has been restricted to 1.3% by volume. For diesel, the specification requires either minimum Cetane index of 40, or max total aromatics of 35% volume.

Japan

Japan moved to 10 ppm sulphur fuels – both diesel and gasoline – in 2008.

Canada

Canada limits sulphur in gasoline to 80 ppm, while that for diesel is 15 ppm. Further, all primary suppliers must meet a sulphur average of 30 ppm. The per gallon cap for Benzene is 1.5% vol. max with an annual pool average of 0.95% vol., or, a flat batch limit of 1.0% vol.

Australia

In 2009 Australia moved to 10 ppm limits for sulphur in gasoline and diesel, from 50 ppm previously, in effect from 2006 for diesel and 2008 for gasoline.

Korea, Republic of

Korea limited sulphur in both gasoline and diesel to 10 ppm, starting 2009.

Mexico

Sulphur content in gasoline is 80 ppm, with 30 ppm gasoline available in three major metropolitan areas, which is proposed to be extended nationwide. The limit for sulphur in diesel is 500 ppm country wide. In three major metropolitan areas and on the US border diesel with 15 ppm is available. It is proposed to set the standard at 50 ppm for diesel country wide from 2015.

Non-OECD Countries

India

As discussed elsewhere from 2010 onwards BS IV fuel with 50 ppm max sulphur is sold in select cities (now 39 in number) and BS III elsewhere.

China

China has selectively introduced Euro IV equivalent fuels in Beijing, Shanghai and Guangdong, while Euro III equivalent fuels are sold in rest of the country.

In February 2013, China announced a timeline for implementation of 10 ppm sulphur fuel standards – China V standards – for both gasoline and diesel. It ought to be noted that while the China V standard reduces sulphur content to 10 ppm, the specifications for aromatics & olefins in gasoline and Cetane number for diesel still falls short of BS IV standards. The timeline for implementation of the China V fuel specification is:

- Nationwide "China IV" gasoline fuel quality standard to be phased-in by the end of 2013 and that of diesel by 2014.
- Nationwide "China V" gasoline and diesel fuel quality standards to be phased-in by the end of 2017.

Hong Kong, Taiwan and Singapore

Auto fuel sulphur content in all three has been restricted to 10 ppm.

Brazil

For diesel, Brazil in 2010 entered in a phase of transition from 1,800 ppm sulphur to 500 ppm, set to go countrywide from 2014. Further timelines have not been indicated. Gasoline sulphur country wide used to be 1,000 ppm till 2013 and from 2014 is set to a maximum of 50 ppm. In select metropolitan centres and regions the stipulated sulphur limits are set at lower levels.

South Africa

In South Africa, there are national level and specific tighter local norms. The national sulphur limit for diesel was 500 ppm generally and 50 ppm in specified locations. In 2017, country wide the sulphur limit is set to be reduced to 10 ppm. The present sulphur limit for gasoline is 500 ppm, but this is set to be reduced to 10 ppm starting 2017.

Russia

The present limit for sulphur in diesel and gasoline is 350 ppm and 150 ppm respectively. These are proposed to be reduced for both diesel and gasoline to 50 ppm in 2015 and to 10 ppm in 2016.

Thailand

The sulphur limit for both diesel and gasoline has been set to 150 ppm since 2005, which is proposed to be lowered to 50 ppm from 2017.

Malaysia

The sulphur limit for both diesel and gasoline has been set at 500 ppm. The changeover to 50 ppm is expected from 2015.

Indonesia

The sulphur limit for both diesel and gasoline is set at 500 ppm. There are proposals to lower the threshold to 50 ppm.

6.4 EXPECTED SULPHUR CONTENT IN AUTOMOTIVE FUELS

The **World Oil Outlook 2013**, published by OPEC has dealt extensively with the issue of reduction of sulphur in automotive fuels, mostly on account of regulatory mandates and the implications this will have on the refinery business. It has projected regional averages of sulphur content in gasoline and diesel starting from 2013 to 2035. What is of particular relevance to this Committee is the projection going forward to 2025. This is at **Table 6.1**.

Table 6.1

Expected Regional Sulphur Content in Gasoline and Diesel

Ppm	2013	2015	2020	2025
	Gasoline			
Europe	12	10	10	10
US & Canada	30	30	10	10
Latin America	435	195	80	45
Middle East	500	280	75	20
Russia & Caspian	180	105	45	17
Africa	875	575	235	175
Asia Pacific	195	135	70	40
	Diesel			
Europe	13	10	10	10
US & Canada	15	15	15	10
Latin America	870	400	155	40
Middle East	1,130	385	130	50
Russia & Caspian	400	220	80	25
Africa	3,350	2,110	890	400
Asia Pacific	325	190	105	45

Source: World Oil Outlook 2013, OPEC, Tables 5.3 & 5.4 pp. 204-205

The timelines that the Committee has worked towards has been on the lines of the expected trajectory in developed economies to 10 ppm sulphur in 2020, even if the rest of the world is not quite expected to keep pace. The timeline under the **Accelerated Transition Path** will result in bringing average sulphur content to ≤50 ppm by 2017 and to ≤10 ppm by 2019-2020.

6.5 Review of India's Current Fuel Specification

6.5.1 BS IV Auto Fuel Standard

The complete BS III and BS IV specifications for gasoline and diesel are at **Annexure 3.1** and **3.2** respectively. Some key parameters of BS III and BS IV gasoline and diesel fuel are presented here in **Table 6.2** and **Table 6.3**.

Table 6.2

Key Parameters for Motor Spirit or Gasoline

	Attribute	Unit	BS III		BS IV	
			Regular	Premium	Regular	Premium
1	Density at 15°C	kg/m3	720–775	720–775	720–775	720–775
2	Sulphur	ppm max	150	150	50	50
3	RON	min	91	95	91	95
	MON	min	81	85	81	85
4	Benzene	% vol. max	1	1	1	1
5	Aromatics	% vol. max	42	42	35	35
6	Olefin	% vol. max	21	18	21	18

Table 6.3

Key Parameters for High Speed Diesel

	Attribute	Unit	BS III	BS IV
1	Density @ 15°C	kg/m3	820–845	820–845
2	Distillation: 95% volume recovery @ °C max	°C	360	360
3	Sulphur	ppm max	350	50
4	Cetane Number	Min	51	51
5	Cetane Index	Min	46	46
6	Flash Point, Abel, min	°C	35	35
7	KV @ 40°C	cSt	2.0–4.5	2.0–4.5
8	Polycyclic Aromatic Hydrocarbon (PAH), max	% wt.	11	11

Note: i) For diesel processed from Assam crude, relaxation of Cetane Number & Cetane Index by 3 units and relaxation in density shall be applicable as provided in the present BIS specification.

ii) Density and 95% distillation recovery temperature limits shall be company pool average values. However, all samples shall meet the density @ 15°C limit of 820-860 kg/m3 and 95% minimum recovery at 370°C

6.5.2 Review of Auto Fuel Quality Specifications in USA, Europe, Japan, South Korea and China *vis-à-vis* India

The global parameters for gasoline and diesel fuel quality in some major regions/countries such as the European Union, USA, Japan, South Korea and China is placed at **Annexure 5** & **Annexure 6** respectively. Select quality parameters for diesel across the world are summarised at **Table 6.4.** It is clear that different countries have different quality parameters for diesel especially in respect of density, distillation recovery, viscosity etc.

Table 6.4

Select Physical Properties for Diesel

	Attribute	Unit	India	USA	EU	Japan	South Korea	China
1	Density	@ 15°C, kg/m3	820 –845	—	820 –845	860 max	815 –835	810– 850 @ 20°C
2	Recovery	95% vol. Recovery °C max	360	—	360	—	—	365
		90% vol. Recovery °C max	—	282 –338	—	360	360	355
3	Kinematic Viscosity	@ 40°C, cSt	2.0– 4.5	1.9– 4.1	2.0– 4.5	1.7– 2.7	1.9– 5.5	3.0 – 8.0 @ 20°C

In regard of diesel density, the USA does not have prescribed specifications, but only requires it to be reported, while Japan has a density specification of 860 kg/m3 max as against 820−845 kg/m3 for India. In both Japan and South Korea the distillation recovery specification, namely T_{90} is at 360° C, while it is T_{95} at 360° C in the case of India. It was initially felt that there might be a scope to revise Indian diesel specification without impacting emissions and ambient air quality as also efficiency and performance of vehicular engine.

India's Diesel Demand Pattern

Gasoline and diesel consumption pattern in India is different as compared to developed countries like the USA, Europe and Japan. Our diesel to gasoline ratio is almost 4½:1 (**Table 6.5**). This results in a requirement to proportionately produce much more diesel in the refinery than elsewhere. Relative prices of gasoline *vis-à-vis* diesel are a contributing factor. The taxation regime has historically been lighter on diesel than on gasoline. In the last many years subsidies extended to diesel has further contributed to skewing preference. These factors are absent in the developed world.

Table 6.5

Gasoline *vis-à-vis* Diesel Consumption in Select Regions/Countries in 2010

Table 6.5: Gasoline vis-à-vis Diesel Consumption in Select Regions/Countries in 2010

	Region/Country	Gasoline MTPA	Diesel MTPA	Share of Diesel
1	**India**	**14**	**60**	**81.0%**
2	European Union	93	287	75.6%
3	Korea Republic	8	19	70.4%
4	China	69	147	68.0%
5	Australia	14	16	54.4%
6	Japan	43	41	48.9%
7	Canada	32	27	45.2%
8	U S A	385	186	32.6%

In order to sustain proportionately much higher production of diesel in India, the physical quality parameters that inhibit diesel output with nil or negligible impact on emissions were re-examined. There was a view that with minor changes in some of these specifications, the quantity of diesel that can be incrementally produced could be significant.

Effect of T_{95} on Engine Performance and Emission Characteristics of Diesel-Fuelled Vehicles

In order to find out the effect of T_{95} limits on engine performance and emission characteristics of diesel vehicles, a sub-committee was constituted by the convenors of Working Group 1 & 2, with Prof. L.M. Das of IIT Delhi, who is a Member of this Committee, functioning as Convenor. The outcome of this study is summarised below.

Fuel properties affect the overall response characteristics of the engine in different ways. While fuel viscosity affects the fuel injection system, contribution of sulphur to aerosol and fine particulate emission has been well-documented.

The distillation process of diesel fuel indicates the amount of fuel that will boil off at a given temperature. In other words, T_{95} is the temperature at which 95% of a particular fuel distils in a standardised distillation test (ASTM D86).

Lower values for T_{95} simply shift to kerosene-oriented diesel fuels. This can decrease efficiency and mileage, as well as increase the maintenance requirements. Higher values for T_{95} indicate more of heavy end distillates and/or spiking with inappropriate components. Higher values can increase the soot going to the emission control system or into the atmosphere and can increase maintenance requirements.

Various studies had been conducted across the world in the past to assess the impact of T_{95} on engine performance and emission of diesel fuelled vehicles. While some of the studies show that reduction in T_{95} point reduces PM, but it results in increase of NO_x emissions. Another study showed that reducing the T_{95} does not have any impact on NO_x, while another study showed that T_{90} did not affect PM or NO_x. Most of the studies indicated that with lowering of T_{95}, PM is reduced while NO_x levels tended to be increased.

The Sub-committee felt that while, there was no conclusive evidence of effect of T_{95} on different emission parameters, it is necessary to bear in mind that with any relaxation in T_{95}, there is a possibility of slight increase in PM emissions as the downside and the possible slight reduction in NOx as a potential upside. This is pertinent particularly so, since the effort is to fast forward the roll out of ≤50 ppm sulphur diesel which would enable the installation of after treatment devices that directly go towards significantly reducing NOx emissions.

However, domains in the developed economies do maintain T_{90} and T_{95} at levels lower than their theoretical maximum, as indeed is the case with both Euro IV & V and with BS III and BS IV. The automobile industry also submitted that they had concerns about higher particulate and NO_x emission if the T_{95} was increased.

Relaxation of Physical Properties in Fuel Specification – Recommendations

The Working Group-3 made the following suggestions in BS III & BS IV auto fuel specifications. However, some of the academic members wanted this matter to be studied further.

- Either density to be made a reporting parameter in line with USA or revise it to 860 kg/m3 maximum in line with Japanese standards.
- Revise T_{95} from 360° C max to 370° C max; or set the standard to T_{90} at 360° C max in line with Japan and Korea.
- Modify viscosity specification from 2.0−4.5 cSt @ 40° C to 1.8−5.0 cSt which will also enable greater absorption of some refinery streams thereby enhancing BS IV diesel output in coming years.

However, following on the deliberations in the main Committee, it was decided that the specifications for BS IV as per the report of the Auto Fuel Committee (2003) will not be changed.[13] In any case for BS V the physical parameters for the above cited properties were to be reverted to be in line with Euro V.

[13] The *Auto Fuel Vision Policy 2003* document had stated in a footnote to the specifications for BS IV diesel that the density and T95 recovery limits as stated for BS IV shall be pool company average values, while all samples will have to satisfy a slightly relaxed density and T95 limits. This Committee has no objection to these recommendations being put into effect if BIS agrees.

6.5.3 Flash Point

For fuels, the property "Flash Point" is defined thus: It is the lowest temperature at which a chemical product yields a vapour which will give a momentary flash when ignited, determined in accordance with specified measurement provisions. Conditions for entrapment of the vapour and the presence of a flame source are necessary.

The flash point of diesel in India has historically been set at levels lower than in developed countries. This has primarily been to meet proportionately higher demand for diesel, for which heavy naphtha streams have been absorbed in diesel.

The flash point of diesel for both BS III and BS IV are set at 35^{o}C. Previously the BIS specification for diesel in India prior to BS III had set the flash point at 28^{o}C. In comparison, the flash point of diesel in both Brazil and Argentina is 38^{o}C; in Canada it is 40^{o}C, in USA (38^{o}C and 52^{o}C), in Japan (45^{o}C and 50^{o}C) and in China (45^{o}C and 55^{o}C).

Following two unfortunate fire accidents in buses, MoRT&H brought the issue to the specific attention of the Committee and the matter was re-examined. The conclusion was arrived that the cause of the fire accident was unrelated to the prescribed flash point.

However, in the media an opinion has been voiced that the prescribed flash point of 35^{o}C for diesel was "self-evidently hazardous" given that ambient (atmospheric) temperatures are often above 40^{o}C in the shade in India, while in Europe which prescribes 55^{o}C has colder ambient conditions.

This view is a misconception. Tropical countries like Brazil and Argentina too have lower flash points. The temperature in and around the engine of the vehicle is well over 100^{o}C – much above the highest flash point prescribed anywhere in the world.

However, it has been determined that existing refinery and operating conditions do permit an increase in the flash point. Accordingly, the prescribed flash point for BS IV diesel is being set at 38^{o}C, while that for BS V diesel is being raised further to 42^{o}C. This is being done primarily on account of working towards a greater convergence of fuel standards with the rest of the world and to assuage even misconceived apprehensions. It is imperative that the oil industry do its utmost to continually enhance the sense of safety and security amongst the citizens.

6.6 Reducing Sulphur in Auto Fuel

As discussed previously reducing the sulphur content of auto fuel, especially diesel, opens up greater options for emission control by way of after treatment devices. In the course of discussion it was initially felt that it may be possible with some effort to move to a modified BS IV specification which will limit the sulphur content to 40 ppm as against the present norm of 50 ppm. However, subsequently the public sector refineries stated their inability to meet 40 ppm norms even on an average basis as they were going to switch the bulk of their facilities from BS III (350 ppm for diesel and 150 ppm for gasoline) to 50 ppm and this would further constrain their ability to abide by the 40 ppm norm which means maintaining sulphur at the refinery dispatch point at 35 ppm.

Hence, the proposal to have a modified BS IV specification for both diesel and gasoline with ≤ 40 ppm sulphur was abandoned.

6.6.1 Behaviour of After Treatment Devices with Improved Fuel Quality

The primary advantage in moving from BS IV toward 50 ppm and even more so towards 10 ppm has to do with the sulphur level in the fuel. It is noteworthy that sulphur exists in petrol and diesel fuel in form of complex organic compounds, ranging from mercaptans, thiophenes, benzo-thiophenes, di-benzo-thiophenes, and their alkylated homologues (the last two groups also known as refractory sulphur compounds). As the regulations move towards lower allowable "sulphur" in fuel (in reality the above mentioned classes of organic sulphur compounds), and the refiner meets the demands using different variations of the hydro-desulphurisation process, the principal challenge lies in removing the refractory sulphur compounds from the liquid fuel. The process of removing them from oil is kinetically limited, owing to which the technology inter-versions for producing ultra-low sulphur fuel tend to be expensive. It becomes progressively more difficult to remove the trace quantities of the refractory sulphur compounds as one moves down to 10 ppm and below of sulphur (actually the sulphur compounds) level. Naturally, improved catalytic systems and reactor technologies at the refinery can make this chemistry possible, but significant investments are needed for such up-gradation.

When these sulphur compounds in diesel or petrol are oxidised, the primary emission from combustion in the engine is SO_2. Some of the SO_2 is further oxidised in its path through the engine, exhaust lines, catalyst and eventually to the atmosphere to different sulphates. In most modern vehicle systems which include oxidation catalysts, much of the engine-exit SO_2 gets oxidised to sulphates (some of which also adsorb nearby water or unburnt hydrocarbon molecules), hence increasing the amount of particulate matter (PM) emitted from the vehicle. Thus, fuel sulphur has a significant impact on fine particulate emissions in direct proportion to the amount of sulphur in the fuel.

The efficiency of some exhaust after-treatment systems is reduced at higher sulphur levels in the fuel, while others are rendered permanently ineffective through sulphur poisoning. The most advanced of these technologies includes De-NO_x catalyst systems, such as Lean NO_x traps (LNT) and Selective Catalytic Reduction (SCR) devices.

Highly advanced particulate filters (Diesel Particulate Filters or DPFs) have been developed to reduce the particulate matter (PM) emissions, with variants such as Continuously Regenerating and Catalysed Diesel Particulate

Filters. These devices are combined in various configurations to enable the vehicle to meet specific emission standards and to minimise impacts on fuel efficiency. Diesel oxidation catalysts (DOC), which reduce HC and CO emissions, and exhaust gas recirculation (EGR) systems, which reduce NO_x, are among the proven technologies which may be combined to have an optimal solution towards reduced emissions as well as fuel efficiency.

6.6.2 Benefits from Reducing Sulphur to 10 ppm

All filter devices would benefit with a lower PM load, while the De-NO_x devices would benefit from a lower SO_2 in the exhaust and hence lesser catalyst deactivation rates. In summary, it can be said that all emission control systems perform better and last longer (better durability) with sulphur-free fuel. It must however be noted that it is also known that as sulphur levels are reduced, fuel stability is affected as reduced thermal stability can result in formation of oxidised products (sludge) that may cause issues like fuel filter plugging. This is an issue that has to be addressed separately by the refiner.

It **unclear** at this point, what might be the **quantitative improvement** in emission levels achieved if we were to move from a modified BS IV at 40 ppm to BS V (10 ppm) sulphur content in automotive fuel.

It is expected that reduced sulphur level would positively improve both performance of the engine as well as the performance and durability of the after-treatment devices for the reasons cited above.

However the improvement in air quality from the change to 10 ppm sulphur from reduced gas phase emission may be quite dramatic with **significantly reduced** PM emissions load (**particularly $PM_{2.5}$**), which would be a good boost to the air quality. Further, **indirect benefits** to the catalytic systems and DPFs and its variants may be significant because some of the refractory sulphur compounds may be removed, which would improve the performance and durability of the catalytic systems.

More importantly, the directional movement to BS V fuels should result in a progressive improvement in air quality standards. This role of improved fuel quality should be monitored on a regular basis by expert agencies which should in turn direct the mid-term corrections or future improvements in fuel quality. It is noteworthy that the source apportionment studies reported thus far indicate only a partial contribution of automobile exhaust in the poor air quality standards, thus improved fuel quality is likely to only affect that contribution in a definitive way. The other contributions also need to be addressed with similar stringent norms.

6.7 SPECIFICATIONS FOR BS V AUTO FUELS

The extant BS IV specifications for automotive fuels are similar to Euro IV. The proposed BS V specification would be broadly in line with Euro V and other similar specifications across the world.

BS IV and the proposed BS V gasoline and diesel specifications are at **Table 6.6** and **Table 6.7** respectively. Proposed BS V specification in respect of gasoline and diesel is given in **Annexure 4.1** and **4.2** respectively.

6.7.1 Gasoline or Motor Spirit

A difference that exists with the extant BS IV norms for gasoline *vis-à-vis* Euro V is in respect of **olefin** content. In the Euro V specification olefin content is restricted to a lower level of 18% by volume, from 21% in Euro IV. There are no separate limits for olefin content in Japanese specifications. In Korea it is set at 16%. In China, the tighter Beijing standards limit olefin content to 28%, while it is set at 30% in general. The recently announced China V specification for olefin is set at 24%.

Table 6.6

Proposed BS V Specifications for Motor Spirit/Gasoline

Table 6.6: Proposed BS V Specifications for Motor Spirit/Gasoline

Sl No	Attribute	Unit	Extant Specifications		Proposed
			BS III	BS IV	BS V
1	Density @15 deg C	kg/m3	720-775	720-775	720-775
2	Distillation				
	E-70	% vol.	10-45	10-45	10-45
	E-100	% vol.	40-70	40-70	40-70
	E-150	% vol. min	75	75	75
	FBP	°C max	210	210	210
	Residue	% vol. max	2	2	2
3	Sulphur	ppm max	150	50	10
4	RON	min.	91	91	91
	MON	min.	81	81	81
5	RVP @ 38^0C, max	kPa	60	60	60
6	VLI (10RVP+7E70)	Max	750	750	750
	Summer (May to July) Other months	Max	950	950	950
7	Benzene	% vol. max	1	1	1
8	Aromatics	% vol. max	42	35	35
9	Olefin	% vol. max	21	21	21
10	Gum (solvent washed)	mg/100 ml max	5	5	5
13	Oxidation Stability	Minutes, min	360	360	360
11	Lead as Pb	g/litre max	0.005	0.005	0.005
12	Oxygen	% wt. max	2.7	2.7	2.7
13	Oxygenates				
	Methanol	% vol. max	3	3	3
	Ethanol		5	5	5
	Iso Propyl Alcohol		10	10	10
	Iso Butyl Alcohol		10	10	10
	Tertiary Butyl Alcohol		7	7	7
	Ethers with 5 or more C atoms per molecule		15	15	15
	Other Oxygenates		8	8	8
14	Copper strip corrosion for 3 hrs @ 50°C, max	Rating	Class 1	Class 1	Class 1

Table 6.7

Proposed BS V Specifications for Diesel

Table 6.7: Proposed BS V Specifications for Diesel

S. No	Attribute		Extant Specifications		Proposed
			BS III	BS IV	BS V
1.	Density @15°C	kg/m^3, max	820-845	820-845	820–845
2.	Distillation T_{95}	°C max	360	360	360
3.	Sulphur	ppm max	350	50	10
4.	Cetane No	min.	51	51	51
5.	Cetane Index	min.	46	46	46
6.	Flash Point	°C min.	35	35	42
7.	Viscosity @ 40°C	cSt	2.0–4.5	2.0–4.5	2.0–4.5
8.	PAH	% wt. max	11	11	11
9.	Total Contaminants	mg/kg max	24	24	24
10.	RCR on 10% Residue	% wt. max	0.3	0.3	0.3
11.	Water Content	mg/kg max	200	200	200
12.	Lubricity, Corrected Wear Scar Diameter (WSD) @ 60°C	Microns, max	460	460	460
13.	Ash	% wt. max	0.01	0.01	0.01
14.	Cold Filter Plugging Point				
	a) summer, max	°C	18	18	18
	b) winter, max	°C	6	6	6
15.	Oxidation stability	g/m3, max	25	25	25
16.	Copper strip corrosion for 3 hrs @ 50°C, max	Rating	Class 1	Class 1	Class 1

Olefins/Aromatics

It may be noted in this context that the proposed BS V gasoline specification (**Table 6.6**, line 8) would limit aromatics to 35%, the same as in Euro V. The US and Japanese standards do not prescribe separate limits for aromatics. The total of aromatics + olefin content in gasoline as per Euro V is thus 53%.

The extant fuel specification in China requires aromatics content to be restricted to 40%, including that for the tighter standard applicable for Beijing and two other metropolitan centres limits. The new China V fuel standard continues to limit aromatics to 40%.

It is proposed that for BS V, the limit for olefin content in gasoline be retained at 21% maximum. The total of olefin and aromatics in BS V (and BS IV) would thus be 56%, marginally higher than the 53% of Euro V. It will be much lower than the China V requirement of 64% total of olefins and aromatics. The recommendation is guided primarily by the fact that most of our refineries use FCCs/Cokers, which produce cracked gasoline that has relatively higher olefin content.

Research Octane Number (RON)

The automobile industry wished that the minimum RON for BS V gasoline be set at 95 RON with the emerging practice in the developed world. Higher RON enables vehicle manufacturers to design and put on road higher compression engines which give improved fuel efficiency. The Euro V standard for gasoline stipulates a minimum RON of 91 or 95 leaving the choice to individual members, but most countries have adopted 95 as the minimum RON. In Japan, the standard is set at 91−92 RON for regular grades and 95 for premium grades. In the USA, four grades of gasoline are being sold with octane number (AKI)[14] of 87, 89 and 91−93. This roughly translates to RON of 91−92, 94 and 96−98. This matter was discussed at length.

First, mandatory RON for gasoline at 95 would require refineries to invest considerable additional sum over and above what was already being needed in order to support the changeover in the fuel standards to BS IV and BS V. Second, the benefits of higher RON would not be available to the existing stock of cars and certainly not to two and three wheelers, that is, the bulk of the consumption. Third, without assured availability of 95 RON gasoline the industry would not be able to introduce more fuel efficient cars. Fourth, the bulk of the market for smaller cars with high compression engines would be the larger cities.

[14] In the USA (and Canada) the octane number is reported as Anti Knock Index (AKI) which is the average of the RON and the motor octane number (MON). Roughly the difference is about 5% when the octane number is around 90 or RON above 90.

The best solution that therefore emerged was that it should be required that in the larger cities, the oil companies should ensure that a significant part of their retail stockists dispense premium gasoline conforming to 95 RON as and when BS V is rolled out. All company outlets may be required to stock and sell premium gasoline with 95 RON, along with the regular 91 RON and at least a quarter of their non-company owned outlets in bigger cities may be required to stock and dispense premium 95 RON at the point where the transition to BS V takes place, that is in 2019−2020.

6.7.2 Diesel

Cetane Number

The Cetane Number is a measure of compression ignition quality of diesel fuel and influences cold start ability and combustion noise. The Cetane Index is calculated based on the fuel's density and distillation range, using a prescribed multi-variable equation. The Cetane index calculations cannot account for cetane improver additives and therefore do not measure total cetane number for diesel fuels which have had additives added for improved performance. Diesel engine operation is primarily related to the actual Cetane Number, and the Cetane Index is simply the estimated (in lieu of direct measurement) of the base (un-additised) Cetane Number. The Cetane Number should equal or exceed, *i.e.* ≥ Cetane Index.

For BS IV and BS V, the Cetane Number for diesel as proposed is carried over from the value in BS III and BS IV which is 51. The Cetane Index similarly is set at 46. These are the same values as in Euro IV and Euro V. In the USA however, the prescribed lower limit for Cetane Number is 40 (ASTM D-975) for the relevant grade (No. 1 D S-15) for automotive use. For Cetane Index there is a choice between meeting a Cetane Index of 40 or “aromaticity” (max) of 35%. In Japan, both Cetane Number and Cetane Index is set at 50.

Flash Point

The issue of Flash Point has been discussed previously (*para* 6.5.3). For BS IV, this limit is being raised to 38°C and in BS V to 42°C. The flash point of diesel in the USA for S-15 is 38°C; that in Canada it is 40°C; in both Brazil and Argentina is 38°C; in Japan (45°C and 50°C) and in China (45°C and 55°C).

Lubricity

The lubricity upper limit has been retained at 460 microns for both BS IV and BS V in continuation of BS III and BS IV norms. In general the severe hydro-treating required for reducing the fuel sulphur content results in a reduction in lubricity and this will intensify as we move to 15/10 ppm sulphur. Better lubricity (*i.e.* lower values) assists better functioning of diesel engines and lower wear and tear.

The Fuel Injection Equipment (FIE) manufacturers have adopted the use of the HFRR (ISO 12156-2:1998), and recommend that all diesel fuel meet a limit of 460 micron maximum Wear Scar Diameter (WSD). For the High Frequency Reciprocating Rig (HFRR) a lower wear scar indicates better lubricity. While India has adopted this level of 460 microns as the upper limit, standards elsewhere permit higher values (that is, worse lubricity) as in the case of the USA where it is 520 microns [ASTM D795, also California (ASTM D6079-02)].

The common position statement 2012 by leading manufacturers of fuel injection systems stated that:

> "**Lubricity**: It is essential that the lubricity of the fuel as measured by the HFRR test specified in ISO 12156-1 meets the requirement of a wear scar diameter not greater than 460 microns. In addition it is recommended by the FIE diesel manufacturers, that 'first fill' of the fuel tank should be with fuel with good lubricity characteristics (HFFR < 400 µm) in order to guarantee good 'run-in' of the injection system components".[15]

[15] "Fuel Requirement for Diesel Injection Systems": Diesel Fuel Injection Equipment Manufacturers, Common Position Statement 2012. The manufacturers were Bosch, Delphi, Denso, Continental and Stanadyne.

It has been found that small additions of bio-diesel can improve the native lubricity of diesel fuel. Tests suggest that bio diesel additives (basically vegetable oils) can improve the lubricity of ultra low sulphur diesels. The addition required in some tests reported[16] from 0.25 & 0.75% for jatropha and palm oil respectively. Other reports however suggest that biodiesel has other ingredients/characteristics that can create a different class of problems in automotive applications.

Oil companies and vehicle manufacturers must see how to strive for better lubricity as the sulphur content in diesel is progressively brought down and what additives – both naturally occurring, like biodiesel and synthetic – can be used in this pursuit.

6.8 Standards for Euro VI

From the information available, there does not seem to be any difference in fuel quality *per se* between Euro V and Euro VI. However, Euro VI vehicular emission standards are far more stringent, which is the expected outcome from improved technology in both automotive and after treatment sphere. A similar approach is regarded to be appropriate in the Indian context as we move towards BS VI emission norms.

6.9 Bottlenecks in North East India

The four refineries in the North Eastern Region of India, namely, Guwahati, Digboi, Numaligarh and Bongaigaon which process Assam crude suffer problems of vintage, small scale and lack in the necessary equipment to produce fuels exactly conforming to BS IV and BS V standards. The relevant parameters are Cetane Number in diesel and aromatics content in gasoline.

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[16] "Biodiesel as a lubricity additive for ultra low sulphur diesel", Subongkoj Topaiboul and Nuwong Chollacoop, Songklanakarin J. Sci. Technol. 32 (2), 153-156, Mar. - Apr. 2010

6.9.1 Diesel Cetane Number

Cetane Number specification of 51 minimum is being carried forward into BS IV and BS V. However, the four refineries in Assam cannot meet the Cetane number specification of 51 for diesel as prescribed by BS III/BS IV. The Cetane Number as discussed above is a measure of compression ignition quality of diesel fuel and influences cold start ability and combustion noise. However, it does not adversely affect vehicle emissions by much.

The Assam refineries in question produce BS III diesel with a relaxed Cetane Number limit of 48. As has been seen earlier the Cetane Number in the USA is set at 40 (outside California) and in Japan it is set at 50. In this context it ought to be mentioned that in the new China V fuel specification the Cetane Number limit for different diesel grades is set at 47, 49 and 51. The China IV standard for Cetane is 45, 46 and 49.

There is no economic justification in investing in the necessary upgrading units to bring the Cetane number of the diesel produced by these refineries to 51, given the small size of the refineries. However, if over time, it is felt that such investment should be done, the funding will have to come from OIDB or Government.

In consequence, specific relaxations had been granted to these refineries for diesel in respect of this parameter for sales made within the North East Region. Such relaxation will have to be continued in the near future. The relaxation (for both BS IV and BS V) will continue to stipulate a minimum Cetane Number of 48 for diesel produced by these refineries.

It ought to be made clear that these refineries will be able to meet the sulphur limit of 50 ppm for BS IV diesel.

6.9.2 Assam Refineries and Aromatics Content in Gasoline

Assam crude has a higher aromatic content and the refineries in the North East primarily process only Assam crude. They are not large refineries and do not have facilities to tap off the aromatics content. Hence they produce gasoline with an aromatic content in excess of the prescribed limit of 35% on account of higher aromatics in its gasoline pool owing to Assam crude oil processing. However, the sulphur and other parameters will be compliant with BS IV norms.

Specific relaxation along the lines of Cetane Number will need to be extended to Assam refineries for sale of its gasoline in the North East Region. The relaxation (for both BS IV and BS V) will stipulate a maximum aromatics content of 40% for gasoline in these refineries.

CHAPTER 7

PRODUCTION CAPACITY FOR HIGHER QUALITY AUTOMOTIVE FUELS IN INDIA

7.1 BS IV AND BS V AUTO FUEL PRODUCTION CAPABILITY

A very detailed examination was conducted to estimate what the maximum production capability of refineries might be for BS IV and BS V auto fuels. This took into consideration investments that are underway, investments that have been sanctioned but not yet implemented and a few where the proposals were about to be or likely to be sanctioned. The investments involved extended from major expansion-cum-modernisation projects and medium sized investments such as catalyst change and refurbishment.

This examination for fuel availability was done refinery wise and prospectively going up to 2025. For the years 2015, 2016 and 2017 the exercise was done on quarter-to-quarter basis as the capability of the system for earliest possible switching to BS IV was sought to be maximised.

The changeover as explained later involves switching a sizeable part of the geography of the country to BS IV in 2015, another chunk in 2016 and the whole nation in 2017. The switch to complete BS V fuels is envisaged in with effect from 1 April 2020. The vehicle industry will produce BS V compliant vehicles with effect 1 April 2020 in so far as new models are concerned and will transition to 100% BS V emission norms within 1 year.

7.2 CHANGES IN THE REFINING BUSINESS

Refining margins are under pressure on account of higher crude oil price without commensurate crack spread for products. As a result, refineries have started switching over to cheaper crudes, which in general are heavy and contain high sulphur. For enhancing the processing capability of such crudes, huge investments have been made in some cases and are required in others for upgrading bottom of the barrel to maximise distillate yields, apart from meeting existing quality of transportation fuels.

Amidst this situation, switching over to 100% BS IV as well as BS V quality will result in further technological interventions/innovations to meet the stipulated auto fuel quality. This will be in a background where there is an ongoing competitive squeeze in the refining business that has resulted in widespread closures.

> "The cascade of refinery closures (earlier) indicated as inevitable . . . arrived in 2012. At the global level, closures have already reached 4 mb/d (200 million tonnes per annum) and are heading to the 5 mb/d mark, affecting not only small and simple plants, but large and fairly complex refineries too.
>
> "The largest proportion of closures – around 1.7 mb/d – has so far occurred in Europe. Developments in the Asia-Pacific are driven by Japan, where more than 0.8 mb/d of distillation capacity has already been closed, or is scheduled to be closed. The wave of closures has also hit the US & Canada, including refineries located in US territories in the Caribbean".[17]

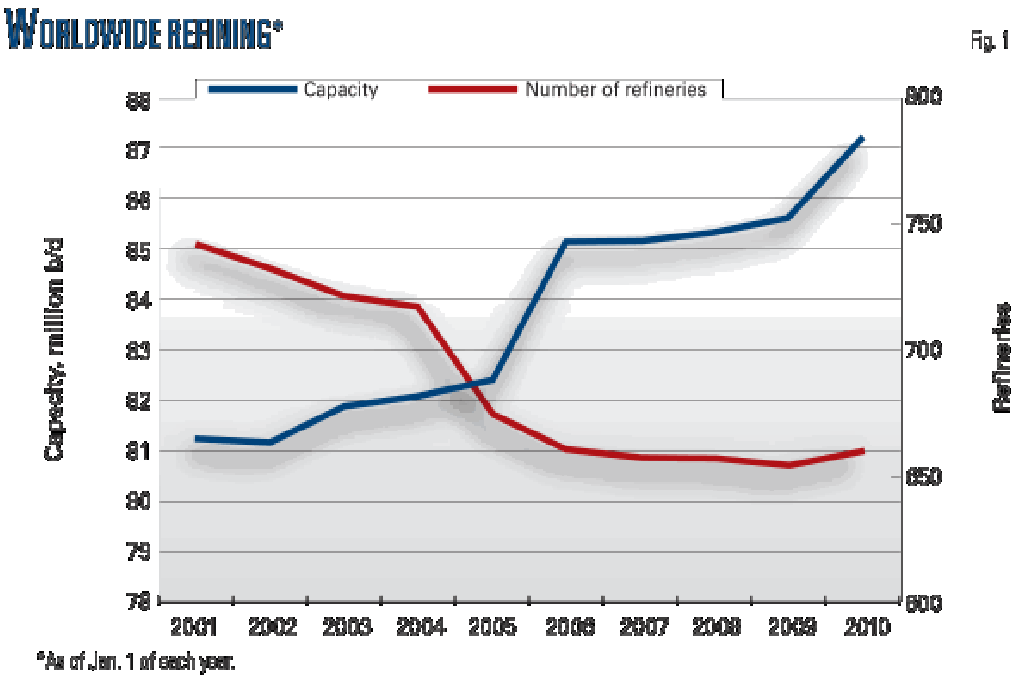
In general the trend has been towards a consolidation of capacity with larger and fewer refineries with more sophisticated and hence more expensive equipment and a phasing out of smaller less sophisticated refineries. This has drastically increased the threshold level for entry into the business, improved scale economies and imparted greater flexibility. However, this has also meant that operating refineries need to invest heavily in modernisation and expansion wherever possible. This task has been harder globally on account of the squeeze on operating margins and even more so in India where regulatory price setting at below cost has depleted the financial surpluses available with refining companies (and also upstream companies) to finance a high level of investment. What has been happening globally to the number of

[17] World Oil Outlook 2012, OPEC, p.16

refineries and to refinery size is well brought out in **Chart 7.1** which has been taken from a report of the Oil & Gas Journal in 2009.

Chart 7.1

Worldwide Refining Capacity



Source: Special Report: Global refining capacity advances; US industry faces uncertain future, Oil and Gas Journal, Dec 2009.

7.2.1 Investments Made to the Configuration and Complexity of Indian Refineries for Compliance with BS IV/V Automotive Fuels

Several process units have been added in Indian refineries in phases between 1997 through 2011 in order to meet gasoline and diesel fuel specifications *viz.* BIS 2000, BS II, III and IV which are given in **Annexure 7**.

Gasoline

For gasoline, these were CRU, CCRU for Octane improvement; FCC gasoline splitter for separation of light cut gasoline for Merox treatment, 70-90°C cut for routing to ISOM unit and heavy gasoline for hydro-treatment; reformate splitter for separation of light reformate for routing to ISOM unit and heavy reformate for gasoline blending; and naphtha splitter for separation into light naphtha as ISOM feed, 90-140°C cut as reformer feed and heavy naphtha as diesel blend; ISOM unit for benzene reduction and octane improvement; NHT and FCC GDS for reduction of sulphur and allied units.

Diesel

In respect of diesel, the units included were DHDS, DHDT, additional reactors in DHDS and DHDT, Hydro-treater Unit, OHCU/HCU, H_2 & Allied units.

7.2.2 Technology and Options

Facilities for Meeting Euro V Similar Gasoline Quality

- Capacity augmentation of VGO Hydro-treating Units or setting up of new VGO Hydro-treaters for pre-treatment of FCC feed.
- Capacity revamps of FCC gasoline treatment units.
- Setting up of new Alkylation unit/Dimerization unit.
- CRU up-gradation.

Facilities for Meeting Euro V Similar Diesel Fuel

- Capacity augmentation of diesel hydro-treating unit *vis-à-vis* setting up of new DHDT.
- New hydro-cracker *vis-à-vis* revamp of existing hydrocracker capacity.
- Conversion of VGO hydro-treaters to mild hydrocrackers.
- Capacity revamps of hydrogen generation units.
- Additional Sulphur Recovery Units.

Hence, detailed studies need to be carried out by the refining companies in order to work out a cost effective solution for mitigating the challenge of complying with BS V norms. Although some of the newer refineries have already been geared up to meet the challenge with the flexibility in-built in their processing units, for the older refineries developing the capability will be a challenge and will require significant investment.

It is recommended that in order to facilitate an industry-wide view, a working group consisting of refineries, EIL, CHT, IIP along-with R&D Centres may be constituted to identify the changes in configurations required in the most cost effective fashion.

7.3 SPECIFICATIONS FOR BS V AUTOMOTIVE FUELS

The Euro V specification is compared with the proposed BS V specification. While sulphur content of 10 ppm is proposed for both gasoline and diesel, olefin content for gasoline is being kept at 21% in line with existing BS IV norms. Diesel density, T_{95} and viscosity specs are carried over from the BS IV specifications. The key parameters of Euro V and proposed BS V specification for gasoline and diesel are similar as may be seen at **Tables 7.1 A & B**.

Table 7.1

Key Parameters: Comparison of Euro V and BS V Fuel Specifications

Table 7.1: Key Parameters: Comparison of Euro V and BS V Fuel Specification (A. Gasoline & B. Diesel)

A. Gasoline

	Attribute	**Unit**	**Euro V**	**Proposed BS V**
1.	Sulphur	Ppm max	10	10
2.	RON	min.	91/95*	91
3.	MON	min.	81	81
4.	Benzene	% vol. max	1	1
5.	Aromatics	% vol. max	35	35
6.	Olefin	% vol. max	18	21
7.	Lead	g/litre max	0.005	0.005

Note: The Euro Notification gives the option to member countries to choose between 89 and 95 as prescribed minimum RON. Most member countries have set it at 95

B. Diesel

	Attribute	**Unit**	**Euro V**	**Proposed BS V**
1.	Density @ 15°C	kg/m^3, max	820 – 845	820–845
2.	Sulphur	ppm max	10	10
3.	Cetane No.	min.	51	51

4.	T_{95}	°C max	360	360
5.	PAH	% vol. max	11	11
6.	Viscosity @ 40°C	cSt	2.0–4.5	2.0–4.5

7.4 Capability to Produce BS IV and BS V Grade Automotive Fuels

The supply of fuels from the refineries will have to switch over from the existing BS III/BS IV mix, to 100% BS IV supply. Gasoline sulphur will shift from 150/50 ppm mix to entirely 50 ppm level and aromatics from 42%/35% to entirely 35% level. This will call for setting up of new units or revamp of CRU/CCRU, FCC gasoline desulphurisation units etc.

Similarly, for meeting 100% BS IV diesel supply, the entire stream component for diesel will need to be hydro-treated, as sulphur in diesel will shift from 350/50 ppm mix to entirely 50 ppm level. The advantages of by-passing DHDS/DHDT unit for some of the diesel component will be lost, thereby necessitating capacity addition, modification as well as catalyst change.

The projected availability of BS IV and BS V quality gasoline and diesel (**Table 7.2**) from domestic refineries is seen to be adequate to meet domestic demand from refineries in the domestic tariff area (DTA) till 2020 for motor spirit, but not for diesel. However, without taking diesel product from the SEZ refinery of RIL there will not be adequate availability of BS IV and later of BS V fuel. Beyond 2020, incremental supplies will be met from new refineries that are being planned.

Table 7.2

Demand & Production Capacity To 2025

	2016	**2017**	**2020**	**2025**
Motor Spirit or Gasoline				
Domestic Demand	21.2	22.7	28.4	41.1
Indian refineries excl RIL SEZ	18.8	24.3	29.5	29.5
Indian refineries incl. RIL SEZ	28.0	33.6	38.8	38.8
Diesel				
Domestic Demand	85.5	90.6	106.7	140.1
Indian refineries excl RIL SEZ	65.8	79.3	103.5	103.0
Indian refineries incl. RIL SEZ	81.8	95.3	119.3	119.0

The summary position of gasoline & diesel production capability for fiscal years starting 1 April of 2016, 2017, 2020 and 2025 are at **Table 7.3**. The details refinery-wise are at **Annexure 8** and **Annexure 9**.

Table 7.3

Production Capacity Prospective To 2025

A: Gasoline/Motor Spirit

Unit: Million Tonnes per Annum

	1-Apr-16			1-Apr-17				1-Apr-20				1-Apr-25			
	BS III	BS IV	Total	BS III	BS IV	BS V	Total	BS III	BS IV	BS V	Total	BS III	BS IV	BS V	Total
Total availability	6.6	28.0	34.6	2.9	18.6	15.0	36.5	0.2	14.0	24.8	39.0	0.2	14.0	24.8	39.0
% demand		132%			82%	66%			49%	87%			34%	60%	
Avail excl. RIL-SEZ	6.6	18.7	25.3	2.9	18.6	5.7	27.2	0.2	14.0	15.5	29.7	0.2	14.0	15.5	29.7
% demand		89%			82%	25%			49%	55%			34%	38%	
Total Domestic Demand			21.2				22.7				28.4				41.1

B: Diesel

	1-Apr-16			1-Apr-17				1-Apr-20				1-Apr-25			
	BS III	BS IV	Total	BS III	BS IV	BS V	Total	BS III	BS IV	BS V	Total	BS III	BS IV	BS V	Total
Total availability	20.6	81.8	102.4	6.0	54.4	41.0	101.4	0.2	53.5	65.8	119.6	0.2	50.9	68.1	119.2
% of demand		96%			60%	45%			50%	62%			36%	48%	
Avail excl. RIL-SEZ	20.6	65.8	86.4	6.0	54.4	25.0	85.4	0.2	53.5	49.8	103.5	0.2	50.9	52.1	103.2
% of demand		77%			60%	28%			50%	47%			36%	37%	
Total Domestic Demand			85.5				90.6				106.7				140.1

7.4.1 Motor Spirit or Gasoline

7.4.1.1 Status in 2016

1. BS IV gasoline availability in 2016 is expected to be 28.0 MMT. However, excluding RIL−SEZ, the figure works out to be 18.8 MMT (89% of demand) against the demand projection of 21.2 MMT.
2. Nine of the 22 Indian refineries, which would be in a position to supply 100% BS IV gasoline from 1 April 2016 are IOC's Mathura, Panipat and Paradip; BPCL's Kochi; MRPL; HMEL Bhatinda, RIL−DTA; RIL−SEZ; and Essar.
3. Three NE refineries namely Digboi, Guwahati and Bongaigaon will produce BS III gasoline only.
4. CPCL-CBR is not producing any gasoline.
5. The other 9 refineries (IOC's Barauni, Gujarat, Haldia; CPCL; BPCL Mumbai; HPCL's Mumbai & Vizag; NRL and BORL) would produce both BS III and BS IV gasoline.

7.4.1.2 Status in 2017

1. BS IV and BS V gasoline availability in 2017 is expected to be 18.6 and 15.0 MMT respectively. However, excluding RIL-SEZ, BS IV and BS V gasoline numbers work out to 18.6 and 5.7 MMT respectively (82% and 25% respectively of the total demand of 22.7 MMT).
2. Number of refineries producing 100% BS IV gasoline will be 9 in 2017. These are Guwahati, Mathura, Panipat, Paradip; CPCL, HPCL Mumbai & Vizag, MRPL and HMEL Bhatinda.
3. Two refineries *viz.* RIL-SEZ and Essar will produce 100% BS V gasoline from 2017.
4. Digboi refinery will produce only BS III gasoline.
5. CPCL-CBR is not producing any gasoline.
6. Five refineries (Barauni, Gujarat, Haldia, Bongaigaon and NRL) will produce mix of BS III and BS IV gasoline.
7. BPCL Mumbai and Kochi will produce mix of BS IV and BS V gasoline.

8. BORL will produce mix of BS III and BS V gasoline.
9. RIL-DTA will produce both BS IV and BS V gasoline.

7.4.1.3 Status in 2020

1. BS IV and BS V gasoline availability in 2020 is expected to be 14.0 and 24.8 MMT respectively. However, excluding RIL-SEZ, BS IV and BS V gasoline numbers work out to 14.0 and 15.5 MMT respectively (49% and 55% respectively of the total demand of 28.4 MMT).
2. Six refineries will be producing 100% BS IV gasoline in 2020. These are Guwahati, Barauni, Gujarat, Haldia, Mathura and Panipat.
3. Seven of the refineries *viz.* Paradip, HPCL Mumbai & Vizag, HMEL, BORL, RIL-SEZ and Essar will produce 100% BS V gasoline from 2020.
4. Digboi refinery will produce 110 TMT of BS III gasoline only, while Bongaigaon refinery will produce mix of BS III (69 TMT) and rest BS IV gasoline. BS-III gasoline from these refineries will need to be evacuated.
5. CPCL-CBR is not producing any gasoline.
6. Six refineries (CPCL, BPCL Mumbai & Kochi, NRL, MRPL and RIL-DTA) will produce mix of BS IV and BS V gasoline.

7.4.1.4 Status in 2025

1. BS IV and BS V gasoline availability in 2025 is expected to be 14.0 and 24.8 MMT respectively. However, excluding RIL– SEZ, BS IV and BS V gasoline numbers work out to 14.0 and 15.5 MMT respectively (34% and 38% respectively of the total demand of 41.1 MMT).
2. Digboi refinery will produce 110 TMT of BS III gasoline only. This along with 69 TMT BS-III gasoline from Bongaigaon refinery will need to be evacuated.
3. CPCL– CBR will not be producing any gasoline.
4. Six refineries *viz.* Guwahati, Barauni, Gujarat, Haldia, Mathura and Panipat will produce 100% BS IV gasoline.
5. Bongaigaon refinery will produce mix of BS III and BS IV gasoline.

6. Seven refineries (Paradip, HPCL Mumbai and Vizag, HMEL Bhatinda, BORL, RIL-SEZ and Essar) will produce 100% BS V gasoline.

7. The refineries which will produce both BS IV and BS V gasoline are six in numbers *viz.* CPCL, BPCL Mumbai and Kochi, NRL, MRPL and RIL-DTA.

7.4.1.5 Refinery Wise Status for Gasoline – Year Wise

The refinery wise status in 2016, 2017, 2020 and 2025 in respect of Gasoline from the point of view of capacity to produce BS IV and BS V grades is presented at **Table 7.4**.

7.4.1.6 Facilities Required for Producing BS IV/BS V Gasoline

The various facilities required for producing BS IV and BS V gasoline would be IndAdaptG at Guwahati refinery, CRU block and Prime G unit revamp at Barauni, Prime G unit at Gujarat, capacity expansion at Mathura & NRL, CCRU catalyst change at Panipat, IndMaX unit at Bongaigaon, facilities at HPCL Mumbai & Vizag, HMEL, BORL, RIL-DTA, Essar; Gasoline desulphurisation unit at CPCL, ongoing CCRU and Isom units setting-up and stabilisation at BPCL Mumbai, IREP completion at BPCL Kochi; new NHT, CCRU & FCC gasoline treating unit and revamp of Isom unit at MRPL.

7.4.1.7 Capital Investment Requirement for Gasoline Quality Improvement

As per the estimates, the new facilities to produce BS IV/BS V gasoline from the refineries would require an investment of nearly Rs 20,000 crore.

7.4.1.8 Actual Position

This is the **Business as Usual** scenario. The actual position will have to be in line with the time line and road map in consonance with the **Accelerated Transition Path** that is laid out in **Chapters 9** through **12**.

Table 7.4

Refinery Wise Status of Producing Different BS Quality Gasoline

S. No.	Company/Refinery	Installed Capacity MTPA	2016			2017				
			BS III	**BS IV**	**BS III/IV**	**BS III**	**BS IV**	**BS V**	**BS III/IV**	**BS IV/V**
1	IOC Digboi	0.65	√				√*			
2	IOC Guwahati	1.00	√				√*			
3	IOC Barauni	6.00			√				√	
4	IOC Gujarat	13.70			√				√	
5	IOC Haldia	7.50			√				√	
6	IOC Mathura	8.00		√			√			
7	IOC Panipat	15.00		√			√			
8	IOC Bongaigaon	2.35	√						√*	
9	IOC Paradip	15.00		√			√			
10	CPCL Chennai	10.50			√		√			
11	CPCL-CBR	1.00	-	-	-	-	-	-	-	-
12	BPCL Mumbai	12.00			√					√
13	BPCL Kochi	9.50		√						√
14	HPCL Mumbai	6.50			√		√			
15	HPCL Vizag	8.30			√		√			
16	N R L	3.00			√				√	
17	M R P L	15.00		√			√			
18	HMEL, Bhatinda	9.00		√			√			
19	B O R L	6.00			√				√	
20	RIL DTA	33.00		√						√
21	RIL SEZ	27.00		√				√		
22	Essar Oil	20.00		√				√		

Note: * with relaxation for aromatics in gasoline

Table 7.4 (Continued)

Refinery Wise Status of Producing Different BS Quality Gasoline

S. No.	Company/Refinery	Installed Capacity MTPA	BS III	BS IV	BS V	BS IV/V	BS III/IV	BS III	BS IV	BS V	BS IV/V	BS III/IV
			2020					2025				
1	IOC Digboi	0.65		√*					√*			
2	IOC Guwahati	1.00		√*					√*			
3	IOC Barauni	6.00		√					√			
4	IOC Gujarat	13.70		√					√			
5	IOC Haldia	7.50		√					√			
6	IOC Mathura	8.00		√					√			
7	IOC Panipat	15.00		√					√			
8	IOC Bongaigaon	2.35					√*					√*
9	IOC Paradip	15.00			√					√		
10	CPCL Chennai	10.50				√					√	
11	CPCL-CBR	1.00	-	-	-	-	-	-	-	-	-	-
12	BPCL Mumbai	12.00				√					√	
13	BPCL Kochi	9.50				√					√	
14	HPCL Mumbai	6.50			√					√		
15	HPCL Vizag	8.30			√					√		
16	N R L	3.00				√					√	
17	M R P L	15.00				√					√	
18	HMEL, Bhatinda	9.00			√					√		
19	B O R L	6.00			√					√		
20	RIL DTA	33.00				√					√	
21	RIL SEZ	27.00			√					√		
22	Essar Oil	20.00			√					√		

Note: * with relaxation for aromatics in gasoline

7.4.2 Diesel

7.4.2.1 Status in 2016

1. BS IV diesel availability in 2016 is expected to be 81.8 MMT. However, excluding RIL-SEZ, the figure works out to be 65.8 MMT (77% of demand) against the demand projection of 85.5 MMT.

2. Fourteen of the 22 Indian refineries, which would be in a position to supply 100% BS IV diesel from 01.04.2016 are IOC Digboi, Guwahati, Barauni, Mathura, Panipat, Paradip; BPCL Kochi, HPCL Mumbai & Visakh, HMEL, BORL, RIL-DTA, RIL-SEZ and Essar.

3. CPCL-CBR will produce only BS III diesel.

4. Rest of the 7 refineries (Gujarat, Haldia, Bongaigaon, CPCL, BPCL Mumbai, NRL and MRPL) would produce both BS III and BS IV diesel.

7.4.2.2 Status in 2017

1. BS IV and BS V diesel availability in 2017 is expected to be 54.4 and 41.0 MMT respectively. However, excluding RIL-SEZ, BS IV and BS V diesel numbers work out to 54.4 and 25.0 MMT respectively (60% and 28% respectively of the total demand of 90.6 MMT).

2. Twelve refineries (Digboi, Guwahati, Barauni, Haldia, Mathura, Panipat, Bongaigaon, Paradip, CPCL, HPCL Mumbai & Vizag and HMEL) will be producing 100% BS IV diesel.

3. Three refineries *viz.* RIL-DTA, RIL-SEZ and Essar will produce 100% BS V diesel from 2017.

4. CPCL-CBR will produce about 0.22 MMT of BS III diesel only, which need to be evacuated.

5. Three refineries (Gujarat, BPCL Mumbai and NRL) will produce mix of BS III and BS IV diesel.

6. Three of the refineries (BPCL Kochi, MRPL and BORL) will produce both BS IV and BS V diesel.

7.4.2.3 Status in 2020

1. BS IV and BS V diesel availability in 2020 is expected to be 53.5 and 65.8 MMT respectively. However, excluding RIL-SEZ, BS IV and BS V diesel numbers work out to 53.5 and 49.8 MMT respectively (50% and 47% respectively of the total demand of 106.7 MMT).

2. Seven refineries (Digboi, Guwahati, Barauni, Gujarat, Mathura, Panipat and Bongaigaon) will be producing 100% BS IV diesel.

3. Eight refineries *viz.* Paradip, HPCL Mumbai & Vizag, HMEL, BORL, RIL-DTA, RIL-SEZ and Essar will produce 100% BS V diesel from 2020.

4. CPCL-CBR will produce about 220 TMT of BS III diesel only, which need to be evacuated.

5. Six of the refineries (Haldia, CPCL, BPCL Mumbai & Kochi, NRL and MRPL) will produce both BS IV and BS V diesel.

7.4.2.4 Status in 2025

1. BS IV and BS V diesel availability in 2025 is expected to be 50.9 and 68.1 MMT respectively. However, excluding RIL− SEZ, BS IV and BS V diesel numbers work out to 50.9 and 52.1 MMT respectively (36% and 37% respectively of the total demand of 140.1 MMT).

2. 6 refineries (Digboi, Guwahati, Gujarat, Mathura, Panipat & Bongaigaon) will be producing 100% BS IV diesel.

3. 9 refineries *viz.* Barauni, Paradip, HPCL Mumbai & Vizag, HMEL, BORL, RIL−DTA, RIL−SEZ and Essar will produce 100% BS V diesel.

4. CPCL−CBR will produce about 220 TMT of BS III diesel only, which will need to be evacuated.

5. Six of the refineries (Haldia, CPCL, BPCL Mumbai & Kochi, NRL and MRPL) will produce both BS IV and BS V diesel.

7.4.2.5 Refinery Wise Status for Diesel – Year Wise

The refinery wise status in 2016, 2017, 2020 and 2025 in respect of Diesel from the point of view of capacity to produce BS IV and BS V grades is presented at **Table 7.5**.

Table 7.5

Refinery Wise Status of Producing Different BS Quality Diesel

S. No.	Refinery	Installed Capacity MTPA	BS III	BS IV	BS III/IV	BS III	BS IV	BS V	BS III/IV	BS III/V	BS IV/V
			2016			2017					
1	IOC Digboi	0.65		√*			√*				
2	IOC Guwahati	1.00		√*			√*				
3	IOC Barauni	6.00		√			√				
4	IOC Gujarat	13.70			√				√		
5	IOC Haldia	7.50			√		√				
6	IOC Mathura	8.00		√			√				
7	IOC Panipat	15.00		√			√				
8	IOC Bongaigaon	2.35			√*		√*				
9	IOC Paradip	15.00		√			√				
10	CPCL Chennai	10.50			√		√				
11	CPCL-CBR	1.00	√			√	-	-	-	-	-
12	BPCL Mumbai	12.00			√				√		
13	BPCL Kochi	9.50		√							√
14	HPCL Mumbai	6.50		√			√				
15	HPCL Vizag	8.30		√			√				
16	N R L	3.00			√				√		
17	M R P L	15.00			√						√
18	HMEL, Bhatinda	9.00		√			√				
19	B O R L	6.00		√							√
20	RIL DTA	33.00		√				√			
21	RIL SEZ	27.00		√				√			
22	Essar Oil	20.00		√				√			

Note: * with relaxation for cetane number in diesel

Table 7.5 (Continued)

Refinery Wise Status of Producing Different BS Quality Diesel

S. No.	Refinery	Installed Capacity MTPA	BS III	BS IV	BS V	BS IV/V	BS III	BS IV	BS V	BS IV/V
			2020				**2025**			
1	IOC Digboi	0.65		√*				√*		
2	IOC Guwahati	1.00		√*				√*		
3	IOC Barauni	6.00		√					√	
4	IOC Gujarat	13.70		√				√		
5	IOC Haldia	7.50				√				√
6	IOC Mathura	8.00		√				√		
7	IOC Panipat	15.00		√				√		
8	IOC Bongaigaon	2.35		√*				√*		
9	IOC Paradip	15.00			√				√	
10	CPCL Chennai	10.50				√				√
11	CPCL-CBR	1.00	√				√			
12	BPCL Mumbai	12.00				√				√
13	BPCL Kochi	9.50				√				√
14	HPCL Mumbai	6.50			√				√	
15	HPCL Vizag	8.30			√				√	
16	N R L	3.00				√				√
17	M R P L	15.00				√				√
18	HMEL, Bhatinda	9.00			√				√	
19	B O R L	6.00			√				√	
20	RIL DTA	33.00			√				√	
21	RIL SEZ	27.00			√				√	
22	Essar Oil	20.00			√				√	

Note: * with relaxation for cetane number in diesel

7.4.2.6 Facilities Required for Producing BS IV/BS V Diesel

The various facilities required for producing BS IV and BS V diesel would be DHDT revamp at Barauni, new DHDT at Gujarat and Haldia, capacity expansion at Mathura, Bongaigaon & NRL, DHDS catalyst change and conversion of gasoline merox to ATF merox at Panipat, change of catalyst in VGO-HDT at Paradip, coker commissioning, OHCU revamp and catalyst change in DHDS and DHDT at CPCL, new DHDT at BPCL Mumbai, IREP completion at BPCL Kochi, revamp of existing DHDT and a new DHDT at MRPL and other facilities at HPCL Mumbai and Vizag, HMEL, BORL and RIL−DTA.

Thus significant investment and time will be required to comply with the BS V quality requirements, considering detailed study, technological options and selection based on cost effective solutions, financial approvals and execution. The existing refineries (particularly old refineries) may face space constraints for implementation of these facilities while complying with OISD norms and statutory clearances.

Keeping in view the above, it is proposed that 100% BS V grade supply can commence from the scheduled date which under Business as Usual would be 1 April 2025 and under the Accelerated Transition Programme 1 April 2020.

7.4.2.7 Capital Investment Requirement for Diesel Quality Improvement

As per estimates, facilities to produce BS IV/BS V diesel from refineries would require an investment of about Rs 60,000 crore, thus making a total investment for both gasoline and diesel to about Rs 80,000 crore.

7.4.2.8 Actual Position

This is the **Business as Usual** scenario. The actual position will have to be in line with the time line and road map in consonance with the **Accelerated Transition Path** that is laid out in **Chapters 9** through **12.**

7.5 THE ISSUE OF FUEL SUPPLY LOGISTICS

7.5.1 Segment-wise Gasoline/Diesel Demand

7.5.1.1 Gasoline

In April-February 2013-14, gasoline consumption was 15.64 MMT showing strong growth of 9.3% over the corresponding period of last year, compared to 5.0% growth in 2012-13. The stronger growth may have been partially a reflection of the weak growth in diesel sales.

Sales of Passenger Cars (Cars, Utility Vehicles and Vans) in the domestic market recorded negative growth in 2013-14, with total number of units sold in the domestic market at 2.50 million, which was a 6.1% decline from the previous year. Domestic sales of commercial vehicles totalled 0.63 million units, a decline of 20.2% over the previous year. Three wheeler sales also fell by 3.7%. Only two wheeler domestic sales registered positive growth of 7.3% to 14.81 million units sold in 2013-14.

While the growth in gasoline consumption was strongly positive, the softening of sales growth in the personal car segment has implications for the strength of future demand growth.

7.5.1.2 Diesel

As against diesel consumption growth in 2012-13 of 6.7%, growth of domestic sales in the first eleven months of 2013-14 showed a decline of 0.9%. This was partly on account of the steady increase in the retail price of diesel and its impact *vis-à-vis* customers’ choice between gasoline and diesel vehicles, in part it was due to improved power generation which reduced dependence on captive DG power, compounding the impact of market linked prices for bulk sales of diesel introduced in 2012-13.

With economic revival demand growth for diesel should pick up on the back of stronger freight movement growth. However, it was felt necessary to rework the demand for diesel and this was carried out by the PPAC.

7.6 CURRENT LEVEL OF BS III AND BS IV GASOLINE & DIESEL OUTPUT

As of today, India excluding supplies from RIL-SEZ refinery is surplus in gasoline and diesel availability (availability of 17.5 & 75.4 MMT respectively against demand of 17 and 69 MMT respectively). However, maximum potential output of BS IV gasoline and diesel or potential maximum availability is 33% and 46% of the demand respectively.

Further, IOC Guwahati, Digboi and Bongaigaon refineries are unable to produce BS IV grade gasoline as of now and will continue to produce only BS III gasoline till 2016. However, Guwahati refinery will start producing 100% BS IV gasoline from 2017 after commissioning of IndAdaptG unit, while Bongaigaon refinery will start producing BS IV gasoline form 2017, but will have to produce a part as BS III due to certain limitations. Digboi will continue to produce gasoline with higher aromatics limit. CPCL-CBR does not produce any gasoline.

Likewise, IOC Guwahati, Barauni, Digboi, Bongaigaon and CPCL-CBR refineries are not in a position to produce BS IV grade diesel as of now. Besides this, HPCL Mumbai and Vizag refineries are also not presently producing BS IV grade diesel. Guwahati, Barauni, Digboi, HPCL Mumbai and Vizag refineries will, however, start producing 100% BS IV diesel from 2016 onwards, while Bongaigaon will start commencement part BS IV diesel from 2016 and 100% from 2017. CPCL-CBR will continue to produce BS III diesel due to limitations.

The refinery-wise present BS III and BS IV gasoline and diesel production numbers/capability are at **Table 7.6.**

Table 7.6

Current Potential Output of BS III and BS IV Fuels

Table 7.6: Current Potential Output of BS III and BS IV Fuels

Unit: million metric tonnes (MMT) per annum

Sl. No.	Refinery	GASOLINE			DIESEL		
		BS III	BS IV	Total	BS III	BS IV	Total
1	IOC Digboi	0.10		0.10	0.34		0.34
2	IOC Guwahati	0.15		0.15	0.60		0.60
3	IOC Barauni	1.05	0.08	1.12	3.08		3.08
4	IOC Gujarat	1.21	0.28	1.49	5.45	0.39	5.83
5	IOC Haldia	0.46	0.09	0.55	2.53	0.49	3.02
6	IOC Mathura	0.57	0.38	0.96	1.33	1.33	2.65
7	IOC Panipat	0.97	0.46	1.43	4.59	2.06	6.65
8	IOC Bongaigaon	0.21		0.21	1.34		1.34
9	IOC Paradip						
10	CPCL Chennai	0.71	0.27	0.98	3.00	0.90	3.90
11	CPCL-CBR				0.22		0.22
12	BPCL Mumbai	1.05	0.37	1.42	4.43	0.78	5.20
13	BPCL Kochi	1.27	0.25	1.53	3.79	0.43	4.21
14	HPCL Mumbai	0.54	0.45	1.00	1.64		1.64
15	HPCL Vizag	0.79	0.17	0.96	2.17		2.17
16	N R L	0.26	0.06	0.32	1.65	0.30	1.95
17	M R P L	0.78	0.12	0.90	4.97	1.20	6.17
18	HMEL, Bhatinda	0.63	0.27	0.90	2.45	0.55	3.00
19	B O R L	0.39	0.40	0.79		2.80	2,80
20	RIL DTA	0.70	0.60	1.30		11.15	11.15
21	RIL SEZ		11.30	11.30		16.00	16.00
22	Essar Oil		1.44	1.44		9.54	9.54
	Total availability	11.87	16.97	28.84	43.56	47.91	91.46
	Total excl. RIL-SEZ	**11.87**	**5.67**	**17.54**	**43.56**	**31.91**	**75.46**
	Domestic Demand (2013-14)			**17.00**			**69.00**
	BS IV availability vs. total demand		**33%**			**46%**	

CHAPTER 8

DEVELOPMENTS IN THE INDIAN AUTOMOBILE INDUSTRY

8.1 India's Automotive Industry

The development of logistic infrastructure – road, rail, waterways and air network – is critical to sustaining economic growth. In India, road transport contributes around 5% of GDP. Proportionately the resources that are consumed in transportation in India is much higher compared to developed or even some other developing countries due to lack of smooth interconnectivity, inadequate or insufficient physical infrastructure facilities, excessive idling time and other inefficiencies including multiplicity of check points for entry taxes and other charges. This makes for higher costs of doing business and highlights an area where with the right interventions, considerable efficiency gains may be available.

Worldwide the automotive industry is one of the largest industries and a key sector of the economy. Over the years, the Indian automotive industry has become resilient and despite recent downturns first in 2008 and 2009 and then again more recently, it was amongst the first sectors to recover after 2009 and has registered impressive growth figures in the recent past. In 2010-11, India as a nation became the **fifth** largest vehicle manufacturer.

Today, India is the world's largest manufacturer of tractors, second largest producer of two wheelers and buses, sixth biggest passenger car maker and the eighth largest commercial vehicle manufacturer. India is expected to show strong growth in vehicle production till 2020 across all segments. Thus,

- Passenger vehicles – about 3 million units presently to 5 million by 2015 and over 9 million by 2020 driven by domestic demand and as a global hub for exports of small cars.

- Commercial vehicles – about 0.8 million presently to over 1 million by 2015 and over 2 million by 2020. Small Commercial Vehicles (SCV), which is a relatively new segment, is expected to grow strongly.
- Two and three wheelers – presently 17 million is expected to touch 22 million units by 2015 and reach 30 million by 2020.
- Tractors – set to approach 0.7 million by 2015 and cross 1 million by 2020.
- Construction equipment – likely to grow by 2.5 times to 0.1 million units by 2015 and almost double to 0.18 million by 2020 driven by the infrastructure sector.

8.2 AUTOMOTIVE INDUSTRY – GROWTH AND CHALLENGES

The automotive manufactures are under continuous pressure to design and manufacture fuel efficient and environment friendly vehicles on a regular basis. There is also a thrust on the use of alternate fuels. The automotive Industry is facing the prospect of the number of vehicles on roads in the world doubling within the next two decades, with strong growth in the developing world. The challenges will primarily be in the following areas:

- Delivering ever better fuel economy
- Meeting Stricter Emission Limits
- Keeping the cost of vehicles low
- Improved vehicle performance
- Affordability of service and maintenance

This will compel the automotive industry to focus on:

- Downsizing of power train
- Light weight construction
- Stringent environment compliance
- Electro-mobility
- Presence/product penetration in emerging markets

8.3 INDIA – THE FUEL/EMISSION ROAD MAP

India broadly adopted the European model – as did many other developing countries – for emissions and fuel specifications, starting with the adoption of BS I in 1999 followed by BS II in 2000 in some cities. The Mashelkar Committee recommendations adopted in 2003 also adopted this approach and the emission roadmap till 2010 was thus based on European standards. However, taking into account local constraints and needs, some changes in the European standards and pattern of rollout were made in India.

The **Auto Fuel Policy (2003)** resulted in reduction in harmful vehicle emissions. It is estimated that gross pollutants from automotive vehicles per unit have seen dramatic reduction by over 90% for cars and over 80% for commercial vehicles up to 2010. However, the number of vehicles on the road has increased dramatically offsetting a part of the improvement. The constitution of the present Committee is an integral part of the path towards further progress which should permit a much greater reduction in harmful pollutant from tailpipe emissions.

8.4 IN-USE VEHICLE MANAGEMENT/INSPECTION & MAINTENANCE PROGRAMME

There is a great need to ensure that in-use vehicles – that is the stock of motor vehicles – are subject to regular inspection & maintenance for emission performance. There is thus an urgent need to institute an effective system for Inspection & Maintenance (I&M) regime for in-use vehicles in India.

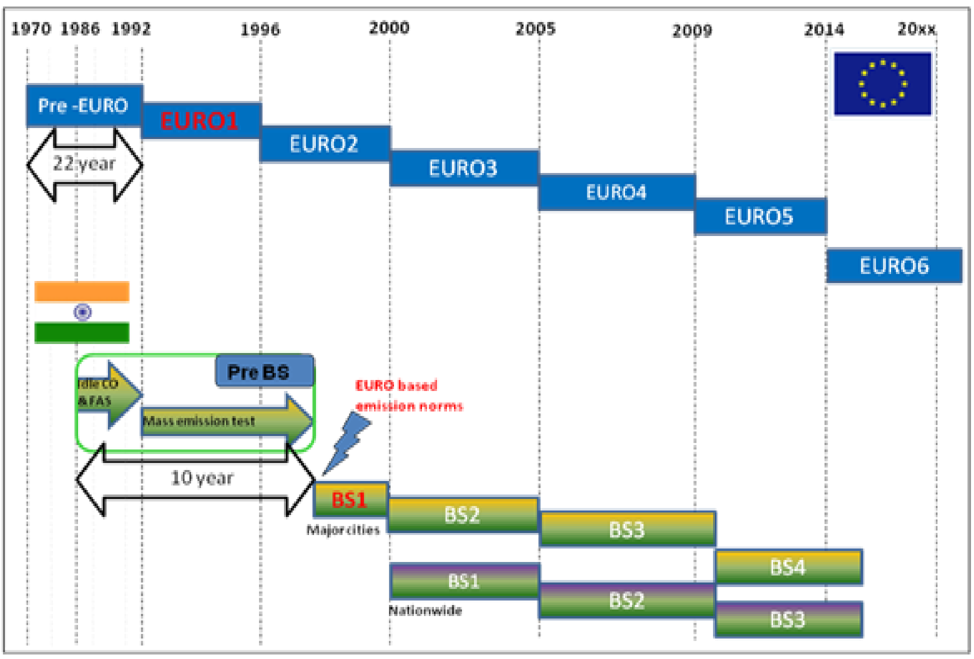
There should be a policy for the phasing out of older commercial vehicles. While, vehicles serving as personal transport cover less and less distance with age that is not the case with commercial vehicles. It is therefore necessary to have a clear process through which older vehicles, especially those which are clearly unable to meet extant emission norms are phased out of service.

8.5 HISTORY OF EMISSION REGULATION IN INDIA

In the early 1990's, emission regulations were first implemented in the country with idling emission limits for Positive Ignition (PI) vehicles and free acceleration smoke for Compression Ignition (CI) vehicles. This was successfully followed by first mass emission testing procedure for gasoline vehicles in 1991 and for diesel vehicles in 1992. These norms were based on the Indian Driving mode for light duty vehicles and 13 mode test for heavy duty vehicles. This continued till 1999, when the first European emission norm was adopted as BS I in India through Supreme Court directive and immediately followed by BS II norms starting from 2000/2001. Subsequently BS III & BS IV emission norms were adopted in 2005 and 2010 respectively in metros and larger cities. At **Chart 8.1** the phases of Emission Implementation in Europe and India are depicted graphically.

Chart 8.1

European Union Emission Implementation Phases



India moved fairly quickly in adopting stringent emission legislations. India reached BS IV (in 13 metro and major cities) in 11 years starting from 1999 while Europe moved from Euro 1 to Euro IV in a period of 13 years. However if we take the time elapsed in complete nationwide implementation it would be a longer interval for India of about 18 years (1999 to 2017). The quality of fuel in India also improved concurrently to support stringent emission norms.

India also adopted On Board Diagnostic (OBD) regulation from 2010 and moved to OBD-II norms from April 2013. This marked a new chapter in monitoring vehicle emission control system including catalytic convertors during vehicle serviceable life.

8.6 NEED FOR STANDARDISED FUEL ACROSS THE COUNTRY

The automobile industry has talked extensively about "one country, one fuel". As long as there are more than one fuel standard (which differs significantly as BS III and BS IV do) the national market is practically divided into segments. Vehicle owners are also put to difficulty in traversing these spaces. While it is desirable to have a single grade of fuel (and hence emissions) available/applicable across the country, there are other realities that temper the achievement of such an outcome.

The primary constraint is due to lack of adequate volumes of BS IV/V (≤50/≤10 ppm sulphur) fuel. Indian refineries will not be in a position till the end of 2016 to produce enough BS IV/V automotive fuel to fully replace BS III and meet the needs of the country. It must also be understood that domestically produced BS III fuel will need a home somewhere, since beyond a limited amount they cannot be exported out of the country.

Therefore, while the desire for a single grade may be supportable in-principle, the ground reality demands a transition time and transition phase. This Committee has laid out the transition plan in phases starting 2015 and completion by the beginning of 2017, as elsewhere detailed.

8.7 FUEL QUALITY RELATED TO THE ABILITY TO MEET EMISSION NORMS

Fuel quality is synchronised with the engine/vehicle technology which is mainly determined by the emission level that the vehicle has to comply. The automotive industry has emphasised that the main impact of fuel quality on engine technology and emission can be:

- Major properties – both chemistry and physical – of the fuel directly affect the engine combustion and thus impact the vehicle tail pipe emission. This impact becomes very critical as emission norms become stringent because the norms are set so low that a slight variation in fuel property may cause impact at the margin.
- Sulphur content, viscosity, density, E-70/100/150 and T_{90}/T_{95}, for gasoline and diesel respectively, RON/Cetane for gasoline and diesel respectively etc. may affect the engine sub-systems and cause emission deterioration during vehicle use. This is pertinent as the vehicle has to satisfy the emission ageing test requirement for 30,000 km to 167,000 km depending on the type of vehicle.
- Sulphur content in the fuel does affect the after treatment devices such as catalytic converter, DPF, some De-NO_x converters etc. There is a detailed discussion at paragraphs 6.5.1 & 6.5.2. Other characteristics of the fuel may also have an impact. In sum this can result in emission deterioration during vehicle use and/or premature failure of after treatment devices. Either way it causes difficulty in meeting sustained emission limits.

8.7.1 Fuel Quality at Retail Outlets

The automotive industry has pointed out that there is evidence of adulteration in some cases of diesel, mostly with kerosene. This needs to be curbed. Government at the Centre and States have been taking steps to curb the diversion of highly subsidised kerosene meant for public distribution to needy families for other uses, including adulteration of diesel both for mobile and stationary use. There is a need to crack down on such diversion and adulteration with greater vigour as it not only undermines public policy, causes losses to the exchequer but also damages vehicles.

In India, oil companies have been maintaining the required specifications at their depots. The quality of fuel at company owned and major retail outlets have maintained adherence to quality standards as per the existing quality control system. However, there are instances where in some retail outlets the rigour of the system requires to be strengthened. There have been instances where gasoline and diesel have been found with undesirable adulterants, which cause failure of vehicle parts and performance.

In advanced countries there is strict fuel quality control at retail out lets. In USA, EPA and CARB have good monitoring mechanism which is quite fool proof. In Japan, market fuel quality is ensured through audit conducted jointly by JAMA, Oil Companies and Regulatory bodies every 6 months. They also have a rigid penalty system for non-compliance. In Europe, EEC directive has spelt out a monitoring procedure to do audit of market fuel and CEN has specified separate specification for fuel quality monitoring at retail outlets.

With the introduction of OBD-II in India, non-compliance of fuel specification and adulterated fuels has the potential to cause failure of many sensors such as O_2 and NO_x sensors. It will also poison the catalytic convertors. This would mean that customer will face frequent glowing of MIL lamp and premature failure of parts. Therefore, the need for stringent quality control at all retail outlets is of utmost importance.

8.8 SPECIFICATIONS FOR GASEOUS FUEL

CNG fuel quality in terms of methane content is seen to vary from region to region. In order to rationalise the CNG quality in India, it is proposed that IS: 15958:2012 should be followed for CNG testing. The CNG specification is at **Table 8.1**. The proposed specification for Auto LPG is at **Table 8.2**.

Table 8.1

Fuel Specification of Compressed Natural Gas (CNG) for Automotive Purposes: IS 15958: 2012

Table 8.1: Fuel Specification of Compressed Natural Gas (CNG) for Automotive Purposes: IS 15958: 2012

	Characteristics	Requirements	Test Method
1	Wobbe Index, MJ/m3, Min	48.8 – 51.0	IS 14504
2	Water content, mg/m3, Max	5.0	IS 15641 (part2)
3	Hydrocarbon (volume % of total organic carbon present)		
	a) Methane, min	90.0	IS 15130 (part3)
	b) Ethane, max	6.0	
	c) C3 & higher HC, max	3.0	
	d) C6 & higher HC, max	0.5	
	e) Total unsaturated HC, max	0.5	
4	Corrosive Components		
	a) Total sulphur, mg/m3, max	20.0	ASTM D3246-05
	b) Oxygen, % vol. max	0.5	IS 15130 (part3)
5	Carbon dioxide & nitrogen, % vol., max	3.5	- do-
6	Other Species (mole %):		
	a) Hydrogen, max	0.1	- do-
	b) Carbon monoxide, max	0.1	- do-
7	Methane number, min	90.0	IS 15320

Table 8.2

Fuel Specification of Liquefied Petroleum Gas (LPG) for Automotive Purposes: IS 14861: 2000

Table 8.2: Fuel Specification of Liquefied Petroleum Gas (LPG) for Automotive Purposes: IS 14861: 2000

	Characteristics	Requirements	Test Method
1	Vapour Pressure at 40°C, kPa gauge, Min/Max	520/1050	ISO 4256
2	C_5 Hydrocarbons & heavier, mole %, max	2.0	ASTM D 2163
3	Dienes (as 1, 3 butadiene), mole %, max	0.5	ISO 7941
4	Total volatile sulphur (after stanching), ppm, max	150	ASTM D 3246
5	Copper Strip Corrosion at 40° C for 1 hour, max	Class 1	ISO 6251
6	Hydrogen sulphide	Pass the test	ISO 8819
7	Evaporation residue, mg/kg, max	100	ISO 13757
8	Free water content	Nil	ASTM E 700
9	Motor octane number (MON), min	88	ISO 7941 plus Annex A
10	Odour	Unpleasant & distinctive down to 20% lower explosive limit	ISO 7941 plus Annex A (Notes 4&5)

8.9 TEST DRIVING CYCLES

There are several International Test Cycles that are used for Emissions and Fuel Economy. The established ones in use in the developed world are the four listed below. Several other countries have drawn or adapted from these test cycles.

- US Test Cycle – A City Cycle and Highway Cycle;
- European test Cycle – there is now a revised cycle: New European Drive Cycle (NEDC);
- Japanese Test Cycle. The previous JC08 cycle has been revised to new JC 10-15 driving cycle;
- Australian Test Cycle.

In most countries, cars are tested for fuel economy and emissions through standard procedures before being authorised for sale. Automotive fuel consumption is generally measured with a test car running on a chassis dynamometer. However, test methods, including test cycles (that is, vehicle running patterns) vary among countries and regions. The test cycles simulate a range of driving conditions, at highway speeds and at speeds more typical of urban driving.

There is a need felt across the world to harmonise driving cycles across countries so as to be able to arrive at meaningful cross-country/region comparison for fuel economy/GHG emissions and other emissions. However, if driving conditions vary significantly in countries, there is considerable merit in adopting a cycle that reflects the reality of driving conditions. This is certainly true for India where traffic movement differs from that which may exist in the developed world. India has the Indian Driving Cycle for testing emission and fuel economy.

8.9.1 Two and Three Wheelers

The Indian Driving Cycle (IDC) was applicable to all Two- and Three-Wheelers till BS III. However in the case of Two Wheelers, establishment of driving cycle called Worldwide Motorcycle Test Cycle (WMTC) was finalised in 2005 and then amended in 2008 to take into consideration the driving patterns of countries like India.

The UNECE/WP.29 has formulated GTR 2 for emission norms for some categories of Two Wheelers, under the 1998 Agreement of UNECE. GTR 2 is applicable to two wheelers with engine cc greater than or equal to 50cc or Maximum speed (V_{max}) greater than 50 km/h (*i.e.* WMTC does not cover mopeds).

WMTC categorises these two-wheelers into different classes (Class 1, 2 and 3) based on engine cc and maximum speed.

WMTC differs considerably from the IDC test cycles specifying higher max speeds, higher acceleration and deceleration ramps, compared to IDC. The impact of WMTC is more aggressive than IDC as maximum speed has gone up in all parts of WMTC. Maximum acceleration has gone up for almost all the cycles except for the Highway and maximum Deceleration has increased.

Due to this development, at the BS III level, as an option, the applicable WMTC driving cycle may be notified by Government of India for gasoline two wheelers other than mopeds.

In addition, as a recent EU initiative, an informal group (EPPR) was formed under UNECE WP.29/GRPE to seek to harmonise driving cycles and test procedures related to emissions and propulsions for all L category vehicles including L5 which are 3-wheelers. Since the scope of the work is very large covering all L categories and all test types, meeting the timeline of 2016, may not be entirely possible.

Hence, it is proposed that:

- For gasoline two-wheelers, other than mopeds, to use the WMTC applicable for setting the BS III, BS IV and BS V Two Wheeler emission norms.
- For Mopeds and Three Wheelers to use the extant IDC test cycle for BS IV and BS V emission norms. Test cycle for BS VI can be reviewed based on the developments in the EPPR group.

8.9.2 Passenger Cars

For Passenger Cars (including MUV), it is proposed to continue the current Indian Driving Cycle for emission and fuel consumption testing. India can choose to shift to a different procedure with BS VII (that is, beyond BS VI). India and Japan have committed to adopt the first three phases of the driving profile, *viz.* Low, Middle and High phases for Class-III vehicles for their domestic regulations (Max speed of cycle with High Phase is around 97.4 km/hr).

India adopted 80,000 kms of durability requirement for emission. Although EU adopted 100,000 kms from Euro V onwards, India continued with 80,000 kms of durability requirement. Now with EU V and EU VI, Europe has adopted 160,000 kms of durability. It is recommended that we choose to increase the durability requirement from the current level of 80,000 kms to 120,000 kms for BS V. With the adoption of BS VI later, durability requirements could be reviewed and enhanced to 160,000 kms if found feasible. It may be noted that the durability requirement in Japan is still 80,000 kms for vehicles.

However, it is recommended to follow the same level of deterioration factors for BS V and BS VI as is followed in Euro V and Euro VI to maintain the stringency of emission limits.

8.10 EMISSION NORMS FOR TWO WHEELERS

Following on discussions in Working Group and with manufacturers, emission norms for two (and three) wheelers have been developed conforming to BS IV standards. As of now two/three wheelers operate only with BS III fuels and have BS III emission norms.

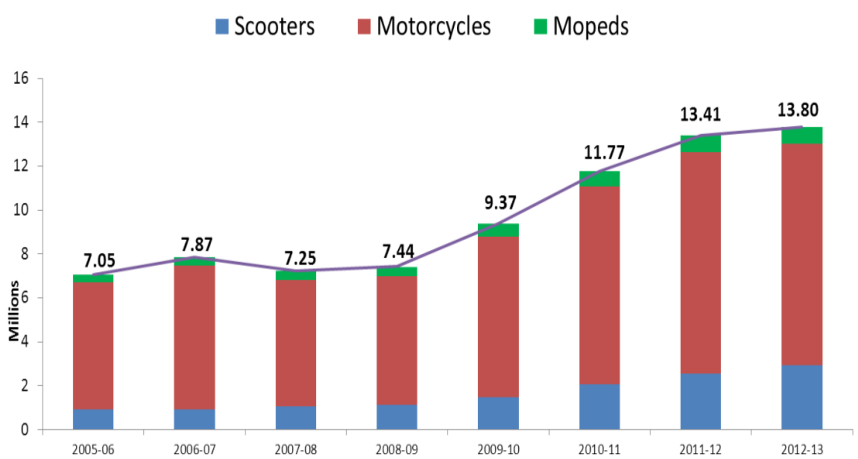
8.10.1 Characteristic of the Indian Two/Three Wheeler Industry

The Indian Two Wheelers Industry is the second largest in the world with almost 12 million new customers every year. This industry provides employment to around 4 million direct and indirectly, in the country. It is now a well-known fact that powered two-wheeled vehicles occupy a leading position in the personal transportation sector both in the urban and rural areas in India. Sales of two-wheelers are nearly 5 times than that of passenger cars for the last several years (**Chart 8.2**). Two-wheelers have been accounting for over 75% of annual domestic sales of all vehicles for the last many years.

Chart 8.2

Two Wheelers Sales in India

Units: Million Units Per Year



The Indian 2 wheeler market has some unique characteristics. The 'around 100 cc commuter bikes' has been and continues to be the dominant category and has revolutionised mobility in India. It is an important "driver" for consumer choice because of ease of handling and manoeuvring etc. It also provides adequate performance levels with high fuel efficiencies. Rural Indian and villagers also have been graduating from cycles in a big way to powered two wheelers (PTW) as a means of mobility for a small family in majority of cases. Scooters have made a comeback and are growing in the last couple of years. Premium commuter's bikes (125–200 cc) are seen to be more popular in urban areas.

Though two wheelers sales in India have been growing in the past few years at double-digit rates and in 2011 surpassed ten million vehicles a year mark, however in 2012-13 sales have been flat on account of higher interest rates and the overall slowdown in the economy. This slow down continues to date.

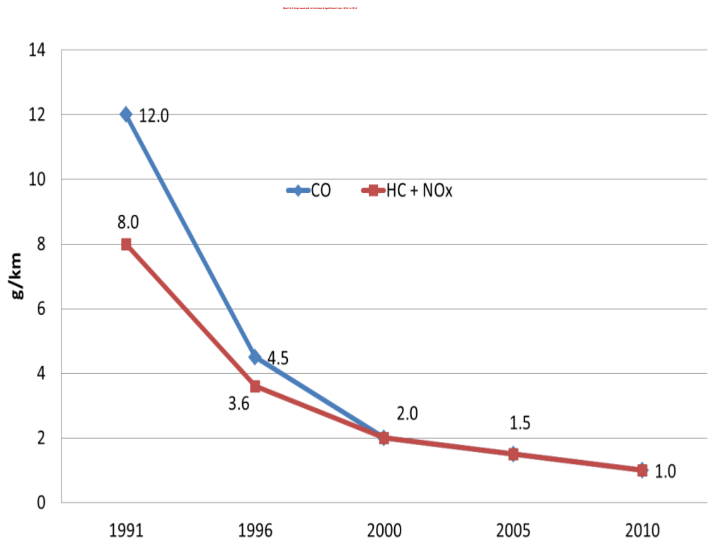
Given the importance of two wheelers in improving and providing personal mobility in India, attention needs to be paid to the possibility of reducing emissions and improving fuel consumption from these vehicles.

8.10.2 Development of Emission Norms in India for 2-wheelers

In 1991 when the emission control regime started in India, the norms for two wheelers started with the only then existing UNECE regulation (R40) but with an India specific Indian Driving Cycle (IDC). Subsequently, these norms were progressively tightened, as is shown at **Chart 8.3**.

Chart 8.3

Improvement in Emission Regulations from 1991 to 2010



Over and above tightening the CO, HC + NO_x limits, a deterioration factor of 1.2 was introduced in the year 1998. From the year 2000 onwards, a relaxation of 20% given for conformity of production (CoP) was removed by the Government, which led to maintenance of very strict production control with minimum variations. BS III emission norms are about 7% for CO and 10% for HC + NO_x of the norms introduced in 1991.

8.10.3 BS IV Emission Norms for Gasoline Two Wheelers

The emission norms put forward in the Gazette Notification (draft) issued by the Government of India (Ministry of Road Transport and Highways) of 14 March 2014 inviting comments, appear to be somewhat on the lenient side. A comparison in the transition from Euro II, III, IV and V emission norms for passenger cars ('M' category) and two wheelers (Class I) was made for purpose of discussion in the Committee meeting held on 22 April 2014.

Presently all two wheelers manufactured in India are with gasoline engine above 50 cc, and maximum speed > 50 km/h; therefore these two wheelers will have the WMTC as test cycle.

The proposed BS IV emission norms (Gazette Notification of 14 March 2014) issued for public comment have:

- A more stringent mass emission norms limits compared to the existing BS III equivalent WMTC norms.
- Limit for Evaporative emissions
- Control of Crank Case Gas emissions.

The above cited notification proposes that BS IV norms will be complied with BS IV reference fuel and use of BS IV commercial fuel, wherever available. Vehicles sold in areas where BS III fuel is available will also be the same models (BS IV compliant). Durability would be lower with BS III fuel in comparison to BS IV fuel till the transition to BS IV is completed.

The Standing Committee on Emission Regulations (SCOE) under Ministry of Road Transport & Highways (MoRT&H) had approved the proposal in April 2013 and MoRT&H has issued the notification for public comments.

Following on the Committee meeting on 22 April 2014 and consultations with the concerned vehicle manufacturers revised emission norms have been prepared keeping in mind both the desire for tighter emission norms and the feasibility of achieving them and they are presented at **Tables 8.3, 8.4 & 8.5**.

So far, the emission norms for two wheelers did not specify a separate limit for NO_x, but a combined limit for HC + NO_x. The practice in the EU and most other jurisdictions is to separately specify for HC and NO_x. It is proposed that we continue with specifying a joint limit for HC + NO_x, but also specify a separate sub-limit for NO_x. The trade-off between fuel efficiency and NO_x has been referred to before as also to the fact that the segment of our population who purchase two wheelers for personal transport also have limited budgets. Furthermore, changes in respect of evaporative norms have a compounding impact on the improvements that manufacturers will have to do. The scale of change in going from carburetted to fuel injection is also very large and require some time for transition, especially if this change over has to happen in a cost effective manner.

The proposed emission norms for two wheelers of different classes presented at **Tables 8.3 & 8.4** are all significantly tighter than what was proposed in the previously referred Gazette notification of 14 March 2014. The norms for BS V at **Table 8.5** have been similarly tweaked, so as to narrow the gap between the statutory norms for this class of vehicles in India as compared to elsewhere.

The details of tailpipe emission and evaporative emission are described in **Table 8.3** below.

Table 8.3

Mass Emission Norms for BS IV for Two Wheelers

Class	BS IV Emission norms (g/km)			Test Cycle
	CO	HC + NO_x	NO_x	
1 & 2-1	1.403	0.790	0.390	As per GTR 2 Amend 1&2 Alt-A and WMTC equivalent BS III
2-2	1.970	0.670	0.340	
3-1 & 3-2	1.970	0.400	0.200	
	1. D. F. is built into the above proposed emission norm 2. These values are with BS IV fuel 3. Norms to be applicable from 1st April 2016			

Classification of Two Wheelers

Class 1	50 cm³ ≤ engine capacity≤ 150 cm³ and V_{max}< 50 km/h or engine capacity < 150 cm³ and 50 km/h ≤ V_{max} ≤ 100 km/h
Sub Class 2-1	Engine capacity < 150 cm³ and 100 km/h <V_{max} ≤ 115 km/h or Engine capacity >150 cm³ and V_{max} ≤ 115 km/h
Sub Class 2.2	115 km/h <V_{max} ≤ 130 km/h
Sub Class 3-1	130 <V_{max}≤ 140 km/h
Sub Class 3-2	V_{max} > 140 km/h.

BS IV emission norms for two wheelers were planned to be applicable for vehicles manufactured from 1 April 2015 as per the Gazette notification of 14 March 2014. However, given the further tightening that has been done, which will require additional development effort by the manufacturers and also the fact that BS IV automotive fuel will become available in about half the country by April 2016, it is suggested that the standards for BS IV emissions for two wheelers become effective from 1 April 2016.

8.10.4 Introduction of Evaporative Emission Control for 2-Wheelers

There are only a handful of regions (*viz.* California, Thailand and Taiwan) that have mandated evaporative emission limits for gasoline two wheelers. Europe is planning to mandate this only from 2016/2017.

Both tailpipe emission control and evaporative emission control are basically intended to reduce the total HC emission emitted by vehicle into the environment. Internationally, two concepts for evaporative emission norm are prevalent. One is to specify HC emission limit (‘x’ g/test). Another is to provide an alternative procedure by which means, if tailpipe HC emissions is reduced further, higher evaporative emission limit values are accepted. In other words, if 2 g/test of HC is the evaporative emission norm, and if tailpipe HC emission norm is further reduced by 0.2 g/km, evaporative emission up to 6 g/test is accepted. This allows the manufacturer to use optimum cost effective solutions for controlling the HC emissions. A similar system is also considered for India and emission limits with the above provision are:

Table 8.4

Emission Limits Based on Evaporative Emission Norms for 2-Wheelers

Table 8.4: Emission Limits Based on Evaporative Emission Norms for 2-Wheelers

Sub-Class	BS IV Emission Norms (g/km)				Test Cycle
	CO	$HC + NO_x$		NO_x	
		Option 1	Option 2		
1 & 2-1	1.403	0.790	0.590	0.390	As per GTR 2 Amend 1&2 Alt-A and WMTC equivalent BS III
2-2	1.970	0.670	0.470	0.340	
3-1 & 3-2	1.970	0.400	0.200	0.200	

Note:
1. D. F. is built into the above proposed emission norm.
2. These values are with BS IV fuel
3. Option 1 applicable if Evaporative emission norm of 2 g/test is complied with
4. Option 2 applicable if Evaporative emission norm of 6 g/test is complied with

8.10.5 Control of Crank Case Emission for BS IV Two Wheelers

It may be mandated that the crank case breather shall be connected to the intake system in the case of four-stroke engines, so that there is no escape of crank case gases into atmosphere. In the two-stroke engines, crank case is not vented to atmosphere and hence this requirement is not applicable.

8.10.6 BS V Emission Norms for Indian Two Wheelers

BS V Emission norms are proposed with a further emission reduction over BS IV norms. The values are given below for Gasoline two wheelers of Classes 1, 2 & 3. The details are given below. BS V emission norms for two wheelers in India will be applicable four years after the implementation of BS IV emission norms for two wheelers.

8.10.7 Mass Emission Limits for BS V for Classes 1, 2 and 3

The proposed BS V emission norms for all class of two wheelers are given in **Table 8.5** below.

Table 8.5

BS V Emission Norms for All Classes of Two Wheelers

Table 8.5: BS V Emission Norms for All Classes of Two Wheelers

Vehicle Class	**BS V Emission Norms**		
	CO g/km	HC + NO_x g/km	NO_x (g/km)
1 & 2-1	1.140	0.450	0.225
2-2	1.140	0.450	0.225
3-1 & 3-2	1.140	0.260	0.130
DF (for all classes)	1.3	1.2	1.2

Note: Applicable for new models from 1 April 2020 and existing models from 1 April 2021

The CO limits are significantly tighter than BS IV limits; that for HC and NO_x are combined with a separate sub-limit for NOx. Indian two wheelers are one of the best in the world on fuel economy. This superior fuel economy has been achieved mainly by designing the engines with lean mixture (air fuel ratio is considerably above stoichiometric ratio). Use of lean mixture ratio, while improving the fuel efficiency and CO emissions tend to increase NO_x emission. Therefore, in order to control the likely NO_x emissions from two wheelers, an additional limit for NO_x is being proposed within the overall limit of HC + NO_x. However, this may limit the extent of fuel efficiency that can be achieved from two wheelers in future.

8.10.8 BS V Emission Norms Two Wheelers with cc < 50 and V_{max} < 50 km/h and Diesel Two Wheelers

Since these classes of two wheelers are not being produced in India, it is recommended that these norms may be developed by the concerned Ministry, as and when their production in India becomes significant or when such norms are included in GTR based on the EPPR.

8.11 EMISSION NORMS FOR THREE WHEELER FOR BS IV AND BS V REGIMES

Traditionally, 3 Wheelers are used for low cost last mile connectivity. These are low powered vehicles usually with single cylinder naturally aspirated engine. For the users of these vehicles, product cost and running cost are of prime importance along with ease of service. Three wheelers are an important mode of transportation in the current infrastructure environment. The three wheeler industry has grown in India considering the requirements of mass transportation and without comparable references in developed countries.

The Indian three wheelers Industry is the world’s largest with over 0.5 million new units entering service each year. Three-wheelers account for 4% of the population of vehicles in India.

8.11.1 Development of Emission Norms in India for 3 Wheelers

Emission norms from BS I (2000) to the proposed BS IV norms for 3 wheelers has seen a reduction of 75% for CO and 47% for HC + NO_x for SI engines. The order of reduction is similar to what transpired in Europe's Tricycles over 17 years where the permissible limits were reduced by 85%. (**Table 8.6**)

Table 8.6

Three Wheeler Emission Norms for SI and CI Engines

Table 8.6: Three Wheeler Emission Norms for SI And CI Engines

Unit: Emission, gms per km travelled

	2000	2005 (BS II)	2010 (BS III)
Spark Ignition (SI) Engines			
CO	4.00	2.25	1.25
HC + NO_x	2.00	2.00	1.25
Compression Ignition (CI) engines			
CO	2.72	1.00	0.50
HC+NO_x	0.97	0.85	0.50
Particulate (PM)	0.14	0.10	0.05

Over and above tightening the CO, HC & NO_x limits, a deterioration factor of 1.2 was introduced in the year 2000. From the year 2000 onwards, a relaxation of 20% initially given conformity of production (CoP) was withdrawn by Government, requiring maintenance of stricter control on production variations.

8.11.2 Proposed BS IV Emission Norms for 3 Wheelers

BS III emission norms for 3-wheelers were notified vide GSR 84(E)/9 February 2009 and implemented from 1 April 2010 in some parts of country and from 1 October 2010, all over India.

It is proposed that the BS IV emission norms for 3-wheelers be as given in **Table 8.7.** It is proposed that they will become effective from 1 April 2016.

Table 8.7

Three Wheeler Emission Norms for SI and CI Engines – BS IV

Table 8.7: Three Wheeler Emission Norms for SI And CI Engines – BS IV

Unit: Emission in gms per km travelled

Spark Ignition (SI) Engines - Gasoline / CNG / LPG						
	BS III		BS IV			Test cycle and test procedure
	CO	HC+NOx	CO	HC+NOx		
				Option 1	Option 2	
Limits	1.25	1.25	0.94	0.94	0.74	IDC BS III TAP
DF	1.20	1.20	1.20	1.20	1.20	

Compression Ignition (CI) Engines - Diesel							
	BS III			BS IV			Test cycle and test procedure
	CO	HC+NOx	PM	CO	HC+NOx	PM	
Limits	0.50	0.50	0.05	0.38	0.38	0.0425	IDC BS III TAP
DF	1.10	1.00	1.20	1.10	1.00	1.20	

Note: 1. For Three Wheeler gasoline engines, evaporative emissions are applicable and the base case limit value is 2 g/test
2. Option 2 is applicable, if Evaporative Emission norm of 6 g/test is complied with
3. For vehicle with CNG/LPG application, current practice of factoring NMHC and RHC emission will continue and evaporative emission tests are not applicable
4. BS IV norms to be applicable from 1st April 2016

8.11.3 Emission Norms for Indian 3-Wheelers for BS V

With the implementation of BS IV emission norms, Indian 3-wheelers, which are predominantly carburetted, will be tuned for lean operation which will keep the fuel efficiency as high as possible. Any further reduction in the NO_x limits would not be possible with carburetted technology. A shift will have to be made towards adoption of stoichiometric ratio and the use of a 3-way catalytic converter will be needed in the case of SI engine.

For CI engines, further reduction in emissions beyond proposed BS IV emission norms will require the incorporation of technologies such as Turbo Charger, High pressure injectors, Sensors and ECU to improve engine efficiency which have not been developed. The proposal for BS V emission norms for 3-wheelers is given at **Table 8.8**.

Table 8.8

Three Wheeler Emission Norms for SI and CI Engines – BS V

Unit: Emission in gms per km travelled

Spark Ignition (SI) Engines (Gasoline/CNG/LPG)						
	BS IV			BS V		Test Cycle and Test procedure
	CO	HC + NO_x		CO	HC + NO_x	
		Option 1	Option 2			
Limits	0.94	0.94	0.74	0.66	0.66	IDC BS III TAP
DF	1.20	1.20	1.20	1.20	1.20	

Compression Ignition (CI) Engines (Diesel)							
	BS IV			BS V			Test Cycle and Test Procedure
	CO	HC + NO_x	PM	CO	HC + NO_x	PM	
Limits	0.38	0.38	0.0425	0.26	0.26	0.038	IDC BS III TAP
DF	1.10	1.00	1.20	1.10	1.00	1.20	

Note:
1. For Three Wheeler gasoline engines, evaporative emissions are applicable and the base case limit value is 2 g/test
2. Option 2 is applicable, if Evaporative Emission norm of 6 g/test is complied with
3. For vehicle with CNG/LPG application, current practice of factoring NMHC and RHC emission will continue and evaporative emission tests are not applicable
4. BS V norms to be applicable from 1st April 2020 for new models and 1 April 2021 for existing models

The three wheeler industry has said that the extent of technological investment and development that will be required in the coming years will be considerable. Given the peculiar conditions that obtain in India considerable adaptation of technology would be called for. The emission standards that have been proposed for BS V assume that these developments will all be successfully achieved in time. However, the possibility that this may not happen while small, remains significant.

Therefore, there is a need to take a review four to five years from notification of these standards to ascertain the technology status and the assumptions that have entered in shaping these emission norms for BS V.

8.12 Emission Norms for Passenger Cars/Light Commercial Vehicles up to 3.5 T GVW and Heavy Duty Vehicles > 3.5 T

For passenger vehicles and commercial vehicles, the extant BS IV emission norms are proposed to be continued. Emission norms for such vehicles corresponding to the proposed BS V fuel standard have been developed and are similar to the Euro V emission norms.

EU Regulations – Direction of Change

The main change in the EU emission regulations for light duty vehicles has been to reduce particulate matter. This will make it almost mandatory for vehicle manufacturers to adopt some form of particulate filters. Particulate number measurement has also been phased-in in the regulation for diesel vehicles. There has been a change in the measurement and control of Hydrocarbons from Total Hydrocarbons to Non-Methane Hydrocarbons in case of gasoline vehicles along with a reduction in NO_x limits. In addition, the particulate measurement has been phased in for gasoline engines employing direct injection technology. By Euro VI, the regulation will become almost fuel neutral for control of NO_x and PM.

Another feature of the European norm is the stringency of the deterioration factors with higher durability norms for emission control. In case of gasoline vehicles, although there is not much apparent change in the emission limits, the stringent DF factors make the regulation stringent.

In case of diesel vehicles Euro V regulation mainly targets reduction of particulate emissions. There is 80% reduction in the limits of particulate matter and 56% reduction of NO_x limits for Euro V. For Euro VI, there is a further reduction of NO_x limits. For BS V it is proposed to adopt the tighter EU Vb straightway and skip the intermediate Euro Va Norms.

The vehicle categorisation that has been adopted for setting emission limits follow the European classification which is given at **Table 8.9**.

Table 8.9

Description of 4 (or more) Wheeler Vehicle Categories

Table 8.9: Description of 4 (or more) Wheeler Vehicle Categories

Category	Description	Sub-category	No. of persons	Mass limit	
M	Carriage of passengers (Minimum 4 wheels)	M1	Up-to 9 persons	GVW ≤ 3500 kg	
N	Carriage of goods (Minimum 4 wheels)	N1 CL-1	NA	Max GVW ≤ 3500 kg	RW≤ 1305
		N1 CL-2			1305< RW ≤ 1760
		N1 CL-3			1760 < RW

Note: EU 70/156/EC, as amended by EU 2007/46/EC. Until Euro IV, there were two sub-groups (EU 2007/46/EC): M1 with GVW≤2500 kg and M1 with 2500 kg< GVW≤ 3500 kg.

The prescribed limits for emissions are similar to Euro 5b. It is presented at **Table 8.10** and **Table 8.11** for passenger cars (that is, class "M" vehicles) that use gasoline/gaseous fuels (Positive Ignition or PI).

Table 8.10

BS IV/V and European Emission Norms for Positive Ignition (PI) Engines

Table 8.10: BS IV/V and European Emission Norms for Positive Ignition (PI) Engines

Norm	Category	Class	RW in kg	CO	THC	NO_x	NMHC	PM	No. of particles
				mg (number for particles) per km travelled					
BS IV & Euro IV	M		All	1,000	100	80	-	-	-
	N1	I	RW≤ 1305	1,000	100	80	-	-	-
		II	1305< RW ≤ 1760	1,810	130	100	-	-	-
		III	1760 < RW	2,270	160	110	-	-	-
Euro V & BS V	M		All	1,000	100	60	68	4.5	-
	N1	I	RW≤ 1305	1,000	100	60	68	4.5	-
		II	1305< RW ≤ 1760	1,810	130	75	90	4.5	-
		III	1760 < RW	2,270	160	82	108	4.5	-
Euro VI	M		All	1,000	100	60	68	4.5	$6.0*10^{11}$
	N1	I	RW≤ 1305	1,000	100	60	68	4.5	$6.0*10^{11}$
		II	1305< RW ≤ 1760	1,810	130	75	90	4.5	$6.0*10^{11}$
		III	1760 < RW	2,270	160	82	108	4.5	$6.0*10^{11}$

Note: Particulate standards shall apply to vehicles with direct injection engines only. BS V and BS VI norms are aligned with Euro V and Euro VI norms.

Table 8.11

BS IV/V and European Emission Norms for Compression Ignition Engines

Norm	Category	Class	RW, kg	CO mg/km	NO_x mg/km	THC + NO_x, mg/km	PM, mg/km	No. of particles
			Kg	mg (number for particles) per km travelled				
BS IV & Euro IV	M		All	500	250	300	25	-
	N1	I	RW< 1305	500	250	300	25	-
		II	1305<RW< 1760	630	330	390	40	-
		III	1760<RW	740	390	460	60	-
Euro V & BS V	M		All	500	180	230	4.5	$6.0*10^{11}$
	N1	I	RW< 1305	500	180	230	4.5	$6.0*10^{11}$
		II	1305<RW< 1760	630	235	295	4.5	$6.0*10^{11}$
		III	1760 < RW	740	280	350	4.5	$6.0*10^{11}$
Euro VI & BS VI	M		All	500	80	170	4.5	$6.0*10^{11}$
	N1	I	RW< 1305	500	80	170	4.5	$6.0*10^{11}$
		II	1305<RW< 1760	630	105	195	4.5	$6.0*10^{11}$
		III	1760 < RW	740	125	215	4.5	$6.0*10^{11}$

8.12.1 On Board Diagnostics

India adopted BS IV OBD-II norms in April 2013. OBD has a big relation to the driving environment including road conditions, fuel variations etc. Before deciding the future stringency of the OBD norms, industry needs to review and prepare a proposal.

8.12.2 Emission Roadmap for BS V and BS VI for 4 Wheelers Weight of < 3,500 kg

There needs to be a roadmap for the transition from the present BS IV regime to BS V & BS VI country wide for 4-wheelers. For regions where 50 ppm sulphur fuel is available, the applicable emission norms would be same as BS IV. The emission limits of BS IV Emission norms shall be as notified vide GSR 84(E) dated 9th February 2009 under Central Motor Vehicle Rules.

The schematic is at **Table 8.12**.

Table 8.12

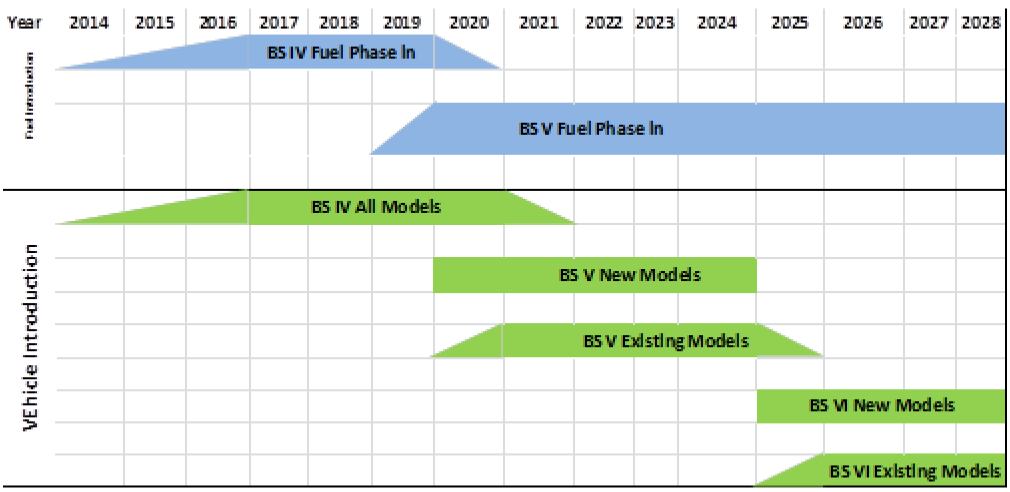
Schematic of Transition of Roadmap to BS V and BS VI

Item	Implementation date			Remarks
	BS IV	**BS V**	**BS VI**	
4-wheeler (< 3,500 kg)	Nationwide implementation in 2017	For new models with effect from 1 April 2020 and continuing models to switch to BS V within one year, *i.e,* before 31 March 2021.	4 years after country wide BS V implementation, *i.e.* from 1 April 2024	▪ Alignments of dates of BS V and BS VI implementation of <3,500 kg with >3,500 kg GVW to synergise development, return of investment and supply chain ▪ Phase-in of regulation like in Europe for < and > 3,500 kg GVW
Fuel quality	50 ppm sulphur	In line with BS V fuel (10 ppm sulphur)	In line with BS V fuel (10 ppm sulphur)	▪ Fuel roadmap to be made available (conventional, bio-fuel and gaseous fuel) ▪ Fuel quality monitoring at retail outlet ▪ Enforcement law/order for curbing adulteration

The proposed emission roadmap for BS IV, BS V and BS VI roll out across the country is given at **Chart 8.4**.

Chart 8.4

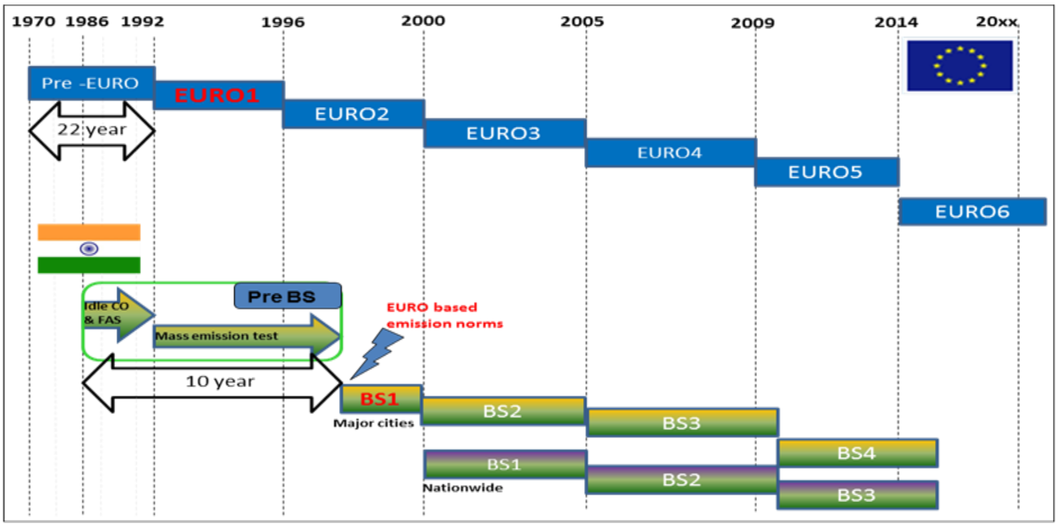
Proposed Roll Out of BS IV, BS V and BS VI Countrywide



For the record, the roadmap followed in Europe is shown at **Chart 8.5**

Chart 8.5

Fuel Standard Transition in India vis-à-vis European Union



8.12.3 Deterioration Factors

The proposed deterioration factors for four wheeler Spark Ignition and Compression Ignition engines are at **Table 8.13**.

Table 8.13

Deterioration Factors

Deterioration Factors (SI or PI Engines)

Norms	CO	NO_x	THC	NMHC	PM	PN
BS V and VI	1.5	1.6	1.3	1.3	1	1

Deterioration Factors (CI Engines)

Norms	CO	NO_x	THC	PM	PN
BS V and VI	1.5	1.1	1.1	1	1

8.12.4 Emission Norms for Heavy Duty Vehicles > 3.5 T GVW

Europe moved to Euro IV standards in 2005, to Euro V standards in 2008/2009 and to Euro VI in 2013 (**Chart 8.5**). In India, where 50 pm sulphur fuel is available, the applicable emission regime is BS IV, which was notified in February 2009 under the Central Motor Vehicle Rules.

Table 8.14

Emission Norms for Diesel Engines > 3.5 Tonnes GVW

Emission, g/KWH	Driving Cycle	CO	HC	NO_x	NH_3 ppm	PM	Smoke (m-1)	PM No. / KWH
		gms per KWH						
BS IV	ESC/ELR	1.5	0.46	3.5	---	0.02	0.50	
BS V (Euro V)	ESC	1.5	0.46	2.0	---	0.02	0.50	---
BS VI (Euro VI)	WHSC	1.5	0.13	0.4	10	0.01	---	$8X10^{11}$

Table 8.15

Emission Norms for CNG or LPG Engines > 3.5 tonnes GVW

Emission	Driving Cycle	**CO**	**NMHC†**	**CH_4**	**NO_x**	**NH_3** ppm	**PM** g/KWH	**PM No.** /KWH
		gms per KWH						
BS IV	ETC	4.0	0.55	1.1	3.5	---	0.03	...
BS V (Euro V)	ETC	4.0	0.55	1.1	2.0	---	0.03	---
BS VI (Euro VI)	WHTC	4.0	0.16	0.5	0.46	10	0.01	$6X10^{11}$
				CNG only			For diesel only	

Note: † The manufacturer may choose to measure the mass of total hydrocarbons (THC) instead of measuring the mass of non-methane hydrocarbon (NMHC). In this case, the limit for mass of THC should be same as for NMHC

Table 8.16

Fixed Deterioration Factors for Heavy Duty Vehicles (alternative to DF based on service accumulation)

Emissions	Driving Cycle	CO	THC‡	NMHC†	CH_4†	NO_x	PM	P No.
BS V (Euro V)	ESC/ETC	1.1	1.05	1.05	1.2	1.05	1.10	---
BS VI (Euro VI)	WHTC/WHSC	1.3	1.3	1.4	1.4	1.15	1.05	1

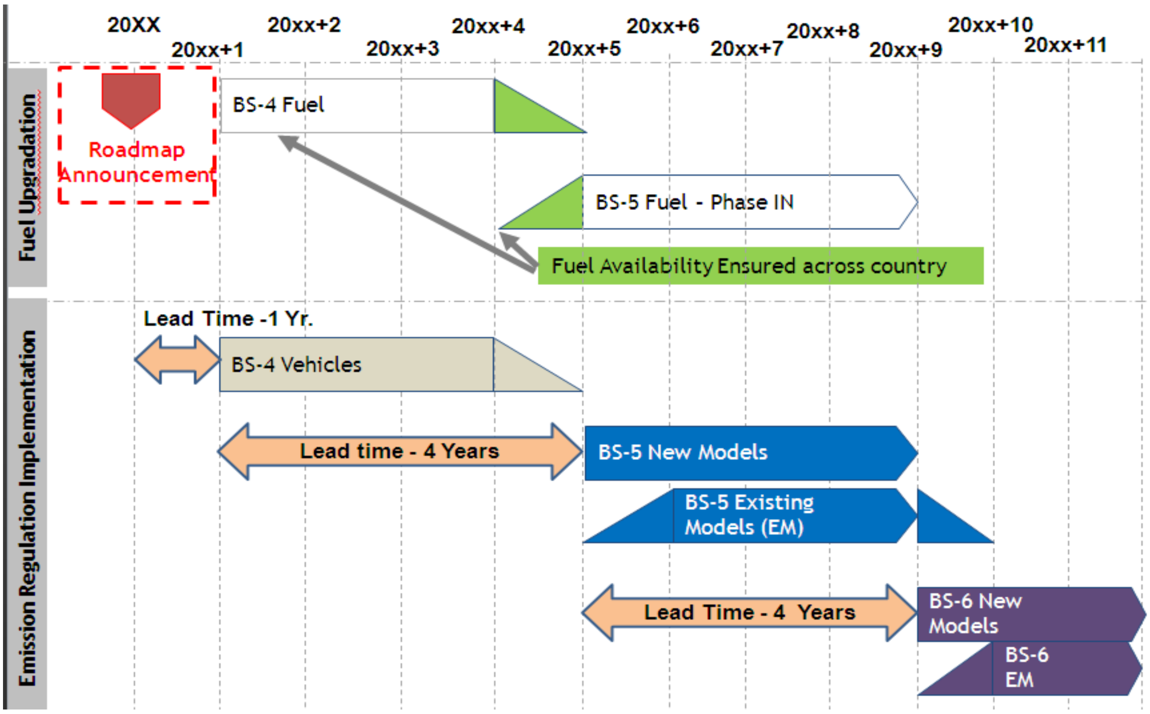
Note: ‡ Applicable for only Compression Ignition Engines

† NMHC and CH_4 applicable to CNG and LPG engines

The emission roadmap for BS IV, BS V and BS VI implementation across the country with phase in approach is at **Chart 8.6**.

Chart 8.6

Emission Road Map for BS IV/BS V/BS VI Implementation in India



8.13 Cost Implication of Next Stage Emission Norms

8.13.1 Two Wheelers

- BS III to BS IV for:
  - Further optimisation of engine
  - Improved carburettors
  - Improved catalytic converters
  - Fuel injection system in some models (Especially class 2-2 & 3)
  - Evaporative emission control system.

  - Connecting crankcase breather to intake system
- BS IV to BS V for:
  - Changeover to Fuel injection system
  - Three way catalytic converter
  - Closed loop engine management system.
  - OBD system

The unit cost can go up to Rs 10,000 per unit

Class	Indicative cost increase, Rs/unit
1 and 2-1	1,000
2-2	4,000
3	6,300

8.13.2 Three Wheelers

3-wheeler SI engines

S. No.	Emissions Norms	Fuelling technology/ After treatment	Fuel	Engine	Approx. cost, Rs/unit
1.	BS III to BS IV	Carburetion	Gasoline	2 stroke	1,000–1,500
		Secondary Air Injection		4 stroke	1,500–2,000
		Evaporative system	Gasoline	2 stroke	1,000–1,500
		CAT improvements		4 stroke	1,500–2,000
2.	BS IV to BS V	Fuel Injection	Gasoline	2 stroke	5,600–6,000
				4 stroke	6,800–7,500
		Three Way Catalytic	Gaseous	2 stroke	8,400–9,000
				4 stroke	7,500–9,500

3-wheeler CI Engines:

S. No.	Emissions Norms	Fuelling technology/After treatment	Approx. cost, Rs per unit
1.	BS III to BS IV	Fuel Injection Equipment	5,000
		Diesel Oxy catalyst consumption	
		EGR POC	
2.	BS IV to BS V	With new similar to common rail (CRS) fuel injection system, electrical cooled EGR & higher loading DOC with DPF	20,000

8.13.3 Passenger Cars & LCV

Implementation of new technologies for meeting BS V and BS VI will have an impact on the sales of the vehicles. This impact is especially critical for the diesel vehicles.

Going to BS VI will again have additional cost impact on diesel passenger cars. Depending on the technology available, it could be an additional impact of around Rs 30,000.

The total cost increase from BS IV to BS VI would be around Rs 70,000 per unit.

S. No.	Category	BS III to BS IV	Rs for BS IV to BS V	Rs for BS V to BS VI
1	4W<3.5T petrol	Implemented	3,000–5,000	4,000–6,000
2	4W<3.5T diesel		30,000–50,000	20,000–-40,000
3	4W<3.5T CNG		3,000–-5,000	4,000–6,000

8.13.4 Heavy Duty Vehicles

The cost implications for Heavy Duty Vehicles are as below

S. No.	Category	BS III to BS IV	Rs/unit for BS IV to BS V	Rs/unit for BS V to BS VI
1	4W>3.5T diesel	70,000–100,000	80,000–100,000	80,000–100,000
2	4W>3.5T CNG	30,000–40,000	30,000–40,000	40,000–50,000

8.14 OTHER COST IMPLICATION

8.14.1 Investment Cost

The estimated investment for moving from BS IV to BS V emission norms would be around Rs 50,000 crore for the industry, as significant capital would be required for integrating new emission control and engine technologies into their facilities. This investment would also have to be made across all types of vehicles *viz.* cars, two wheelers, three wheelers and heavy duty vehicles of various fuel types *i.e.* gasoline, Diesel, CNG and LPG. Further improvement of vehicles to meet the next stage of BS VI emission norms could result in additional similar investments by the auto industry.

8.14.2 Impact of BS V on Growth of Small Vehicles

Traditionally, India has been a small car market, with 70% of passenger cars sold being small vehicles.

Auto Mission Plan released in 2006 dwelt on the importance of small vehicles for Indian market. Auto Mission Plan 2006-16 recommended special drive to make India a Small car Hub for domestic market and exports as well.

In the light of the goal of making India a hub for small vehicles, it becomes essential to focus on this segment of the automotive sector and develop a policy specific to the sector considering the impact. Lower excise duty on small cars has helped in keeping the costs low to incentivise the vehicle for the price sensitive Indian customer.

India targets its export market to expand at a fast pace, presently CAGR is 33%. As per IHS estimates, India set to topple Japan, world's largest small car producer, building as many as 3 million units. In addition to strong domestic demand, India is well on its path of becoming a global production hub for small cars. In 2009, it surpassed Japan to become the largest small car market in the world, accounting for the sale of around 900,000 small cars compared to 700,000 units sold in Japan. India is also now the second-largest exporter of small cars, behind only Japan.

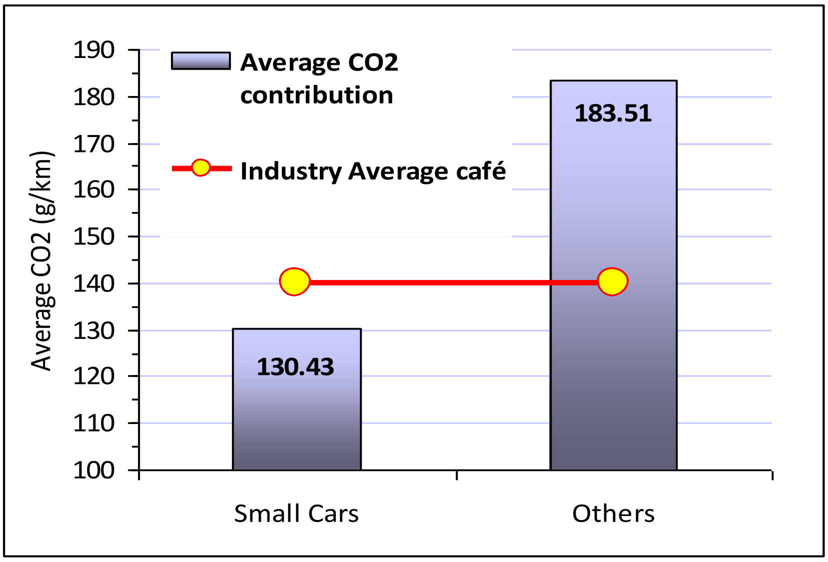
8.14.3 Contribution of Small Vehicles

India today has an efficient fleet, owing to a strong presence of small vehicles. In 2010, 86% of gasoline and 64% of diesel vehicles belonged to small car category.

Chart 8.7 shows CO_2 produced from vehicles in 2013. It is clear from this graph that small vehicles have a positive impact on the Overall Corporate Average Fuel Efficiency of the Auto industry. This data, based on industry performance in 2010, shows that the average CO_2 from small cars is 30% lower than that of other than small cars.

Chart 8.7

CO_2 Contribution by Vehicle Type



Even in 2013, small cars have shown consistently better fuel efficiency (lower CO_2). This has a positive contribution to the fuel consumed by such vehicles in the field resulting in lower demand of fuel.

In view of this, it is imperative to keep focus on this important segment of the Indian Automotive market.

Small commercial vehicles typical to the Indian market emerged in 2005. This segment meets the stringent emission norms and has helped improve the ambient air quality. Sales of these vehicles have improved over the years owing to good customer response.

BS V cost impact is likely to have a bearing on the sales trend of these vehicles and hence the impact on ambient air quality.

8.14.4 Cost Impact of implementing BS V on Growth of Small Vehicles

New technology will have to be implemented to comply with BS V norms in future. Technology solutions will impact vehicle sales due to additional cost. As per current estimates, additional cost for diesel and gasoline vehicles will be around Rs 40,000 and Rs 3,000 respectively. This is independent of cost impact due to fuel economy standards in future.

Moving ahead for BS VI norms, there will be additional cost impact again on diesel passenger cars. Depending on the technology available, it could be around Rs 20,000. The total cost to reach BS VI from BS IV would be around Rs 60,000 per unit.

The impact of Euro 5 implementation in Europe in 2009 is already felt and as seen from one of the studies done by INOVEV, small diesel vehicles will almost extinct in the coming years. The impact on bigger vehicle's cost, although felt, is not so strong, as the impact of such technologies will reduce as a percentage of the initial cost of the vehicle.

India is predominantly a small car market. Diesel vehicles have shown a varying penetration in this segment due to fluctuations in the fuel prices. Cost impact of BS V can have adverse impact on the growth of the small cars in diesel segment.

8.14.5 Impact of Fuel Economy Regulation

India is going to adopt a fuel economy regulation based on fleet average of manufacturer's models. Diesel vehicles with 20% lower CO_2 than corresponding gasoline vehicles will help in reducing the fleet average of a manufacturer. However, the fleet average fuel consumption of the manufacturer will increase with lowering of weight of the fleet. Low diesel penetration along with low fleet mass in subsequent years will make it difficult to meet the CAFÉ/FE regulation.

To abide by Fuel Efficiency standards, manufacturers have to shift focus towards gasoline vehicles through further improvement in fleet fuel economy. Considering gasoline vehicle CO_2 improvement targets for Year 2022, SIAM data reflects target improvements of 5% to 47% across vehicle fleet.

Based on the estimates, additional cost of improvement could be around Rs.10,000 to 15,000 in small vehicles depending on the vehicle size, which will be in addition to cost of technology upgradation that the manufacturers will anyway do to meet stringent emission regulation in future.

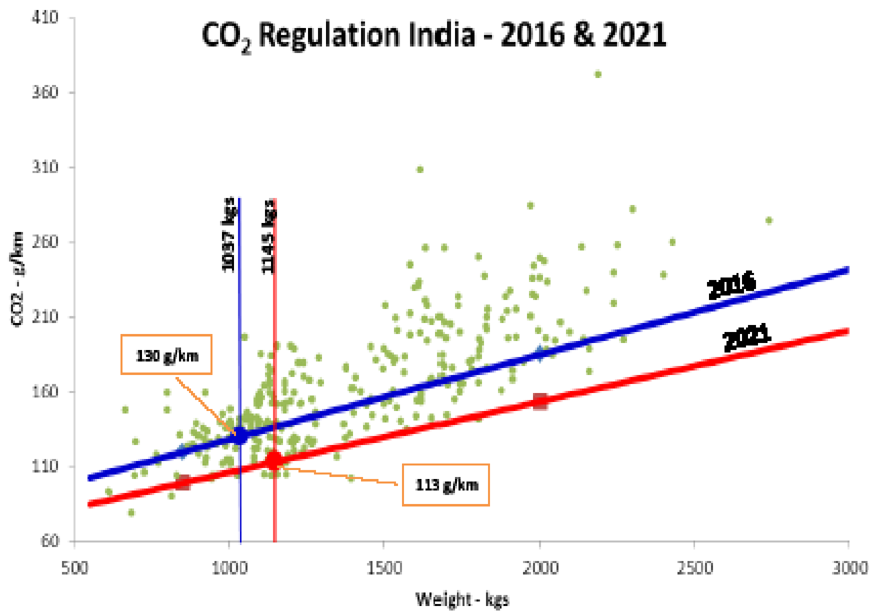
8.15 Issues Relating to Prospective Improvement in Fuel Efficiency

Government of India, through Ministry of Power, finalised and notified the fuel efficiency regulations for India on 30 January 2014. These regulations will be implemented by Ministry of Road Transport & Highways. The new regulations envision a continuous reduction in fuel consumption over a ten-year period. They will be implemented according to a corporate average fuel consumption model, meaning that there will not be a set standard for every vehicle produced but rather weighted fleet-average standards for each manufacturer.

The first stage of the Fuel Efficiency regulation states that a manufacturer will have to meet an annual limit of 129.8 g/CO_2 per kilometre (~18.2 km/l), at a base average weight of 1,037 kgs for vehicles manufactured from 1 April 2016 to 1 April 2017 (**Chart 8.8**).

Chart 8.8

Fuel Efficiency Regulation for Passenger Cars in India



This regulation will be mandated for M1 category of motor vehicles (commonly known as the passenger vehicles, weighing below 3,500 kgs). Several measures would be taken by the industry to adopt the stringent fuel efficiency regulations such as improvement in engine efficiency, improvement in transmission efficiency, reduction of weight, use of alternative fuel, etc.

Further, in the subsequent stage a manufacturer will have to meet an annual limit of 113 g/km of average CO_2 (~21 km/l) at a base average weight of 1,145 kgs, which will be implemented from the fiscal year 2021-22 onwards. This is equivalent to approximately 22 km/l at the base vehicle weight of 1,037 kgs. A copy of the notification is placed in **Annexure 10**. After the implementation of Fuel Efficiency regulations for passenger cars, rules for Heavy Duty Vehicles, two wheelers and three-wheelers would be implemented subsequently.

It is not possible for India to benchmark the Indian norms with some of the developed countries as Indian road conditions are very different from that in developed nations, which does not allow the automotive industry to use technologies like low resistance tyres, etc. which makes a big difference in fuel efficiency. In view of the poor road conditions, Indian vehicles need to have higher road clearance which increases the drag coefficient and therefore the fuel consumption.

Further, the fuel available in India with RON 91 does not allow the industry to tune high compression engines optimally for achieving the best fuel efficiency in comparison to high Octane (95 RON) fuel as in some developed countries. The automotive industry would like to have 95 RON mandatorily with BS V rollout.

However, these factors have to be seen in conjunction with the fact that the bulk of the existing stock of vehicles will not be able to take advantage of 95 RON gasoline. It will be unfair to make them pay the higher price of 95 RON when they will not be able to take the benefit of it. It has been thus recommended that 95 RON gasoline should be made widely available in the larger cities which are likely to be the main markets for high compression fuel efficient passenger cars.

Countries like Japan have higher penetration of Hybrids and Electric Vehicles, which they are targeting to reduce their fleet CO_2 averages. Penetration of such vehicles will be very low in India even in 2020.

It should be understood that new vehicle fuel efficiency regulation will have a limited impact on the quantum of fuel saving in the country. For larger saving of fuel, improvements in road infrastructure, decongestion and fleet modernisation and driver education will have a greater impact on improving the fuel savings. It would also be imperative that alternative safe and comfortable mass mobility options are provided for society, which will minimise the requirement to use private passenger vehicles at all times.

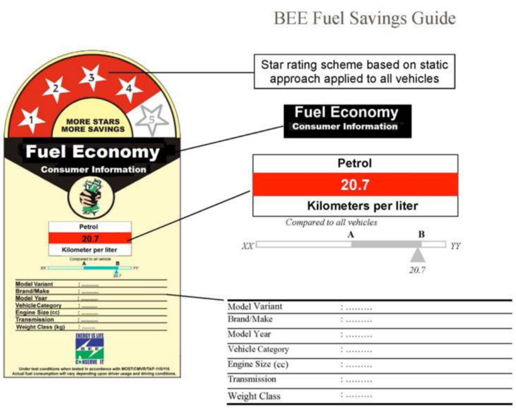
8.15.1 Labels

The Society of Indian Automobile Manufacturers announced a voluntary labelling programme for cars in the year 2009. The SIAM fuel economy label, which is displayed at a car dealership for consumer information and education, segments the vehicles according to the weight of the car and its relative performance in the same weight segment.

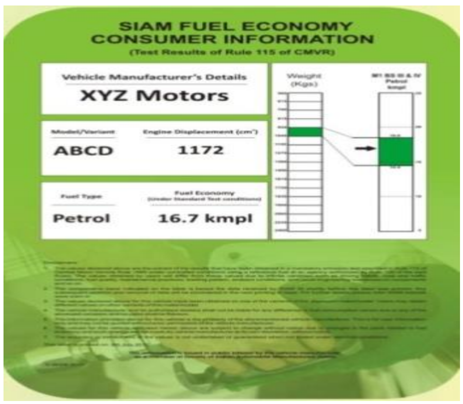
Notwithstanding the above, Bureau of Energy Efficiency has proposed to introduce mandatory labels for passenger vehicles in near future. Apart from displaying the fuel economy of the vehicles, the label would rank fuel efficiency by a five-star system which will depend on the weight of the vehicle. These indicative labels are reproduced below (**Chart 8.9)**.

Chart 8.9

Labels for Fuel Efficiency – Mandatory and Voluntary



Proposed Mandatory Fuel Efficiency Start Rating Label



SIAM Voluntary Fuel Economy Label, since 2009

CHAPTER 9

ROADMAP FOR THE ROLL OUT OF BS IV GASOLINE/DIESEL THROUGHOUT INDIA

9.1 DECISION ON FULL NATIONWIDE COVERAGE BY JAN-MAR QUARTER 2017

As discussed previously it is necessary to transit in a way which provides geographical integrity to the fuel and hence emission regimes in the country. The transition period as also discussed would be 2015 to 2017. By 1 April 2017, all across the country, the retail outlets would sell only BS IV gasoline and diesel, with the relaxations as already described for the North East region in respect of Cetane and Aromatics.

In order to achieve the conversion targets, BS IV gasoline and diesel needs to be made available to the depot/terminals from the source refineries three months before the target date of start of sale of BS IV gasoline and diesel from retail outlets. The three month period is needed to complete the change-over at the depot/terminal and in the retail outlet/customers' storage tanks and in pipeline stocks from BS III to BS IV grades.

In order to achieve roll out of conversion in the selected regions by 1 April 2015, BS IV gasoline and diesel will have to be made available in the requisite quantity from 1 January 2015 in the refineries. For conversion of the second batch of regions by 1 April 2016, BS IV gasoline and diesel will have to be made available from 1 January 2016 and for the third batch of conversion on 1 April 2017, BS IV gasoline and diesel will have to be made available from 1 January 2017.

The complete switch in from BS III to BS IV would be completed in the refineries by the end of 2016. The first quarter of calendar year 2017 will be taken up in completing the change-over in inventories and pipeline stocks so as to ensure that 100% BS IV auto fuels are at retail outlets countrywide with effect from 1 April 2017. The region wise roadmap and milestones for implementation of BS IV fuels are given below at paragraph 9.2.

9.2 INTERMEDIATE MILESTONES IN 2015 AND 2016

Considering the availability across refineries and the logistics for positioning of product, the intermediate milestones for conversion to BS IV grade gasoline and diesel (in addition to already converted cities), taking geographical blocks is proposed as below and with effect at retail outlets from 1 April of the year (**Maps 9.1** to **9.6**):

2015 The whole of Northern India covering Jammu & Kashmir, (except Leh/Kargil[18]), Punjab, Haryana, Himachal Pradesh, Uttarakhand, Delhi and the bordering districts in Rajasthan and Western Uttar Pradesh.

Where part of the State is being covered, the relevant districts will be listed. This will be the case with Rajasthan and Uttar Pradesh at this stage. The selected districts of Rajasthan are Bharatpur, Alwar, Hanumangarh and Sriganganagar. The districts of West Uttar Pradesh to be covered are Saharanpur, Muzaffarnagar, Baghpat, Meerut, Bijnor, Ghaziabad, Gautam Buddh Nagar, Bulandshar, Jyotiba Phule Nagar, Rampur, Moradabad, Aligarh, Budaun, Bareilly, Mathura, Mahamaya Nagar, Etah, Agra, Ferozabad, Etawah and Mainpuri.

[18] Supplies to Leh and Kargil can be made only by road when the passes are open (Rohtang and Zozilla passes). These passes are only in the months of April to September. Therefore, the process of moving BS IV gasoline and diesel to these areas will begin from April 2015 and the retail outlets will be converted by September 2015. Thus BS IV MS and HSD will be available at the retail level in Leh and Kargil with effect from 1 September 2015.

BPCL has intimated that their supplies to Uttarakhand are made from BORL, Bina, Madhya Pradesh. While they will be able to cover Uttarakhand for diesel, they have a problem with gasoline on account of slightly higher aromatics content. BPCL has therefore been given two options. First, is to supply its retail outlets in Uttarakhand from supplies (requirement of 8,000 tonnes per month) from other oil marketing companies. This has the drawback of recovery of CST and other taxes etc. Second, they can meet the gasoline needs of Uttarakhand with a temporary relaxation of aromatics content to 40% maximum (in place of 35% as in BS IV). As new facilities are coming on line at BORL, BPCL feels that in future – by August/September 2016 this problem will not be there. The temporary relaxation for BPCL's gasoline sales in the State of Uttarakhand in aromatic content to 40% will thus be valid only up to 30 September 2016, provided the company chooses this option.

2016 All of Goa will be covered. All of Kerala, Karnataka, the newly formed State of Telangana (formerly part of Andhra Pradesh), Odisha, and the Union Territories of Daman & Diu, Dadra-Nagar-Haveli and Andaman & Nicobar. Parts of Maharashtra (Mumbai, Thane and Pune districts) will be covered. Parts of Gujarat (Surat, Valsad, Dangs and Tapi districts) will also be converted.[19] In addition a corridor spanning the highway link through Gujarat and Rajasthan linking Northern India to the ports on the West Coast will also be sought to be covered.

2017 The rest of the country

[19] The Oil Marketing Companies have wanted this stage to become effective with effect from 1 July 2016, on account of time needed for BPCL Kochi to settle in during the quarter ended March 2016. However, it is felt that they will be able to meet the deadline with extra effort.

The maps representing the areas/geographical regions proposed for roll out of BS IV and BS V gasoline and diesel from 2015 to 2020 are given at the end of this chapter in **Maps 9.1 to 9.6**.

9.3 SOME LOGISTICS ISSUES THAT WILL NEED TO BE TAKEN CARE OF

Several issues of detail in the logistics of the changeover need special attention and will have to be kept in mind from the outset in order for the plan and timeline to successfully materialise.

9.3.1 Key Success Factors

i. The actual roll out will be critically dependent on the availability of BS IV gasoline and diesel from the source Refinery three months prior to the target date. Any slippage will affect the implementation timeline.

ii. During the conversion process, there will have to be additional movement from the private sector Stand Alone Refineries, *viz.* RIL and Essar at Jamnagar. This will require a higher rail slate in this sector. Railways have a constraint in moving rakes to this sector, so lifting at the refineries could become an issue. Currently RIL/Essar are not moving gasoline through the coastal mode

iii. Paradip refinery would be a regular surplus supply source of BS IV fuels in this period. It will also require evacuation by rake, where Railways may have limitations.

iv. IOCL/BPCL are currently moving product from North East refineries to outside the North East for purpose of evacuation of the refinery. These products from the North East which will have different specs from BS IV may be permitted to be sold in the areas converted to BS IV during the transition phase, that is, up to 2017.

v. After conversion of Northern Region States by 1 April 2015 as per the planned roll out, BS IV product availability for sustaining the demand during any shutdown of refineries at Mathura/Panipat/Bhatinda could become a cause of concern as other alternate public sector refineries (Koyali, Barauni, BORL) which are connected by pipeline will not have converted to BS IV. In such an event there will be greater dependence on RIL/Essar and movement by rail will have to increase.

9.3.2 Issues of Assistance from Railways, Compensation of Taxes and Costs

i. Railways may be advised to increase the rake availability in Jamnagar sector as lifting of material from RIL/Essar will have to increase and also to provide priority for movement of POL products to ensure timely availability of product.

ii. Similarly priority needs to be provided for POL rake movement in Paradip sector.

iii. Ports need to give priority berthing for POL vessels as coastal movement is likely to increase.

iv. To avoid criss-cross movement of product, State specific inter-company transaction charges, such as Entry Tax, First Point Tax and Purchase Tax, if any, may be exempted during the conversion process or should be allowed to be passed on in the retail price in the sales made in the concerned State.

v. Dilution losses incurred due to sale of BS IV grades at BS III rates for a period of three months during the Roll Out for conversion as and when required will require to be compensated.

9.3.3 Assistance from Ministry of Shipping

i. Oil Industry representatives to be made member of the Trust at all Major Ports under TAMP;

ii. Port Infrastructure like availability of Tug Boats, Pilots to be improved at all ports to avoid berthing delays and consequently improve jetty occupancy at all ports;

iii. Fresh water supply to vessels at all Ports to be arranged by the concerned Port Trust;

iv. Uniform guidelines for Long Term Agreements with Oil Companies for development of Jetties at All Ports to be issued;

v. Walk-in Berthing Priority for Oil Industry Vessels to be made available at Ports where Jetties have been constructed by Oil Companies;

vi. Berthing Priority to be given for POL/LPG vessels at all other Ports, beyond 24 hours from arrival;

vii. Slop Receiving Facilities to be arranged by Port Authorities at all Major Ports;

viii. Adequate dredging work to be carried out to maintain/increase available drafts (especially at Haldia and Kandla);

ix. Jetty Structures/Facilities to be modified (including Un-Loading Arms) at Mangalore and Kandla for berthing of VLCCs.

9.4 Roll Out of BS V

The oil marketing companies submit that while the investment for the transition to BS IV is for the most part under execution or approved or likely to be approved, that is not the case with the investments that will be required to shift to BS V.

The investments that will be needed to convert the older refineries of the OMC to 100% BS V fuel will be quite large and at the existing level of depressed profitability it may be hard for them to justify raising the large resources to fund the capital expenditure. This is the "**Business as Usual**" scenario where they feel that it may not be possible for them to upgrade their refineries to become fully compliant with BS V before the end of 2024. Hence, the retail level transition can become effective from **1 April 2025**.

However, the OMCs have submitted that if the funding sources are assured to them then it will be technically possible for them to accelerate the changeover such that the refineries become fully BS V compliant by the end of 2019. In that event the complete transition to BS V will become possible at the retail outlet by **1 April 2020**.

This is the "**Accelerated Transition Scenario**" which from the public policy point of view would be the desirable one.

9.4.1 Introduction of BS V Fuels – Logistical Issues

This is however no reason for BS V fuels to await launch before the start of the complete transition to BS V. It can be introduced along with BS IV in retail outlets as a premium fuel to the extent that BS V fuel is available at the refineries for domestic sale. Considering that the catalyst life will be considerably extended by the use of 10 ppm sulphur fuel, appropriate education will surely create a significant demand for 10 ppm sulphur fuels especially in larger cities.

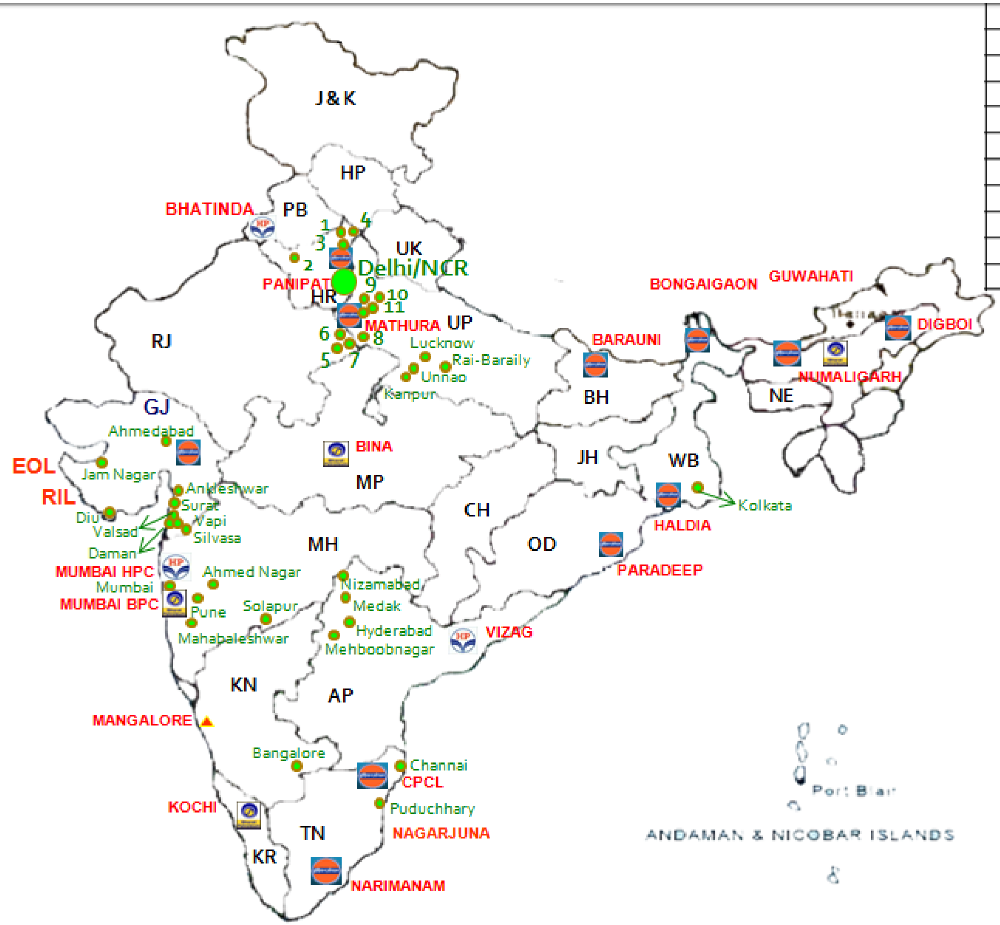
It could also be ensured that across the country, specified outlets on the highways stock BS V auto fuels so that vehicle owners/operators who choose to use BS V fuels do not have to switch back to BS IV fuels in the normal course of events. Automobile manufacturers can adapt their strategy to such a roll out plan for BS V.

The conversion/dilution period that will be applicable to BS V will be similar to that used in the area wise conversion of BS IV as discussed here, even though the completion of the process to country wide level is envisioned to occur in a period of one year.

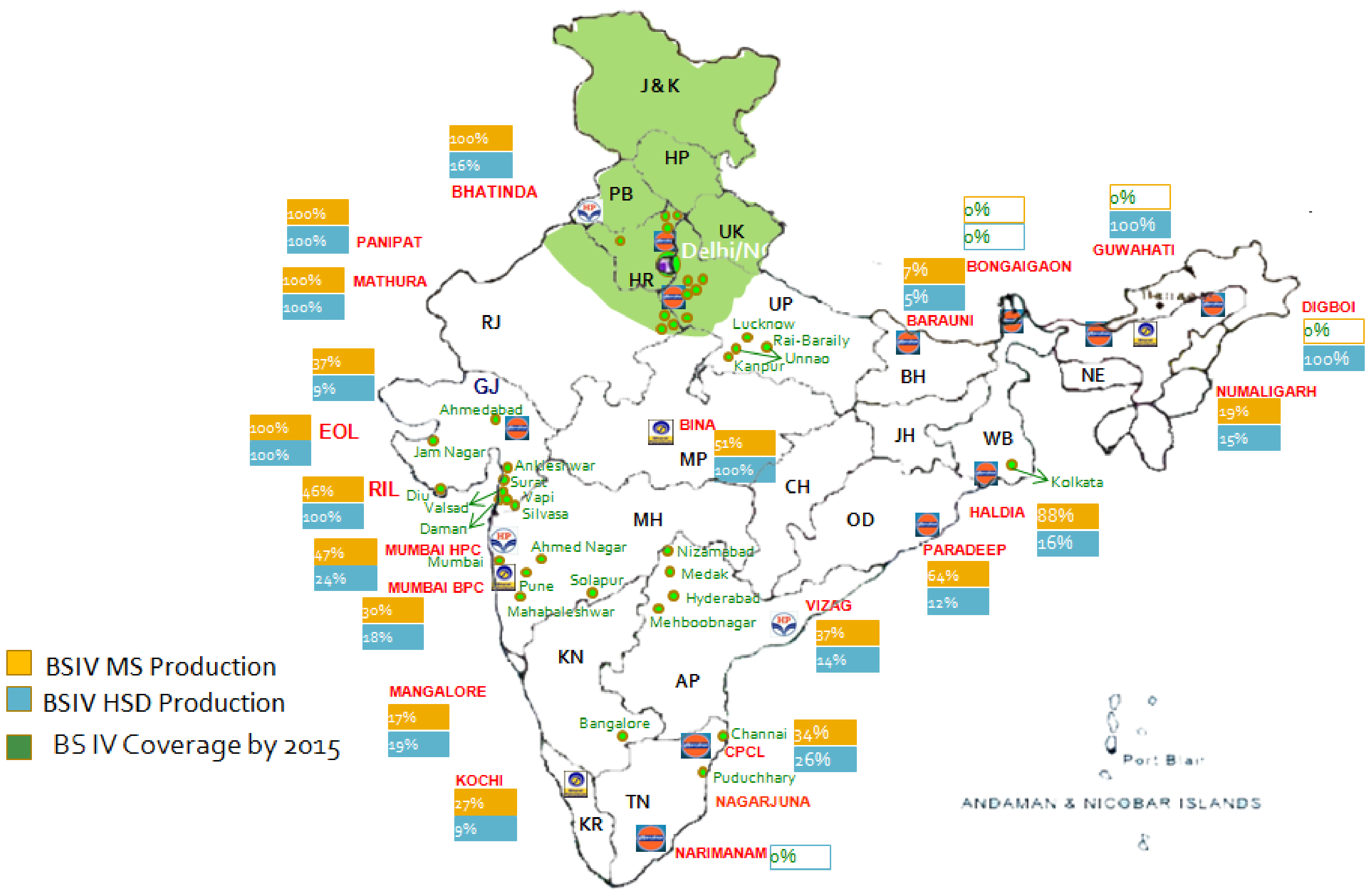
The first geography to be fully covered with effect from 1 April 2019 would be the Northern Region as defined by the area proposed to be covered to BS IV in 2015, with the addition of the rest of Rajasthan and all of Gujarat. The rest of the country is slated to go to full BS V with effect from 1 April 2020. Alternatively, the switch can be made simultaneously across the country with effect from 1 April 2020.

Map 9.1: Cities with BS IV as on Date

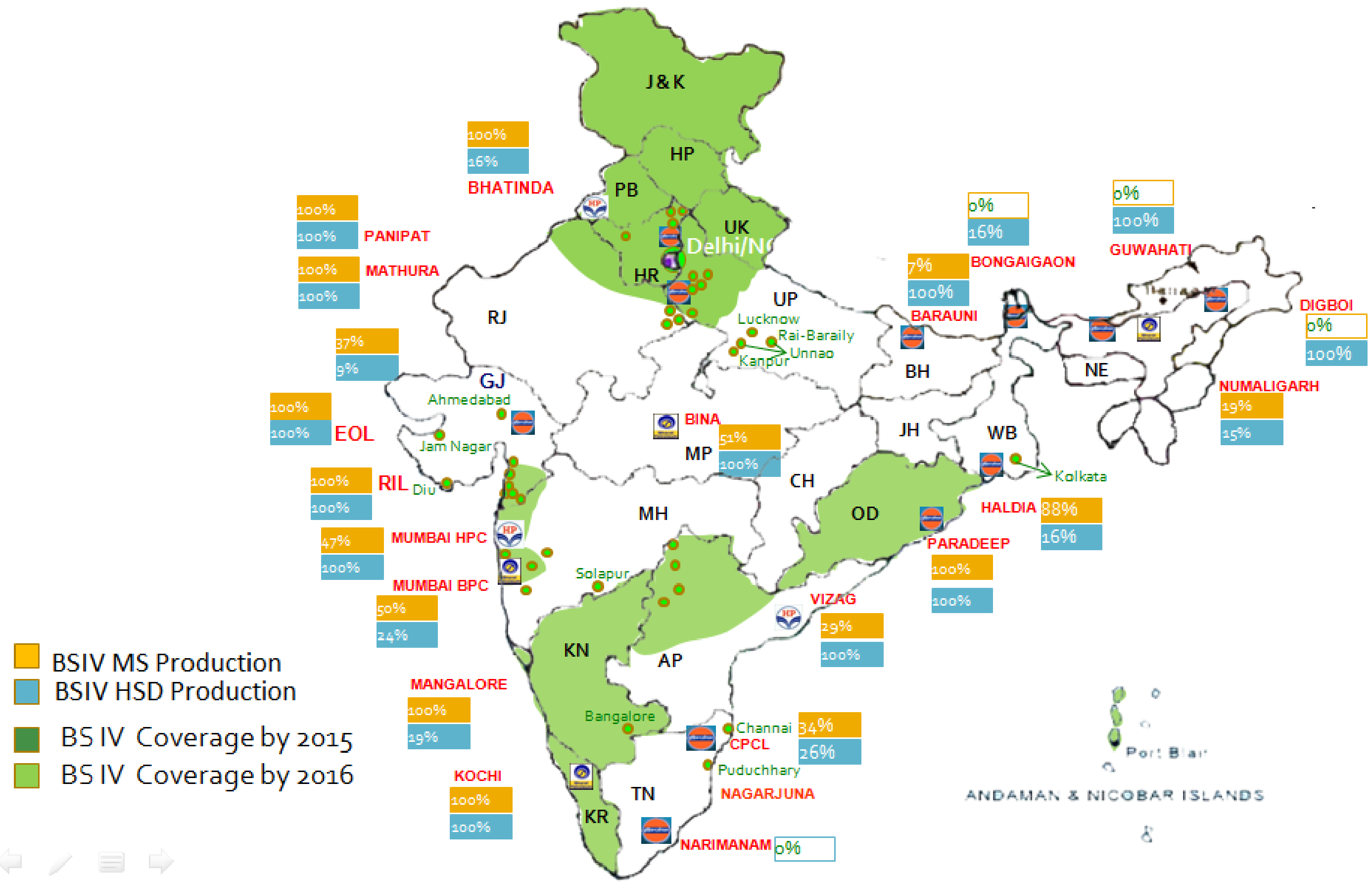
1	Kurukshetra
2	Hissar
3	Karnal
4	Yamuna Nagar
5	Hindaun City
6	Bharatpur
7	Dhoulpur
8	Agra
.9	Aligarh
10	Kosikalan
11	Vrindavan



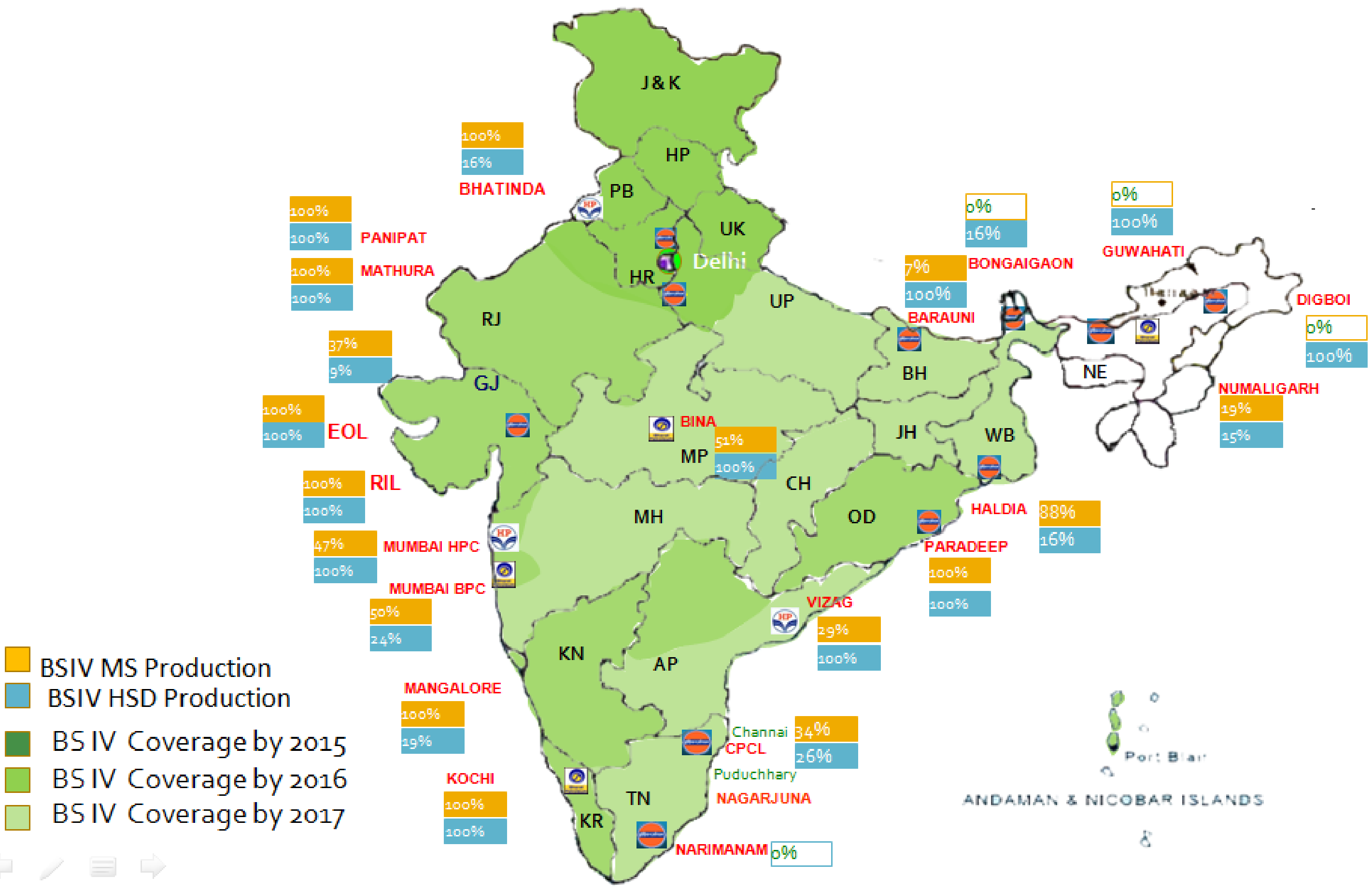
Map 9.2: Proposed Conversion to BS IV by 1 April 2015



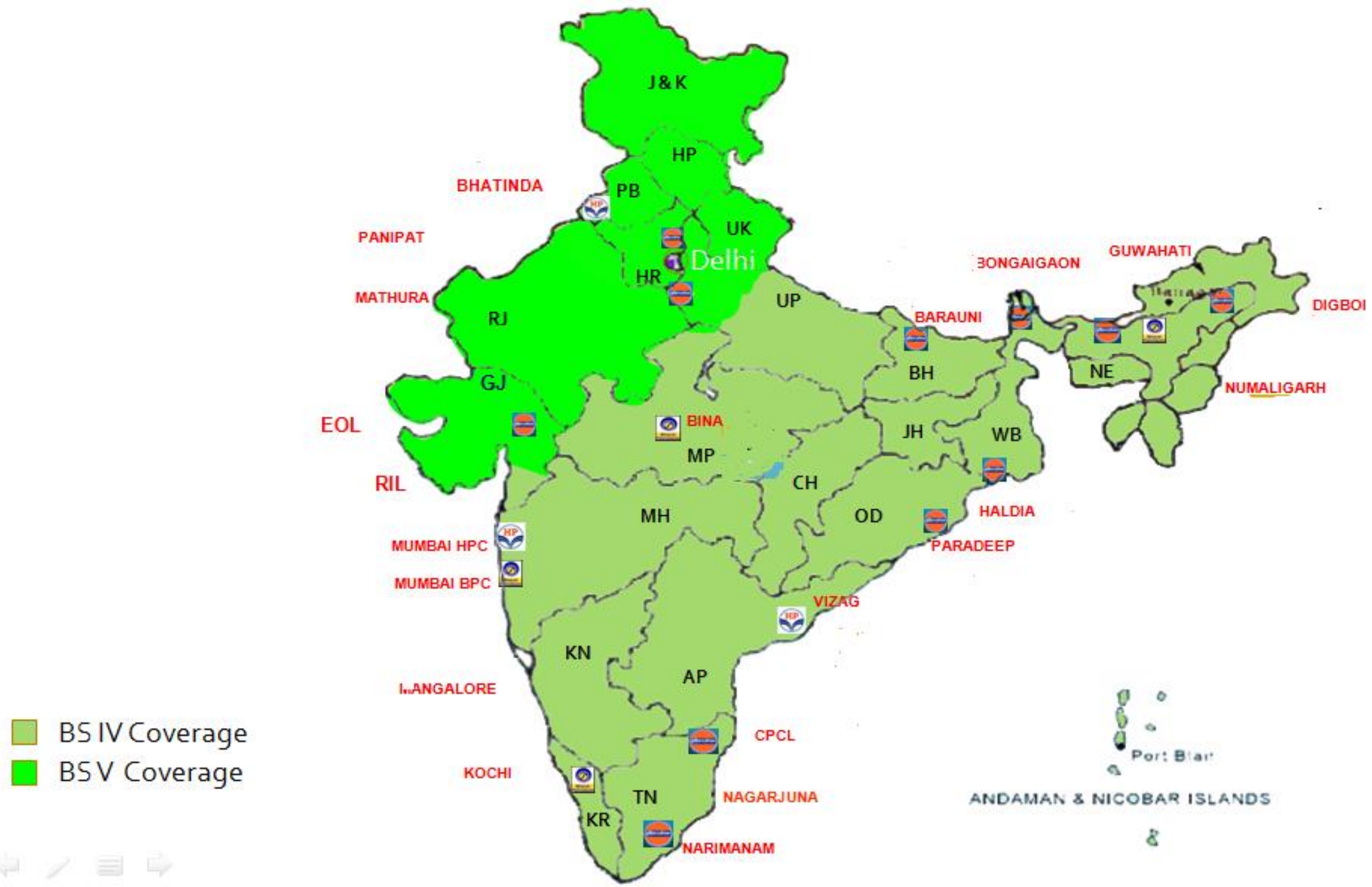
Map 9.3: Proposed Conversion to BS IV by 1 April 2016



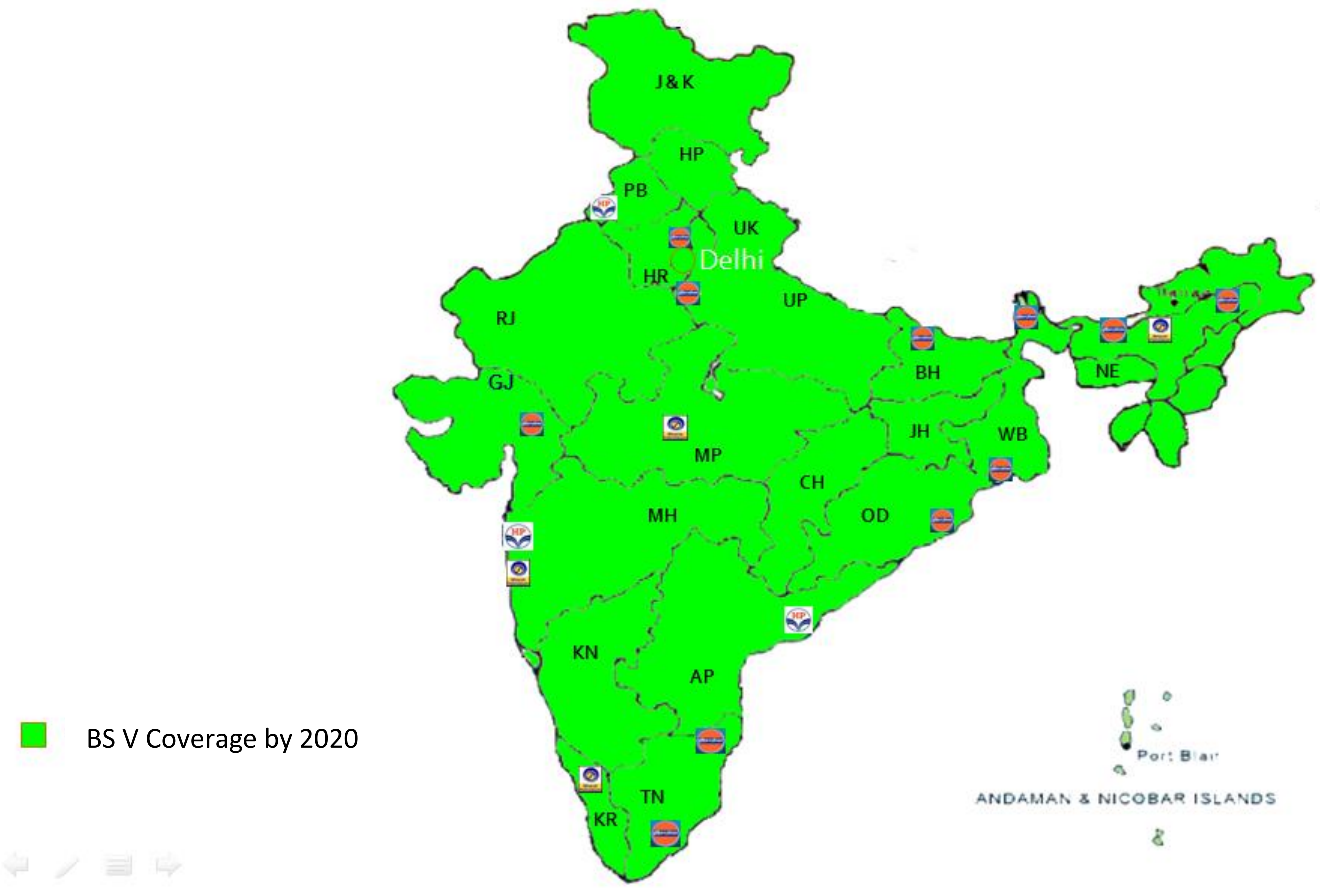
Map 9.4: Proposed Conversion to BS IV by 1 April 2017



Map 9.5: Proposed Conversion to BS V by 1 April 2019



Map 9.6: Proposed Conversion to BS V by 1 April 2020



CHAPTER 10

ALTERNATIVE AUTO FUELS

10.1 ALTERNATIVE FUELS

Though liquid fuels will continue to have major presence due to their reach and ease of logistics, other fuels which may be looked into are:

- CNG
- LPG
- Bio Fuels
- Electric vehicles
- Hybrid vehicles
- Hydrogen/Fuel

10.1.1 Natural Gas – A Low Hanging Fruit

Worldwide, natural gas reserves are more abundant than oil. Looking at the recent gas discoveries in East Africa, Central Asia, Middle East and recent successes in commercial exploitation of shale gas in US, gas may play an increasingly dominant role in the energy mix of India too.

Government has prioritised power and fertiliser sectors for domestic gas allocation. At present around 5 MMSCMD of domestic gas and 4 MMSCMD imported LNG is being supplied to transport sector. As of today, natural gas is the only established alternative which can substitute crude oil based fuels on a large scale. Also, to the extent that gas for CNG use is also transported through trunk pipelines, it increases the economic viability of the trunk lines.

Currently CNG is being supplied as an automotive fuel in about 50 cities. This is further likely to be expanded in more cities if the supplies of gas made available.

As of 31st December 2013, there were 922 CNG stations in 10 states of India (Andhra Pradesh, Delhi/NCR, Gujarat, Haryana, Maharashtra, MP, Rajasthan, Tripura, UP and West Bengal) serving more than 1.9 million vehicles.

10.1.2 Major Benefits for Switching Over From Liquid Fuels to NG/CNG

1. Logical choice to replace liquid fuels owing to its benign environmental qualities.
2. No adulteration and pilferage.
3. Emits significantly less pollutants such as CO_2, HC, CO, NO_x, SO_x and particulate matter (PM) compared to petrol and diesel and no presence of carcinogens like benzene and aromatics.
4. For a diesel engine to match emission levels of CNG engines, incorporation of advanced technology such as SCR (Selective Catalytic Reduction) and particulate traps as also use of ultra-low sulphur diesel is required.
5. Use of CNG in cities will enable public transport to upgrade emission standards to Euro V equivalent BS V spec. CNG engines need to be equipped with oxidation catalyst to take care of NO_x levels and some particulates that comes from lubricants burning.
6. Environmentally, it is a preferred fuel for city public transport with start-stop type of operations. Delhi and Mumbai are success story of gas as a fuel.
7. Even at full market price, gas is cost competitive relative to non-subsidised liquid fuels.
8. Price of gas is likely to be more stable than oil given that supply of gas would be stable.

9. Natural Gas Highways can be created to shift Heavy Commercial Vehicles/Trucks/Public Transport to CNG.

10. Use of gas as a transport fuel can enhance energy security.

11. Emission benefits of replacing diesel with CNG vehicles are:

Fuel	CO, g/km	NO_x, g/km	PM, g/km
Diesel	2.4	21	0.38
CNG	0.4	8.9	0.012
Reduction	84%	58%	97%

10.1.3 Economics of Using CNG as Fuel

1. CNG can compete with diesel in terms of energy efficiency and easily scores over gasoline even at delivered R-LNG price up-to US$ 17/MMBTU. Purely on energy-equivalence basis, price of US$ 17.85/MMBTU for gas corresponds to US$ 100/barrel of oil at crude parity basis. The slope offered by suppliers with respect to crude oil is generally 75-80% of crude parity price which corresponds to US$ 13.4 to 14.3/MMBTU at crude price of US$ 100/barrel.

2. Further, CNG at present prices is almost equal or better in terms of running cost with diesel. Under-recovery of diesel, if done away, CNG will fare far better. The table below gives a tentative snapshot for a 1300-1500 cc hatchback car in Mumbai and Ahmedabad.

	Unit	Retail Selling Price as on 1 March 2014	Fuel Economy (Rs km/Unit)	Running Cost (Rs / km)
		At Mumbai		
Gasoline	Rs / litre	82.13	14	5.87
Diesel	Rs / litre	63.86	17	3.76
CNG	Rs / Kg	38.95	20	1.95
		At Ahmedabad		
Gasoline	Rs / litre	77.10	14	5.50
Diesel	Rs / litre	61.77	17	3.63
CNG	Rs / Kg	58.75	20	2.94

3. In spite of imported gas being at a discount to crude parity prices, there are several inland taxes at various stages that erode some of the advantage. A comparison is given here.

S. No.	Attribute	CNG	Crude oil
1.	Import duty	5%	Nil
2.	VAT	12.5 – 15% VAT	4% (declared goods)
3.	Excise duty	14.42% (incl. cess @ 3%)	Rs3.56/litre on diesel
4.	Service tax (inclusive of cess)	12.36% on trunk pipeline transmission tariff as also City Gas Distribution network tariff	

4. Other factors that affect the attractiveness and viability of CNG as an alternative fuel are:
   - Additional investment for conversion/substitution to a CNG vehicle *vis-à-vis* petrol/diesel vehicles.
   - Average monthly kilometres running of vehicles.

10.1.4 Pre-requisites for Gas as a Transport Fuel on Nation-wide Basis

1. Completion of a national gas grid with trunk pipelines connecting different regions needs to be in place. There is an existing 14,000 km NG pipeline network, while another 5,000 km is under various stages of implementation.
2. Natural gas can be distributed economically in a city only by pipeline. A city gas grid needs multiplicity of users to aggregate demand from different sectors to have sufficient volume to make the grid economically viable.
3. Investment in refuelling station is a critical factor for the success of the CNG business. Compared to a petrol/diesel pump station, the investment in a CNG filling station is higher.
4. In view of the convenience of use with petrol and diesel, and the additional cost of converting a petrol vehicle to CNG, there is a

reluctance to change over to CNG unless there is a substantial price differential in favour of CNG.

5. CNG as a fuel can be considered for use in city buses, cars, 4 wheelers, 3 wheelers and commercial vehicles (LCV & HCV).
6. Trucks/buses running on intercity services may not find CNG convenient and viable unless wide re-fuelling CNG network is created along major national & state highways. Two wheelers are not a market for CNG.
7. PNGRB has planned to introduce city gas facilities in 300 cities. The potential of additional CNG stations in cities and on highways, especially intersection points may be planned in near future.

10.1.5 Position of Automobile Industry

Auto industry is willing to support usage of CNG. Technology to roll out CNG vehicles is also available with leading manufacturers. However, industry seeks a clear, stable and predictable policy regime before committing heavy investments required to roll out Natural Gas vehicles on large scale.

A number of automobile manufacturing companies are producing dual fuel vehicles (CNG plus petrol). However, the sales of such vehicles are limited to cities where CNG supplies are available in cities like Delhi & Mumbai. Sales of CNG vehicle have seen a very high growth due to large savings on fuel price as the price of CNG is comparatively much lower than diesel & petrol.

10.1.6 Major Issues & Govt. Support Required for Making Gas a Popular Choice in Auto Fuel Policy

The concerned Working Group had felt that considering environmental and economic benefits to the nation, City Gas Distribution (CGD) should continue to be given the high priority for purpose of allotments. This is however a much larger issue and the Committee cannot endorse this view. The Working Group also has voiced several tax proposals. These have not been listed here. The fiscal policy and other related issues have been dealt separately in another chapter.

10.1.7 Conclusion

CNG use as an automotive fuel needs to be developed as a national mission. In view of the above, it is observed that:

- Natural Gas/CNG is the best option to replace liquid fuels.
- It is not only environment friendly but also economical.
- Over the ownership life, CNG vehicle is definitely cost effective.
- Diesel price should be aligned to market prices.
- Government should support growth of cleaner fuels.

10.2 AUTO-GAS/AUTO LPG

Auto-Gas is the abridged name for automotive Liquefied Petroleum Gas (LP Gas or LPG). LPG is predominantly propane and butane, where propane ranges 30-99%. It is derived either as a product from crude-oil refining or from natural-gas or oil production. It is generally refrigerated for large-scale bulk storage and seaborne transportation as a liquid, but is transported and stored locally in pressurised tanks or bottles (cylinders).

Auto-Gas is one of the preferred alternative fuel with more than 21 million vehicles operating worldwide. It generates considerably less emissions than other fossil fuels, protecting the environment and human health while mitigating the threat of climate change. According to authoritative scientific testing, Auto-Gas yields about 50% less CO, 40% less HC, 35% less NO_x and 50% less O_3 forming potential compared to gasoline. According to some studies, Auto-Gas outperforms Euro IV/V diesel when emissions are measured on a full fuel-cycle basis and when LP Gas is sourced mainly from natural gas processing plants.

Use of Auto-Gas is still concentrated in five countries *viz.* Korea, Turkey, Russia, Poland and Italy – together account for more than half of global Auto-

Gas consumption today. Share of Auto-Gas in total automotive-fuel consumption varies from a mere 0.1% in the United States to 18% in Turkey.

In the two largest Asian countries *viz.* Korea and Japan, a large number of taxis and light-duty vehicles run on Auto-Gas on account of incentives and government mandate. In Europe, private cars comprise the main market. Gasoline vehicles can be converted to Auto-Gas at moderate cost. As conversion technology for diesel vehicles is less advanced than for gasoline vehicles, diesel conversions are rarely competitive. Korea, however, by exception has most of the vehicles as Original Equipment Manufacturer (OEM) vehicles.

10.2.1 Auto LPG as Fuel in India

The issuance of amended Motor Vehicle act 2000 by the Ministry of Road Transport & Highways and LPG (Regulation of use in Motor Vehicles) order in the year 2001 by Ministry of Petroleum & Natural Gas paved the way for introduction of LPG as automotive fuel in the country.

Retailing of Auto LPG through an Auto LPG Dispensing Station (ALDS) could commence in late 2002 with the introduction of LPG conversion kits duly approved by ARAI.

Presently there are about 900 Auto LPG Dispensing Stations. However, throughput of 60 KL/month was far lower than in FY 2007 and FY 2008.

Factors which influence use of LPG as Auto Fuel:

1. LPG as an Auto Fuel provides environmental benefits in terms of reduced vehicular emissions especially PM_{10}
2. Fuelling time almost same as liquid fuels
3. Frequency of fuelling as good as liquid fuels
4. Bi-fuel mode is possible in case of LPG fuelled vehicle
5. LPG can be easily transported and made available for use

10.2.2 LPG Vehicle Population and Potential

	No. of vehicles	Avg. consumption/ month, litres	A-LPG potential, MMTPA
4-wheelers	965,807	100	0.60
3-wheelers	279,200	250	0.50
2-wheelers	4312	20	0.001
		Total	1.10

Estimated Auto LPG potential of 1.1 MMTPA does not include vehicles that are fitted with unauthorised kits. Out of 1.1 MMTPA, Auto LPG sold through ALDS is only 0.35 MMTPA.

10.2.3 Drivers/Issues Relevant to Auto LPG

1. Auto LPG is available from diversified sources like Natural Gas, Refineries, Petrochemical Plants, Fractionators etc. thereby minimising the risk of dependence on a single source.
2. LPG is globally surplus and is expected to remain so due to increasing Natural Gas production and addition of refining capacities.
3. Additional cost for Auto-Gas dispensing is low as it generally makes use of the existing service-station infrastructure for distribution of conventional fuels.
4. Implementing Auto LPG programme is easier and cheaper compared to CNG, since it does not call for an elaborate gas grid/network, compressor station at refuelling stations etc.
5. It generates considerably fewer emissions than other fossil fuels, protecting the environment and human health while mitigating the threat of climate change.
6. Authorised Auto LPG consumption is 0.35 MMTPA at present. However, based on data of import of Auto LPG Kits/Tanks the consumption potential is 1.1 MMTPA.

10.2.4 Auto LPG Price Differential with Gasoline

1. Auto LPG sales flourished as long as its price was <= 60% of gasoline price. In recent months Auto LPG price increased to 80% of gasoline price and affected its growth.
2. Gasoline to Auto LPG retail selling price differential of 40% is a must to ensure new conversions. Global Practice is, however, to maintain price differential of around 50%.
3. As can be seen from the Table given below, cost per km for Auto LPG car in Delhi and Mumbai is almost equal to that of petrol and higher than that of diesel. However, auto LPG prices have spiked in last 2 months because of increase in LPG prices on account of winter season across the globe and are likely to come down to a level where it is around 20% less on cost per km. basis in comparison to petrol.

Price as on 01.03.2014					
Fuel	km/litre	Mumbai		Delhi	
		Rs/litre	Cost Rs/km	Rs/litre	Cost Rs/km
Gasoline	14.0	82.70	5.91	73.16	5.23
Diesel	17.0	63.86	3.75	55.48	3.26
Auto LPG	10.5	61.39	5.84	55.26	5.26

10.2.5 Cost of Conversion

Besides savings in fuel, two other factors determining the attractiveness and viability of Auto LPG as an alternative fuel are:

- Additional investment for conversion/substitution to Auto LPG *vis-à-vis* gasoline/diesel vehicle.
- Vehicle conversion cost varies from US$ 500 in developing countries to US$ 3,500 in United States. The premium for an OEM vehicle is typically at least US$ 1,000 for a light-duty vehicle.
- Average monthly running of kilo-meters for each type of vehicles in different cities.

10.2.6 Safety & Inspection Requirement in LPG Vehicles

Auto LPG is safe and comparable to liquid fuels in terms of safety. However,

- Registration Certificate (RC) endorsement for fuel change needs to be mandatory.
- Insurance certificate needs to be amended to incorporate the change of fuel as well.
- Commercial taxis, autos and buses need to undergo safety and leakage tests at the time of Annual fitness checks.
- For private vehicles, OEMs to incorporate leakage testing as a part of their service schedule at their dealers end.
- For retrofitted vehicles which carry endorsement on their RC books for change of fuel, OEM approved service centres/RTA approved centres to carry out leakage testing as a part of regular servicing of the vehicle.

10.2.7 Survey by Nielsen for Petroleum Planning and Analysis Cell (PPAC)

Findings are as under:

1. 62% of petrol is consumed by 2-wheelers owing to their sheer numbers on the road, while 3-wheelers accounts for 6% petrol consumption.
2. Disparity in petrol & diesel prices is leading to dieselisation even in the passenger car segment which now accounts for 19% diesel consumption.

10.2.8 Two wheelers, a Fundamental Form for Transportation in India

1. A 2-wheeler is a least energy intensive vehicle, but highest in terms of numbers on road.
2. Composition of 2-wheelers in vehicle population has grown from 9% in 1951 to 75% in 2013.
3. CNG though technically feasible is not practical for 2-wheelers because:
    - Bulky and costly CNG tank installation
    - Non-availability of CNG across India

4. Auto LPG in 2-wheeler segment can be a great initiative as it would benefit in respect of emissions, fuel bill and foreign exchange.
5. Auto LPG would meet BS IV norms and more.

10.2.9 Customer Perspective - Economic Competitiveness

100-125 CC Motor Cycle					
Fuel	km/litre	Mumbai		Delhi	
		Rate, Rs /litre	Cost, Rs /km	Rate Rs litre	Cost Rs /km
Gasoline	60	82.70	1.38	73.16	1.22
Auto LPG	60	61.39	1.02	55.26	0.92
Savings			26.5%		24.5%

Note: The mileage on Auto LPG is equivalent or even higher than gasoline as observed in Bajaj Platina (OEM) and retro-fitted bikes/scooters in Gujarat

Auto LPG can reduce 2-wheeler fuel bill by 25-40%. Thus an additional expenditure of about Rs6000/- either on an OEM bike or retro-fitment can be recovered in 12-15 months. Unlike 4-wheelers, in 2-wheelers there is a direct vapour withdrawal system ensuring complete combustion of air gas mixture, leaving no un-burnt hydrocarbon and highest mileage equivalent to gasoline even with 15% less calorific value fuel.

10.2.10 Infrastructure

Adequate infrastructure is available to meet import requirement:

- Import locations with achievable capacity of 6+ MMTPA, which is good enough to meet increased Auto LPG demand.
- Effective storage capacity of 500 TMT.
- Logistics Tankers
  - Total Industry Bulk Tankers: > 11000
  - Over 1000 Tankers dedicated for ALDS
- Pipelines
  - Jamnagar-Loni
  - Vizag-Secunderabad
  - Panipat-Jalandhar
- Auto LPG Dispensing Stations: 1,100 plus

10.2.11 International Scenario

2-wheelers running on Auto LPG are in use in China and many parts of Southern Asia. Shanghai has banned petrol scooters/mopeds and allows only LPG scooters in the city due to air pollution. About 190,000 gasoline mopeds were eliminated during 2001-2004, replaced by 140,000 LPG mopeds as of 2004, at that time city had over 100 Auto LPG refuelling stations. In 2009, Auto LPG refuelling stations spread to 25 cities and had become a major alternative fuel in China. Motorcycles account for a large portion of the Auto LPG with over 260,000 Auto LPG motorcycles in Shanghai alone. According to the Turkish Statistics Institute's report, the nation had over 25 Lakh (15.7% of total vehicles) motorcycles running on Auto LPG. To reduce pollution levels, Vietnam has also begun producing scooters running on Auto LPG since 2006.

10.2.12 Conclusions

The concerned Working Group had views on changes in taxation treatment for auto LPG kits and OEM supplies – both Central and State duties – and common nationwide treatment for VAT at concessional rates. These have been dealt separately in another chapter.

The Working Group felt that all 3 wheelers and other public transport vehicles should run on alternative fuels, particularly, CNG or Auto LPG.

10.3 Use of Di-Methyl Ether (DME) & Methanol as Auto Fuels

Methanol is an alternative fuel for internal combustion engines either in combination with gasoline or directly. It is used in racing cars in many countries including China. Chemical derivative of methanol *viz.* Di Methyl Ether (DME) can be blended with LPG for home heating and cooking and can also be used as a diesel replacement for transportation fuel. However, availability of DME as a competitive automotive fuel will be an issue.

10.3.1 Methanol as a Transport Fuel

European Fuel Quality Directive allows up to 3% methanol with an equal amount of co-solvent for blending in gasoline sold in Europe. China uses more than 3 million tonnes of methanol/year as a transportation fuel in both low level blends used in existing vehicles and as high level blends in vehicles designed to accommodate the use of methanol fuels.

Methanol Usage in India

Methanol consumption in energy segment is substantial as blending component of gasoline as Methyl Tertiary Butyl Ether (MTBE), Tertiary Amyl Methyl Ether (TAME) and Di-Methyl Ether (DME).

Looking at the falling Rupee and widening CAD, use of imported Methanol for blending does not seem feasible at current import prices as given below.

Methanol Import Price Ex-Terminal		
US$/tonne	600	
Rs /kg	38	1 US$ = Rs 62
Rs /litre	30	
Rs /litre (in equivalent energy terms as that of gasoline)	58	Energy density is around 49% of that of gasoline. So, to have same energy in volume terms, quantity required is more.
Inland transportation, Rs./litre	2	
Total	60	

Refinery Transfer price of gasoline on landed cost basis is about Rs 45/litre. At Rs 60/litre, methanol blending does not seem practical, unless it is produced domestically at much cheaper rates.

10.3.2 Is Methanol a Safe Fuel to Use in India?

1. Methanol has a high toxicity in humans. As little as 10 ml of pure methanol can cause permanent blindness by destruction of the optic nerve, while 30 ml is potentially fatal.
2. From a safety view point, methanol-based fire burns invisibly, while gasoline burns with a visible flame. This can delay visual detection of the fire and the initiation of fire suppression.

3. Pure methanol cannot be used as a fuel in car at high levels, as it is corrosive to certain materials used in engines and fuel lines. Low-level blends of methanol can, however, be used in cars where the fuel is available. Its low energy content means that fuel consumption will be higher than hydrocarbon fuels.
4. Methanol is readily biodegradable in both aerobic (oxygen present) and anaerobic (oxygen absent) environments.

10.4 ETHANOL AS A TRANSPORT FUEL

Ethanol is an organic solvent, similar in properties to the hundreds of other components of petroleum-derived gasoline. Yet, there is a big difference: ethanol itself burns cleaner and burns more completely than petrol it is blended into. Sugar cane juice and molasses are the most common, cheaper and renewable natural resources for ethanol production. In India, ethanol is mainly derived by sugarcane molasses, which is a by-product in the conversion of sugar cane juice to sugar.

10.4.1 Studies Conducted by IOC (R&D) and ARAI with 10% Ethanol Blended Petrol

1. 10% ethanol blended petrol fortified with additive package (anti-oxidant and corrosion inhibitor) meets IS 2796-2008 spec.
2. No drivability problem with E_{10} (10% ethanol blended) petrol.
3. Fuel economy, however, deteriorated by about 2% with the use of E_{10} petrol *vis-à-vis* normal petrol due to lower calorific value of ethanol.
4. Reduced carbon monoxide (CO) and total hydro-carbon (THC) and increased nitrogen oxides (NO_x) with E_{10} petrol *vis-à-vis* normal petrol.
5. With E_{10} petrol on new vehicles, acetaldehyde emissions were found significantly high.

10.4.2 The Ethanol Blending Programme

In India, ethanol made its foray into the transport sector as a fuel additive in 2001. In view of surplus ethanol availability in the country, MoP&NG commissioned pilot projects in sugar producing states to examine techno-commercial feasibility of using it on large scale. During the R&D studies on new generation passenger cars and two wheelers with 5% and 10% ethanol gasoline blends, it was observed that blending of ethanol in gasoline increases Octane number of the blended fuel (1.3 unit with 5% blend) and (3.4 unit with 10% blend), thereby giving an opportunity to oil marketing companies for reducing benzene. However, higher volatility of blends would require removal of lighter components. As ethanol increases the oxygen content in the blend, additional dosage of anti-oxidant and metal de-activator is required to meet potential gum specification. Toxicity studies conducted by ITRC concluded that blending of ethanol in gasoline will not increase the toxicity of the blend.

Oil companies marketed 5% ethanol gasoline blend during the pilot project in three locations *viz.* Miraj/Hazarwadi and Manmad/Panewadi in Maharashtra and Bareilly/Aanola in U.P. in 2001. Based on the success of these pilot projects and to enhance the country's energy security, Government of India mandated blending of 5% ethanol with petrol in 9 States and 4 Union Territories in the year 2003 and subsequently mandated 5% blending of ethanol with petrol in 20 States and 8 Union Territories in November 2006 on an all-India basis except a few North East states and Jammu & Kashmir.

The ethanol blended motor spirit is extended a special concession on central taxation where the assessable duty is restricted to the central excise duty on ethanol (@12.4%), as against the central excise duty of Rs 9.20 per litre (previously Rs 14.78 per litre) normally levied on gasoline.

10.4.3 Status of Ethanol Blended Petrol (EBP)

Ethanol blending was considered as a path-breaking policy and the government envisaged that it would reduce India's dependence on imported oil and enhance its energy security. The hopes for that premise came from Brazil's bio-fuel programme, which began in 1976 and transformed the South American nation into the world's first sustainable bio-fuel economy. Close to 94% of cars sold in Brazil are flexible fuel cars that can handle ethanol blends from 18 per cent upward.

Government of India unveiled the National Bio Fuel Policy in October 2008, which required oil companies to sell petrol blended with at least 5% of ethanol. It proposed that the blending level be increased to 20% by 2017.

The Cabinet Committee on Economic Affairs mandated 5% blending of ethanol with petrol in November 2009, and fixed the ethanol price at Rs27/- per litre for 3 years in December 2009. As per planning, the project should have taken off. However, blended petrol is available only in 13 states that the average blend is 2%.

10.4.4 Issues of Pricing & Imports

The International Competitive Bidding (ICB) floated by Oil Marketing Companies witnessed an offer for 62 crore litres of ethanol against requirement of 82 crore litres but the price was prohibitively high at Rs69.50 to Rs92.00 per litre. It is clear that importing ethanol from world markets for blending is not feasible at this point. If at all blending targets have to be achieved, they have to be achieved with local procurement.

10.4.5 Economics of Using Ethanol

Against international offers, average Indian offer price was Rs43/- per litre (at depot) for 55 crore litres, which would be at a fixed price in Indian rupee, thus completely insulating from the vagaries of international oil prices and exchange rate volatility. Also, if current target of 5% blending (105 crore litres) is achieved, it will result in replacement of around 1.8 Million Barrels of crude oil. This will result in savings of around US$ 197 million in foreign currency. At 10% blending, savings will be over US$ 377 million. This will also help in bringing down current account deficit and improving rural and co-operative economy.

10.5 Hydrogen as a Transport Fuel

Hydrogen being a clean, reliable and sustainable source of energy has been recognised as a fuel for the future. However, it comes with certain challenges which are to be addressed before it can be used in large scale for public transport and power generation.

Hydrogen is one the most abundant elements available on earth but not in elemental form. Hydrogen production technologies in commercial use today are catalytic steam reforming of natural gas, naphtha and other hydrocarbons, partial oxidation of hydrocarbons and coal gasification and electrolysis of water.

10.5.1 Environmental Benefits of Hydrogen as an Energy Carrier

- It lowers sulphur in fuels
- Enables catalytic converters to remove other pollutants from transportation fuels *viz.* NO_x, PM and VOCs.
- Helps conserve precious natural resources by enabling refiners to increase the amount of fuel that can be produced from every barrel of crude oil.
- Enables refiners to use all qualities of crude, regardless of how heavy or sour.
- It can be used to produce electricity in a fuel cell for the cleanest option or in an internal combustion engine, where emissions are significantly reduced compared with other fuels.

- Can produce electricity; electricity can produce hydrogen, creating an energy loop that is renewable and neutral to the environment.

10.5.2 Comparison of Vehicular Emission from Different Fuel

Pollutant	Gasoline engine	Diesel engine	Hydrogen engine
CO	√	√	X
HC	√	√	X
NO_x	√	√	√
PM/smoke	X	√	X

Hydrogen is a carbon neutral fuel. The only pollutant from an Internal Combustion Engine powered by hydrogen is NO_x, which is extremely low.

10.5.3 Hydrogen Economy

The concept of a hydrogen economy was first originated in the early 1970s. Hydrogen economy comprises 3 functional areas: production, storage & distribution and end-use.

Production

Currently, about 50 MMTPA of hydrogen is consumed world over mainly for ammonia fertiliser, chemical and refining areas. The technology for hydrogen production is well established and bulk of it is produced from fossil fuels through steam reforming: 50% from natural gas, 30% from oil and 20% from coal. Electrolysis of water represents only minuscule of world production. It is also produced as a by-product in the chemical industry. The cost of commercially available hydrogen is high for applications in automobiles and for power generation etc.

Storage

Economic, efficient and safe hydrogen storage is the key to hydrogen economy. It can be stored as i) pressurised gas, ii) cryogenic liquid, iii) solid fuel as chemical or physical combination with materials, such as metal hydrides and carbon materials. However, high pressure gaseous hydrogen storage offers the simplest solution in terms of infrastructure requirement and has become the most popular and highly developed method.

High pressure and high-purity hydrogen at room temperature has significant deleterious effects on the mechanical properties of metals, a phenomenon known as embrittlement.

Distribution

Hydrogen pipelines exist only in some areas of United States. Tube trailers and cylinders of compressed gas may be transported by barge, rail and truck. Hydrogen is usually transported in liquid form if distance is more than 1000 miles and vaporised for use on-site. Compared to compressed gases, liquids are easier to transport, have a higher energy density and are easier to handle. The cost of distribution for hydrogen is about 15 times higher than for an equivalent amount of liquid hydrocarbon fuel.

10.5.4 Safety

Concerns regarding hydrogen safety due to some previous accidents are one of the main obstacles to be addressed. Hydrogen is the lightest gas (14 times lighter than air), highly flammable, odourless, and burns with a colourless flame. When used as a fuel, it supplies more energy per unit mass, than the popular fuels used today. Hazards associated with hydrogen can be characterised as:

1. Physiological (frostbite and suffocation).
2. Physical (embrittlement and component failures).
3. Chemical (burning or explosion).

10.5.5 Main Causes for a Catastrophic Event

1. Mechanical or material failure.
2. Corrosion attack.
3. Over pressurisation.
4. Enhanced embrittlement of storage tanks at low temperatures.
5. Boiling liquid expanding vapour explosion (BLEVE).
6. Rupture due to impact by shock waves and missiles from adjacent explosions.

10.5.6 Codes and Standards

Codes and standards are important for commercialisation of any new technology or product. Even though industry uses hydrogen extensively, its application in transport sector demands a completely separate set of codes and standards. BIS has already set up a committee for this in 2010.

10.5.7 World Wide Hydrogen Fuelling Stations

Twenty-seven new hydrogen refuelling stations were opened throughout the world in 2012, bringing the total number of hydrogen refuelling stations in operation to 208 as of March 2013. As per the information available, a total of 80 hydrogen refuelling stations are currently operated in Europe, 76 in North America, 3 in South America and 49 in Asia.

10.5.8 Indian Status Towards Hydrogen Economy

Ministry of New and Renewable Energy (MNRE) had set up the National Hydrogen Energy Road Map with the objective to identify the paths, which will lead to a gradual introduction of Hydrogen Energy in the country, accelerate commercialisation efforts and facilitate creation of Hydrogen Energy Infrastructure in the country. It provides a comprehensive approach to the development of components of hydrogen energy system, ranging from production, storage, transport, delivery, applications, safety & standards, education & awareness among others. The National Hydrogen Energy Road Map has identified two initiatives:

1. Green Initiatives for Future Transport (GIFT).
2. Green Initiative for Power Generation (GIP).

Hydrogen Vision 2020 – (GIFT)

- Hydrogen cost at delivery point @ Rs 60-70/- per Kg.
- Hydrogen storage capacity to be 9% wt.
- Adequate support infrastructure including large number of dispensing stations to be in place.
- Safety regulations, legislations, codes and standards to be fully in place.

Hydrogen Application for Transportation

- Hydrogen in Internal Combustion Engines.
- Hydrogen in fuel cells.
- Hydrogen Electric Hybrid vehicles.

Targeted Hydrogen Powered Vehicles on Road

- 1,000,000 vehicles on road:
  - 750,000 2/3-wheelers.
  - 150,000 cars/taxis etc.
  - 100,000 buses & vans etc.

However, main challenge is cost reduction and policy support.

10.5.9 Path Forward as per NHEB Road Map

1. Develop Standards, Codes, Regulations and Policy for acceptance of Hydrogen Energy.
2. Develop a Technology Plan for Hydrogen Energy.
3. Develop Public-Private Partnership Projects.
4. Develop Hydrogen Energy System for Transition to Hydrogen Economy.

10.6 Electric Mobility

The transportation sector alone accounts for over half of total domestic consumption of refined petroleum products and road transport accounts for close to 90% of this. Impact of transportation energy use on environment can be classified in four distinct yet interrelated set of factors *i.e.*

i) vehicle efficiency
ii) vehicle use & distance travelled
iii) type of fuels or energy sources used in transportation
iv) overall system efficiency of the infrastructure

In addition to achieving higher efficiencies through better designs for lowering rolling resistance, aerodynamic drag and light weighting etc., much higher gains can be made through greater adoption of Hybrid/Electric Vehicles.

Department of Heavy Industries has launched National Mission for Electric Mobility (NMEM). NMEM arose from recommendations of Prime Minister's Group on Technology for fast-tracking introduction and manufacture of full range of electric vehicles, including hybrids. Government had approved the taking up of this initiative on a National Mission mode, along with setting up of a high level apex structure in the form of National Council for Electric Mobility (NCEM) and National Board for Electric Mobility (NBEM).

10.6.1 National Electric Mobility Mission Plan (NEMMP) 2020

The NEMMP 2020 is the National Mission document providing the vision and the roadmap for the faster adoption of xEVs (full range of hybrid and electric vehicles) and their manufacturing in the country.

10.6.2 Need For Electric Mobility

Globally, automotive industry is passing through a paradigm shift. The past century has been the era of internal combustion engine (ICE) primarily on account of the ease of use, availability and low-cost of fossil fuels. The shift to electric mobility has become necessary on account of fast depletion of fossil fuels, rapid increase in energy cost, impact of transportation on the environment and concerns over climate change. These concerns are driving Governments and automotive industries to invest heavily towards developing vehicles based on alternate propulsion systems including electric mobility.

As a result of sustained GDP growth and urbanisation, primary energy consumption is expected to increase by 70% in next ten years. The increasing gap between domestic crude oil production and consumption coupled with hardening of the crude prices is a serious challenge to India’s energy security.

Thus adoption and focus on full range electric vehicles from mild hybrids to pure electric vehicles can help in mitigating the energy issues.

10.6.3 Global Scenario

Various alternate power-train technologies are available today *viz.* Hybrid Electric Vehicle (HEV), Plug-in Hybrid Electric Vehicle (PHEV), Extended-Range Electric Vehicle (ER-EV) and Battery Electric Vehicle (BEV). These are collectively referred to as xEVs.

HEVs have both internal combustion and electric drives, which work in tandem leading to higher fuel efficiency. If the battery is used only when vehicle is started or stopped, for regenerative braking and limited electric motor assist, it is classified as mild hybrid. Whereas, full Hybrids have full electric launch assist and motor drive. PHEVs and Extended Range Electric Vehicles (ER-EV) can run on batteries alone for a significant length and have ICE backup. BEVs run solely on batteries.

Different countries have different strategies:

i) USA aims to have 1 million PHEVs by 2015 and has been subsidising private initiatives, which includes 2.5 Billion US$ grant for battery development and 2.4 Billion US$ loan to OEMs for xEV production.

ii) China plans to have 5 million xEVs by 2020 and has earmarked 15 Billion US$ over next three years for R&D on vehicles and components, 4.4 Billion US$ over next 10 years on pilot projects and 5 Billion US$ for half million public chargers.

iii) Japan has targeted 2 million xEVS by 2025 and has earmarked 250 million US$ over next three years for R&D on vehicles and components.

iv) France aims to have 2 million BEVs and PHEVs by 2020 with an investment of 380-430 million US$ for battery investment and pilot projects for vehicles and 2 Billion US$ public investments for recharging network of 1 million recharging points by 2015. Further the French companies and government also plan to buy 100,000 electric vehicles.

10.6.4 Indian Scenario

The Indian automotive market is dominated by 2-wheelers. Population of 2-wheelers is almost 75% of the total vehicles. Within the passenger car segment, sale of small cars (of length less than four meters and having engine capacity less than 1200 cc for petrol engines and less than 1500 cc for diesel engines) is approximately 75% of the total sale of passenger cars. All this points out to the fact that Indian consumer is value conscious and affordability plays a major part. This fact is very crucial in development of implementation strategy for Electric vehicles in India.

At present India is power deficit by 8–10%, has poor road infrastructure and high levels of traffic congestion. The strategy for supporting electric vehicles in India has to be tailored taking into account the ground realities of India.

10.6.5 Challenges to Adoption of Electric Mobility

Various barriers can be clubbed into four broad areas which need to be overcome for improving electric mobility:

i) Consumer Acceptability: this includes issues relating to low consumer awareness, current price performance gap etc.

ii) Technology Development: existing low level of R&D in this area in the country, limited current capabilities etc. are some of the concern areas.

iii) Manufacturing Investments: includes limited domestic manufacturing capabilities and non-existent supply chain.

iv) Lack of xEV related Infrastructure: like provision of battery charging infrastructure.

Demand incentives should be accompanied by measures for spurring localisation of manufacturing and greater investment in R&D and technology acquisition. The efforts for addressing the infrastructure related issues need to be addressed continuously from the very beginning of the road map.

10.6.6 Government Support for Implementation

Government's continued & sustained support will be required for creating a critical market size for xEVs through bridging higher acquisition costs, under JNNURM or other scheme, for an optimal number of xEVs of different segments for an agreed duration. The creation of adequate charging infrastructure, development of battery swap and fast charging as viable business models coupled with improvements in range, performance, charging time, and cost reductions through R&D efforts are expected to play a key role in addressing this issue.

In India, the 2-wheelers are used by the majority of population as major mode of transport for small distance transportation (10-100 kms./day).The companies are manufacturing battery operated 2/3 wheelers in the country. However, due to poor infrastructure and high cost and reliability, consumers do not buy battery operated vehicles. There is a need for infrastructure creation and providing fiscal incentives for developing electric mobility.

CHAPTER 11

PUBLIC POLICY, REGULATORY AND FISCAL CONSIDERATIONS

11.1 THE PUBLIC POLICY FRAMEWORK

It has been stated previously that the principal objective of developing a fuel standard and emissions pathway to 2025 is the consideration for public health. There are subsidiary consideration also, especially that regarding improving fuel efficiency. Even as the targets for fuel efficiency improvement have been separately prescribed, the Committee has borne in mind that to the extent that prescriptions for fuel quality and emissions norms can impact fuel efficiency and indeed there are often strong trade-offs here, fuel efficiency must be given adequate importance to the extent that is possible without undermining the principal objective of protection of public health.

11.1.1 Vehicle Tailpipe Emissions and the Larger Challenge of Air Quality

It has been found in the Source Apportionment Study cited above that automobile tailpipe exhaust is not the only source of ambient air pollution and in many cases not even the principal one. However, that does not detract from the fact that (a) automobile tailpipe emissions are a very important component of the sources of ambient air pollution, (b) given the growing pace of vehicle ownership and use, vehicle tailpipe emissions will only grow in quantum, (c) that the only way to deal with rising quanta is to make the quality much better and (d) the remit of this Committee is to prescribe standards for fuel and emission norms going up to 2025.

It has to be understood that working on vehicle tailpipe emissions cannot by itself deal with ambient air quality deterioration. Other public policy initiatives are needed to contain the other sources of contribution – be it coal based thermal power plants, industrial stacks, garbage burning or emissions from kitchen fuels. The recommendations that have been made by this Committee have been made in the expectation that initiatives will indeed be taken in other important areas so that the combination of all of these initiatives will combine to have the desired outcome on ambient air quality.

11.2 IMPERATIVES FOR SUCCESS

Success of a policy initiative has many ingredients. Aside from correctly diagnosing the problem, and prescribing suitable and feasible solution pathways, it also has to ensure that financial viability of the producing stakeholders – in this case the petroleum refineries, vehicle manufacturers, alternative fuel providers, logistics service providers and retailers – is preserved, while the health of the public stakeholder is protected.

It also has to ensure that the economic framework that is expected to support the implementation of the prescribed policy is consistent with competitive market dynamics. Finally, while some call on fiscal support is inevitable, given the pattern of ownership and pricing policy practised in refined petroleum products, care needs to be ensured that it is also minimal, given the many other objectives that public policy must necessarily have to serve.

Specifically in this instance, it should be made clear that Oil Marketing Companies who have been made to bear large financial costs on account of policy decisions on pricing of sensitive refined petroleum products for many years now, cannot be realistically expected to be able to make the investments that are necessary for producing automotive fuel to higher standards which can support improved vehicle tailpipe emission standards. Significant costs have been incurred which have not seen adequate returns coming to the companies and more investment is required. These direct costs of additional capital expenditure and higher operating costs have to be allowed to be passed on to the customer. There are also some indirect costs, many of which are perhaps one-time in nature relevant at the time of transition that also needs to be passed on.

Subsidising consumption of gasoline and diesel from the general revenues of the Government is not a good idea. There are many calls on the exchequer – be it for basic sustenance, education, public health or economic infrastructure – which should take complete precedence. The pricing of gasoline has passed out of the regulated sphere and it is hoped that the same will become true for diesel in the near future.

11.3 INVESTMENT REQUIREMENT BY REFINERIES

The CONCAWE Report No 1/13 (2013) titled "Oil refining in the EU in 2020, with perspectives to 2030" has assessed the capital expenditure for modernising refineries in the European Union. It is expected that increased capacities of EU refinery units will boost distillates production and reduce residue output, while meeting fuel quality. Significant capacity reductions have been announced in units that boost gasoline production and distil crude. This trajectory is expected to bring them in line with regulatory and policy expectations. The cumulative investment required between 2008 and 2020 has been estimated by CONCAWE to be $51 billion of which $30 billion has already committed on announced projects.

Total refining capacity in 27 EU countries plus Norway and Switzerland, is reported to be 760 million tonnes per year. Were the investment figure of $30 billion *already committed* to be applied on per tonne basis across Indian refineries, the inferred investment required for Indian refineries with installed nameplate capacity (excluding Paradip) of 215 million tonnes, would work out to US$ 8.5 billion. For the complete $51 billion the *pro rata* equivalent investment required for India would be over $14 billion.

11.4 INVESTMENT NEEDED TO MEET BS IV AND BS V FUEL QUALITY NEEDS

Based on a preliminary analysis, on a refinery to refinery basis it was found that in order to meet 100% BS IV/BS V quality requirements for both gasoline and diesel, the required capital expenditure needed, some already committed and rest under approval, will work out to nearly Rs 80,000 crore, that is, over $13 billion. The total capital expenditure decomposed by company is at **Table 11.1**. Most of the required capital expenditure will be on account of public sector refineries, which are generally older units.

Table 11.1

Investments Required by Indian Refineries to Meet BS IV/V Standards

Table 11.1: Investments Required by Indian Refineries to Meet BS IV/V Standards

Unit: Rs in Crore

	BS IV			BS V†			Overall Total
	Gasoline	Diesel	Sub-total	Gasoline	Diesel	Sub-total	
IOCL	3,230	3,188	6,418	8,630	8,908	17,538	23,956
BPCL	2,077	15,868	17,945	1,275	350	1,625	19,570
HPCL	360		360		6,304	6,304	6,664
CPCL	200	565	765				765
CPCL-CBR ‡		500	500				500
MRPL		3,375	3,375	1,500		1,500	4,875
NRL *		15,000	15,000		50	50	15,050
PSU Refineries	**5,867**	**38,496‡**	**44,363**	**11,405**	**15,612**	**27,017**	**71,380**
HMEL				500	300	800	800
BORL	250	50	300		220	220	520
RIL				660	360	1,020	1,020
Essar	380	280	660				660
Total	**6,497**	**38,826**	**45,323**	**12,565**	**16,492**	**29,057**	**74,380**
Estimate of other non-specified facilities that will be needed for completion to BS V							**6,000**
Grand Total						**Say Rs 80,000 crore**	**80,380**

Note:
† In several cases, the capital investment required as between BS IV and BS V cannot be separated and have been reported under the former head.
* Indicated is a lump sum figure for expansion to 9 MMTPA and upgrading both gasoline and diesel.
‡ At CBR, there is no scope for further upgrading diesel to BS V quality and a different line of disposition of CBR is required once transition to BS V is initiated.

The bulk of the investment required for upgrading automotive fuels to BS IV standards are already underway and expected to be completed over 2014, 2015 and 2016. Some small investments that are needed are approved or in an advanced stage of approval and will be completed by the end of 2016/early 2017. However, the DHDT unit required for producing BS IV diesel at BPCL's Mumbai refinery has yet to be approved. In the case of investments needed to achieve BS V fuel standards, some of the investments shown in **Table 11.1** are yet to be approved. However, in the event of the timelines recommended by this Committee being accepted and notified by Government, the necessary approvals will have to be made and there is enough time to ensure that they are completed and operational by the time of the roll out of BS V automotive fuels in 2019 and 2020.

11.5 Incremental Operating Costs for BS IV and BS V Fuels

There are clearly higher costs that are incurred in the pursuit of improved standards for fuel quality. The aspect of cost is important to stress, as the improvement in fuel standards are being done by mandate, not in response to normal market signals. When mandatory behaviour is prescribed, policy should ensure that conditions should permit the burdens of the mandate to be recovered by the regulated entity, in this case the refinery. Since over the last decade when these mandates were being prescribed, the selling price of both gasoline (deregulated with effect June 2010) and diesel was (and continues to be) controlled, there is an obligation for policy to ensure that the mandated costs are recovered by the oil companies.

11.5.1 Cost Based Approach

It is known that an array of capital equipment is required to be installed to bring the refined automotive fuel to standards that can pass any given mandate and that changes have to be made in utilities to support the new production regime. It is also a fact that a green field refinery will be so configured, such that it is able to produce output at a quality level that corresponds not only to the extant regime, but also to the prospective quality regime as prescribed by mandate. It is therefore not hard to understand why the bulk of investments needed to enable refineries to produce BS IV and BS V fuels are older units.

In 2003, a detailed study[20] was conducted for the Asian Development Bank to compute what the incremental cost would be to move diesel production from the then existing high sulphur content regime towards lower sulphur and ultimately to 50 ppm and 10 ppm sulphur content diesel. The unit costs used are probably long out-dated, but it is interesting to take note of since it did try and model the prescribed trajectory for a large number of Asian refineries with a variety of configurations across as many as twelve Asian countries.

The study looked at incremental refining costs (including capital servicing and operational costs) for a baseline output level of diesel with 3,000 ppm sulphur and stepwise reduction to 1,000 ppm, then 500 ppm, 350 ppm, 250 ppm, 50 ppm and finally 10 ppm. What is pertinent here are the incremental cost estimates for progressively going from 500 ppm sulphur downwards. A summary of these incremental operating costs are placed at **Table 11.2.**

Table 11.2

Estimated Incremental Cost for Asian Refineries for 12 Countries to Produce Low/Ultra Low Sulphur Diesel

Table 11.2: Estimated Incremental Cost for Asian Refineries for 12 Countries to Produce Low/Ultra Low Sulphur Diesel

Unit: US cents per litre

	Cost of taking Sulphur Cumulative from		
	From 500 ppm to 50 ppm	From 350 ppm to 50 ppm	From 50 ppm to 10 ppm
Mean	**1.64**	**1.61**	0.07
Median	**1.66**	**1.65**	0.02
First Quartile	**1.64**	**1.58**	0.01
Third Quartile	**1.67**	**1.66**	0.08
Standard Deviation	0.06	0.07	0.10

20 "Cost of diesel fuel desulphurisation for different refinery structures typical of the Asian Refining Industry": Enstrat International, for Asian Development Bank, January 2003.

The estimates made for 50 ppm sulphur content diesel seems to be much more persuasive, given the very wide range for the estimates for 10 ppm sulphur diesel which went from 20 cents plus for three countries and 1 to 2 cents for the rest. The problem is most likely on account of the difficulty in obtaining reliable data on clearly differentiated capital and other costs that would be required in these mostly older refineries for producing 10 ppm sulphur at a time when they were mostly making 3,000 ppm and higher sulphur content diesel. The incremental estimates to produce 50 ppm sulphur diesel starting from 500/350 ppm level is about 1.65 cents per litre.

For going to 10 ppm sulphur perhaps the estimate made for Singapore refineries of 24 cents incremental cost compared to 50 ppm sulphur diesel may be seen to be reasonable.

Of course these cost estimates date back to 2001 or at best 2002 and thus has to be viewed with even greater caution. However, if we do not make any adjustments to price increases between 2001 and 2014, the estimated incremental cost for 50 ppm sulphur diesel is seen to Rs 1,000 per kilolitre relative to 500/350 ppm sulphur content – that is, BS III fuel.

11.5.2 Price Differentials in the Retail Market in the US

Markets do trade different grades of fuel and an inference can be drawn from quotations across grades to determine what the premium/discount may be in respect of a particular parameter. The US Energy Information Agency does publish weekly retail prices of different grades of gasoline and diesel. These do show a clear and steady differential in the retail selling prices grade wise. These differences must stem from differences in cost otherwise in an open market they would not continue to survive the pressure of market dynamics.

At **Table 11.3** the average retail selling price and the premium gradient for gasoline between the first week of January 2011 to April 2014, over a period of 171 weeks, is presented. The retail prices of diesel containing low sulphur alongside ultra low sulphur is reported by US EIA only for the period February 2007 and December 2008 (96 weeks), since after that period mostly ULSF diesel with 15 ppm and less sulphur was being sold on the highway. The data for gasoline and diesel for the two respective periods available are reported at **Table 11.3**.

Table 11.3

Weekly Retail Prices of Different Grades of Gasoline and Diesel in the USA Reported by US EIA

Unit: US cents per litre

	Weekly Retail Selling Prices		Premium over Regular	
	Mean	**Median**	**Absolute**	**% Regular**
Conventional Gasoline				
Regular	91.95	92.12		
Mid Grade	95.26	95.55	**3.43**	3.7%
Premium	99.57	99.75	**7.63**	8.3%
Reformulated Gasoline				
Regular	96.68	97.03		
Mid Grade	101.02	101.47	**4.44**	4.6%
Premium	103.75	104.27	**7.24**	7.5%
Diesel (No 2 Gas Oil)				
Low Sulphur >15 – 500 ppm	88.60	84.67		
15 ppm Sulphur	90.77	87.06	**2.39**	2.8%

Note: i) Gasoline: Regular is octane 85–87; mid grade is 88–90 and premium is >90 (91–93). In terms of RON this is approximately to RON of 91–92, 94–95 and 96–98 respectively.

ii) Reformulated Gasoline differs from conventional gasoline primarily on account of lower permissible aromatics content of 25%.

iii) Low Sulphur Diesel is defined to be >15 to 500 ppm sulphur, but in practice when it was being sold, the sulphur content was in excess of 80 ppm.

Source: Energy Information Agency, US Department of Energy

If these price differentials were to be used as a guide, it would suggest that the premium between 80/100 to 500 ppm sulphur and 15 ppm sulphur should be in the range of 2.4 cents per litre or about 2.8% of the price of the higher sulphur diesel. These are somewhat higher than the 1.7 cents per litre computed differentials in 2002 and reported at **Table 11.2**. The figure of 2.4 cents works out to about Rs 1.40 per litre.

The gasoline premiums between grades are much steeper and these are not on account of sulphur but octane ratings. They are high, both in terms of cents per litre and as a proportion of the regular (91 RON) gasoline. In local currency the differential works out to Rs 2.10 and Rs 4.60 per litre for the increase in RON from 91 to 94/95 and to 96/98 respectively.

11.5.3 Price Differentials in the International (Asian) market

An examination of bulk price quotations in the Singapore market showed a steady and significant price premium for lower sulphur diesel and gasoline. Quotes from the Japanese market showed clear price differential for different octane (RON) rating. These are summarised at **Table 11.4**. The period which the prices represent start January 2012 and end mid-April 2014.

Table 11.4

Differentials for Sulphur in Diesel and Octane Rating (RON) in Gasoline

Unit: US cents per litre

January 2012 to Mid-April 2014	Singapore		
	Diesel Price Differentials		
	Sulphur 500 to 50 ppm	Sulphur 50 to 10 ppm	Sulphur 500 to 10 ppm
Median	**0.82**	**0.29**	**1.07**
Q1	0.56	0.24	0.93
Q3	1.07	0.37	1.31
Mean	0.83	0.30	1.11
Std Dev	0.41	0.11	0.43
Median as % Base Price	**0.79%**	**0.27%**	**1.03%**

	Singapore		
	Gasoline by RON		
RON	92 to 95	95 to 97	92 to 97
Median	**2.65**	**2.16**	**4.71**
Q1	2.45	1.52	3.96
Q3	2.78	2.44	5.30
Mean	2.53	2.01	4.51
Std Dev	0.36	0.77	0.94
Median as % Base Price	**2.71%**	**2.21%**	**4.82%**

In respect to sulphur content in diesel, though there is some volatility in the premium as evidenced by the fairly high standard deviation, the median price differential of US 0.82 cents per litre (49 paise per litre) between 500 and 50 ppm sulphur is strongly supported by the differential structure between 50 and 10 ppm and cumulatively between 500 and 10 ppm. The latter works out to US 1.07 cents per litre, that is, 64 paise per litre. It is to be noted that these price differentials are much lower than that emerging from the weekly retail prices in the US market and are also less than the unit cost based estimate presented earlier.

11.5.4 Extant Practice and Background

For improving quality of Auto Fuels from BS II/III to BS III/IV norms, Refineries had installed facilities involving capital investment of about Rs 35,000 crore. In addition incremental operating cost for quality improvement was also incurred. The oil industry had indicated to the MoP&NG an incremental operating cost of Rs 2.64 per litre ($ 7.86/bbl) for gasoline and Rs 1.43 per litre ($ 4.64/bbl) for diesel.

However, Government in March 2010 allowed a quality differential of 41 paise per litre for BS IV gasoline and 3 paise per litre for BS IV diesel. IOCL wanted diesel sulphur quality premium of 1.2 paise per litre, Cetane Number improvement differential of 39.7 paise per litre, recovery improvement of 28.3 paise per litre and recovery of investment & operating cost of 64.7 per litre, *i.e.* a total Rs 1.339 per litre.

However, this proposal was not accepted by PPAC, on the grounds that the basis of IPP/TPP price fixation is based on price quotes of equivalent fuel grades in the international market.

It is understood that in the case of diesel, the adjustment for BS III (that is 350 ppm sulphur) above the base quotes used for price computation which was based on 500 ppm sulphur quotes, was obtained using an interpolation method which is US 5 cents per barrel presently (previously up to 30 cents). Then again, in working out the retail selling price an allowance of 4 paise per litre is being presently allowed for BS IV over the BS III price. However, for calculation of under-recovery a higher premium of 18−20 paise per litre (reduced by 4 paise) is used. However, the direction was made for the period ending September 2013 and it is due for a recast.

11.5.5 Full Compensation and Cognizance of Cost Differentials

The policy effort has been to move the pricing principle of petroleum fuels away from a cost based approach towards a market price linkage. This is indeed the desirable approach as cost based approaches unduly protect inefficient producers and penalise customers.

However, when the reality is that there is regulation, sometimes explicit, sometimes informal, it is essential to reiterate and particularly when regulatory mandates make companies incur expenditure, the additional cost cannot be ignored and must be allowed to be **fully reflected in the retail selling prices**. This is especially because differential qualities are not traded in the market with the same level of activity and while it may be relatively easy to arrive at the market price for the most commonly traded quality, this is not necessarily so for other qualities.

The refineries were asked to indicate their capital servicing and operating costs per litre for moving from BS III to BS IV operating regimes. The median cost differential indicated for gasoline was Rs 0.91 per litre and that for diesel was Rs 2.20 per litre.

The above cited differentials sought by the oil refineries are more in line with that observed in the retail selling prices in the USA, the wholesale quotes in key international trading centres and the cost based approach for diesel that was cited previously, than they are with extant differentials that are allowed under the regulatory arrangements.

One more point needs to be made here. As has been noted the contemporary quotations for low sulphur diesel are not available courtesy of the US EIA after December 2008, and the likelihood is that over the next few years, quotations for even 150/350/500 ppm sulphur and perhaps even 50 ppm sulphur automotive fuels can become less reliable on account of declining trading volumes.

In such cases, it will be necessary to **work on the quotation from the more actively traded product** and then **use this base price to derive the price for the other less actively traded product**. The reality of **the difference in production cost must be fully and satisfactorily captured** in the pricing of the product.

There is thus a clear and urgent need to officially take cognizance of what are the acceptable range of differentials between the mandated grades for gasoline and diesel.

11.6 FISCAL SUPPORT SOUGHT

A range of fiscal support has been discussed in the proceedings of the Committee. They range from the request of refineries for fiscal help to meet the mandated fuel standards, to requests from advocates of alternative fuels to find wider market acceptance, to requests from manufactures of vehicles for incentives for lower emission technology and products. Given the nature of government ownership in public sector refineries and the special burdens imposed on them on account of regulated pricing over the past several years, they feel that direct fiscal assistance for their capital expenditure programmes should be favourably considered. The private sector refineries too have a complaint on account of the burdens that pricing policy has exposed them too, leaving them holding unproductive retail outlets as they were not considered eligible for subsidy.

These have been summarised below. However, given the nature of the refining and oil industry, costs are generally recoverable from sales, as long as

Government does not prevent it. The suitable remedy in this case is that Government should permit costs to be fully passed on. In the case of alternative fuels, several requests have come up on account of incentives or equitable treatment. This class of issues is discussed on merits. Finally, there are some issues relating to tax treatment and these too are discussed on merits.

11.6.1 Refineries' Case

Examples are cited regarding fiscal incentives for the manufacture of low and ultra low sulphur fuels. In the nineties, Japan had extended provisions for additional deductions for corporation tax and accelerated depreciation on equipment purchase. The local government in Tokyo had also initiated a two year programme in 2001 to subsidise up to 10 yen/litre for supplies of 50 ppm sulphur diesel. Similarly Hong Kong in 2000 reduced the import duty on 50 ppm sulphur diesel and within two months, 50 ppm diesel became the main fuel supplied at local filling stations. In 2007, the environmental protection department of Hong Kong issued concessional duty to promote market penetration of 10 ppm sulphur diesel.

The principal problem with automotive fuels in India is that policy has not allowed the recovery of a full price from the customer. Since the exchequer has been intervening in the process and doling out subsidies, the oil companies have also got squeezed directly by way of "contribution" and disallowance of appropriate mark-ups for fuel quality, including that for sulphur.

The greatest assistance that Government can extend to help the oil companies make the necessary investment in a financially sustainable manner is to let the companies charge the customer the appropriate competitive price. Gasoline prices have been deregulated and diesel should be allowed to go the same way as early as possible.

Further it ought to be made clear that in the formulae that underpin both regulated and (informally) the unregulated prices should adjust appropriately and fully for the premium on account of lower sulphur diesel and gasoline, as also for other quality/grade parameters such as octane rating for gasoline.

There are however some small refineries, especially those in the North East where the large investments that are needed to bring them up to BS IV and finally BS V may not be possible to be justified on financial grounds alone. Here Government may be called upon to provide additional capital support to make these investments viable and the emphasis should be on reasonable investment rather than expansion, especially if the local market does not warrant the increase in capacity.

11.6.2 Alternative Fuels

A range of requests for tax incentives/disincentives and subsidies have been made by the Working Group dealing with alternate fuels. The issue of tax treatment for imported LNG (*vis-à-vis* crude) and State VAT (*vis-à-vis* diesel) has been dealt with separately later.

The other requests range from having lower road tax for vehicles using CNG to exemption of Central Excise Duty/lower VAT for auto LPG kits, exemption of excise duty on molasses used for manufacture of ethanol for blending with gasoline, to capital subsidies for electric/hybrid motor vehicles.

As stated elsewhere, the principal assistance that Government can extend to the fuel modernisation programme is (a) to give the mandates regarding quality and timeline and (b) allow the refineries to fully recover their costs.

Excessive dependence on tax engineering and complicated fiscal concessions has rarely delivered efficient solutions and inevitably has been the cause of unintended outcomes which can incur heavy costs elsewhere in the system. The impact on grain prices flowing from the tax concessions to ethanol blending in the USA is a case in point. The ethanol blending programme in

India survives on account of the large concession on central excise duty made as between conventional gasoline and ethanol. This has had consequences for the users of ethanol in the chemical industry which can claim the same environmental benefits as in the use of ethanol as a motor fuel.

However, for urban mass transit there is an unambiguous case for capital assistance and this is indeed being provided by way of plan grants and viability gap funding. State and local governments are also contributing from their budget.

There is scope for greater budgetary subvention, including by way of related resource raising, to ensure the quick and widespread roll out of urban mass transit, including electric buses.

11.6.3 Relative Prices of BS III *vis-à-vis* BS IV Auto Fuels

The argument that it is proving counter-productive that BS III fuels, especially diesel, are being priced lower than that of BS IV fuels has been separately discussed above. There is a view that BS III fuel should be priced higher than BS IV fuel on the ground that the cost of externalities (environmental and health) should be reflected in the consumer price differential between BS III and BS IV fuels. However, that would mean that proscriptive views would inform pricing. For practical considerations, the main objective would be to ensure that BS III fuel is not purchased when BS IV fuel is available, only on grounds of private financial advantage, as indeed seems to be happening for long haulage trucks and tractor trailers.

The cost and price differentials ranging from cost-approach to market-price approach has been extensively discussed at paragraphs **11.5.1** through **11.5.3** above. It has also been noted that refineries are asking for an average (across the different refineries) for a compensation of Re 0.90 and Rs 2.20 per litre for gasoline and diesel respectively (paragraph **11.5.5**).

Looking at the evidence available, it is felt that a compensation of 75 paise per litre should be extended for both gasoline and diesel as between BS III and BS IV automotive fuels.

If the base international price on which the pricing is done is 500 or 350 ppm sulphur fuel, the add-on for BS IV should be 75 paise per litre. On the other hand, if the base international price used for price build up is 50 ppm sulphur fuel, then a discount should be applied amounting to 75 paise per litre. This should be done immediately.

11.6.4 Equalising Retail Prices of BS III with BS IV automotive fuels

High Sulphur Cess

However, there should not be a difference between the retail selling prices of BS III and BS IV automotive fuels since that creates a needless and counterproductive incentive for people to choose to buy BS III fuel even where BS IV fuel may be available. This equalisation can be achieved by imposing a cess – "**High Sulphur Cess**" – of 75 paise per litre on BS III automotive fuels and this amount should not go to the refiners but will accrue to OIDB. Funds from OIDB can be recycled for helping finance the cost of modernisation and upgradation needed to move rapidly towards BS IV auto fuel and eventually to BS V auto fuel by 1 April 2020.

The penetration of BS IV for gasoline is about 25% and that for diesel 16% presently. With the accelerated roll out this proportion is expected to increase sharply from 1 April 2015 onwards. The equalisation of BS III and BS IV retail prices will also incentivise movement in favour of BS IV from the moment that this price action is taken. Assuming that the decision is given effect from 1 July 2014, there will be a steady decline in BS III fuels up to January 2017 (when BS III will stop being produced), it is estimated that an amount of **about Rs 10,000 crore** will accrue over the three year period – 2014-15, 2015-16 and 2016-17 – that will be involved in the full transition to BS IV automotive fuels.

11.6.5 Special Cess on Auto Fuels for Financing Refinery Upgradation

Special Fuel Upgradation Cess

It has been seen that the capital investment that will be needed for the complete upgradation of refineries to BS IV and finally to BS V is of the order of **Rs 80,000 crore**. It has also been seen that if things are left to their existing course, including financial resources, this improvement will take many, many more years to be completed than is contemplated in the **Accelerated Transition Path**.

If the slower course were to be adopted five or more number of years will be required for the transition away from BS III to BS IV and finally to BS V. This would entail a **large cost in terms of public health** as discussed in **Chapter 5** of this report.

Had it been technically possible this Committee would have opted for an even earlier roll out of BS V automotive fuel and the corresponding BS V emission norms. However, financial constraints are inherently different from technical ones in that easing financial constraints are often within the scope of public policy decision making.

The best way to ease the financial constraint is the imposition of a special cess that will accrue to the OIDB and be made available to the refineries to fund the investment needed for upgrading to BS IV and finally to full BS V automotive fuel production.

It is hence recommended that a **"special fuel upgradation cess" of 75 paise per litre** on all gasoline and diesel sold in India be imposed and this cess accrue to the OIDB. Assuming that this cess is made effective from 1 July 2014, then over a period seven years up 30 June 2022, the total accumulation would be **Rs 64,000 crore**. This assumes a modest 5% annual increase in domestic sales volumes.

The accumulated OIDB cess can be deployed to finance the modernisation and upgradation of refineries so as to enable them to produce BS IV and BS V grade fuels in a manner that is consistent with the charter and regulations of the OIDB.

It is likely that most or all of the funding from OIDB to the refineries will be in the form of term loans. It is recommended, that keeping in mind the financially stretched conditions of the refineries and oil marketing companies, concessional sub-market rates of interest may be extended for loans made for the purpose of installation of new plant or for upgrading of existing equipment for the purpose of meeting BS IV and then BS V fuel standards. The manner and project selection criteria will have to be in line with OIDB guidelines and practice and guidance of the Ministry. However, the tenor of the loan could be extended to more than 10 years so as to incentivise the refineries to travel on the path of **accelerated transition**.

11.6.6 Tax Related Issues

11.6.6.1 Import Duty on Crude Oil and LNG

For many years now, the import duty on crude petroleum is **nil**, while previously it had been 5% and before that 10%. The import duty on LNG – except when directly imported for power generation – remains at 5%.

There is no logic for the separate treatment on account of import duty as between crude petroleum and LNG. They go towards similar uses and LNG is in many ways a preferable substitute for liquid fuels.

It is recommended that the tax treatment on imports should be identical as between crude petroleum and LNG. If the former is accorded **nil duty**, the latter should also get the same benefit. If the import duty in crude petroleum is in future made a **non-zero levy**, the same should also be applicable in the case of LNG. Exact equivalence in tax treatment would allow the individual economics of the competitiveness of the two fuels play out fully.

11.6.6.2 Incidence of Central Excise Duties on Product Sourced from SEZ/EOU

A major issue of tax treatment has been raised by private refiners. Presently, the units which are in the Export Oriented or Special Economic Zone can sell product in the DTA on paying the applicable (for SEZ units) Basic Customs Duty (BCD) and the Additional Duty in lieu of Central Excise Duty also called Countervailing Duty (CVD). However, the CVD paid on the clearance of the product from the SEZ areas into the DTA under the existing rules cannot be set-off against the CVD payable on sales made in the DTA. Thus, in effect the Central Excise Duty is imposed twice over, which clearly cannot be the intent of policy.

This incidence of applicable central excise duties twice over makes the supply of product from SEZ into the domestic market a financially prohibitive exercise. Since the SEZ unit is capable of producing fully BS IV grade and large quantities of BS V grade fuels, the rollout of better grade of fuels will be assisted provided the domestic market is able to source these fuels from the SEZ unit without having to incur the incidence of excise duties twice over.

It is recommended that in the computation of taxes payable on purchase from SEZ/EOU the incidence of central excise (basic, additional and special) be levied only once at the point of entry into the DTA when the concessional import duty is also levied. Thereafter the product should be treated as equivalent to tax paid product from refineries in the DTA.

11.6.6.3 Treatment of Import Duty for Computing Under Recoveries

Domestic refineries have raised the issue that in the computation of under recoveries, the incidence of import duty on product has tended to be ignored. The fact however remains that import duty on product is a notional one for the purpose of computing the domestic retail selling price based on international bulk sale prices. Import of crude for some time now does not suffer any burden of customs duty.

Therefore the expectation that the Finance Ministry will agree to reimburse amounts that are clearly linked to the payment of a tax (customs duty) which has not been collected is a bit optimistic. However, by not reimbursing the notional customs duty, to that extent the effective protection for domestic refineries is reduced to nil, which may be excessively harsh especially considering the older vintage and sub-scale units that continue to operate and produce significant quantities of product at a relatively higher operating cost.

The best course of things would of course be to deregulate the pricing system so that the anomaly of making a demand for reimbursement against a tax from the exchequer that has not been paid does not arise. As far as the customer is concerned, the levy of customs duty in the computation is the equivalent of the effective protection that policy has accorded to the industry.

However, to the extent that the price of diesel continues to be regulated and the under-recoveries need to computed and paid out, the customs duty component – fully or in part – should be equated to a "cost disadvantage" due to the sub-economic scale and vintage of some of the refineries in the public sector.

11.6.6.4 State Taxes on R-LNG/CNG/LPG Auto Gas on *vis-à-vis* Diesel

The State VAT on Natural Gas/CNG varies widely and is in many cases as high as 15% *ad valorem*. The State VAT on LPG other than that for domestic use is also variable and high. The demand that CNG etc. should be treated as "declared goods" has been made before this Committee.

However, the taxes concerned are State taxes and will be determined by the respective State Governments. There is no public policy compulsion to treat them as basic necessities of life and hence accord them "declared goods" status.

However, the Committee recommends only a **moderate rate** of State VAT (or GST as and when it rolls out) should be imposed, which will encourage the use of this environmentally cleaner fuel.

11.6.6.5 Swapping Costs Connected with Tax

At present if refineries in the DTA were to swap product, the Central Sales Tax (CST) in effect would have to be absorbed by the unit offering the swap. During the roll out of BS IV area wise, recourse to swapping product across geographies as between the OMCs can be of assistance.

However, the retail price is computed on the basis on import (and export) parity where the payment or liability to pay CST does not enter the picture. Therefore, the seller in such a swap is saddled with an unrecoverable cost and this can become a disincentive that would not be in the public interest.

As long as CST exists, the payment has to be made by only one party to the swap and the entity receiving the swap has to reimburse the manufacturer on the one hand but not pass on the incidence to the retail customer on the other.

There are other "unrecoverable" taxes such as octroi etc., and these are presently being recovered through the **State Specific Cost** mechanism – where such taxes and duties are recovered on the sales made in the respective State.

The CST involved on any amounts of product that may have to be **swapped** in order to facilitate the roll out in the transition to BS IV across the country can also be recovered through this **State Specific Cost** mechanism.

11.6.6.6 Rationalising Rates of Central Excise Duty on Gasoline & Diesel

There is a serious anomaly in the treatment of "branded" and regular gasoline and diesel for the purpose of Central Excise Duty.

The situation is as follows:

Under Notification 12/2012/ S No 70:	Applicable Duty
Motor Sprit commonly known as Petrol	
i) Intended for sale without brand name	Rs 1.20 p per litre
ii) Other than that specified at i) above	Rs 7.50 p per litre

Under Notification 12/2012/ S No 71:	Applicable Duty
Diesel	
i) Intended for sale without brand name	Rs 1.46 p per litre
ii) Other than that specified at i) above	Rs 3.75 p per litre

Additional Excise Duty	
Motor Spirit	Rs 2.00 p per litre
High Speed Diesel	Rs 2.00 p per litre

Special Additional Excise Duty	
Motor Spirit	Rs 7.00 p per litre
High Speed Diesel	Rs 1.00 p per litre

Exemption under Notification 28/2002 for Special Additional Excise Duty:	
Motor Spirit	Rs 6.00 p per litre
High Speed Diesel	NIL per litre

The upshot of this is that the total central excise duty (before application of 3% education cess) works out to be:

Motor Spirit without brand name	Rs 9.20 p per litre
Motor Spirit with brand name	Rs 15.50 p per litre
High Speed Diesel without brand name	Rs 3.46 p per litre
High Speed Diesel with brand name	Rs 5.75 p per litre

The same product for the same application is thus being charged **widely** different rates of excise duty. The "branded" products are premium automotive fuels that result in improved engine life and better long term mileage and policy should encourage their use, not discourage it. But that is indeed what the outcome of this differential duty structure has been since it was introduced in 2008. Even the narrow revenue objectives would not have been fulfilled as "branded" fuel sales have fallen sharply.

It is urged that the Department of Revenue make immediate changes in this situation and bring the duty rates of gasoline and diesel on par, irrespective of whether they are regular or premium, *i.e.* branded.

The rates of excise duty on gasoline and diesel are fixed rates, not *ad valorem*. The argument can be made that a higher priced product – which premium fuels indeed are – should be taxed at a higher rate. This legitimate concern can be taken care of by imposing a small differential in the excise duty of **50 paise per litre**, which will more or less maintain the *inter se* tax proportionality as between regular and premium automotive fuels, as long as the duty rates remain fixed and do not change to *ad valorem*.

11.6.6.7 Dilution and other costs

During the phased roll out from BS III to BS IV and later from BS IV to BS V, some is a one-time cost involved. Oil Marketing Companies will received BS IV from 1 January of the year of transition. However, the switchover to BS IV will be completed only on 1 April of the year. On receiving BS IV they will be liable to pay the BS IV price, but sell at BS III rates at the retail outlets till 1 April of the year.

To resolve this problem of **uncompensated costs** it is recommended that Oil Marketing Companies will begin to charge and receive the BS IV price part way through the transition period, **namely 1 February** of the year, since the dilution is front-ended. From 1 February the **High Sulphur Cess** will also be stop being levied in the concerned geography and therefore the price to the customer will not change.

11.6.6.8 Other Tax Concessions Sought

A large number of other tax concessions have been sought by refiners and OMC in respect of both direct and indirect tax (both Centre and State). They include capital grants, concessional duties and accelerated depreciation for income tax. However, it is felt that these lack merit and the main public policy support should be in the form of deregulated retail prices that allow refiners to fully reimburse their capital and operating costs. The only case for capital assistance that the Committee can sympathise with is that of modernisation of the small refineries in the North East of India.

11.7 OTHER REGULATORY ISSUES

There are a range of other regulatory issues involved which are dealt with sequentially.

11.7.1 Actions Required for Ensuring Inspection and Maintenance of Vehicles Related Issues

Inspection and Maintenance (I&M) is one of the areas that should be improved to reach the goal of improved ambient air quality. Vehicle pollution strategy consists of four components *i.e.* increasingly stringent new vehicles standards, specifications for clean fuel, proper inspection and maintenance of in used vehicles and transport and travel management.

Best practices for I&M include:

- Centralised I&M system where inspection and maintenance are carried out independently.

- Identifying high emission vehicles that are in need of repair and ensuring that they are properly fixed.
- Accelerated replacement of old vehicles or retrofitting them with after treatment devices.
- Frequency of inspection should vary for vehicles with different mileage accumulation rates.
- Linkage of I&M with registration data so that failure to present proof of inspection leads to denial of registration.
- Data management system to enable transmission of all real time test data as generated.
- Complement I&M with road side testing or remote sensing.
- Raise public awareness of health benefits that can result from successful I&M programme.
- Ensure that service industry has sufficient equipment and know-how to properly repair vehicles.
- Calibration audits test equipment and audits of test centres.

11.7.2 Retrofitting NO_x Control Devices – Selective Catalytic Reduction (SCR)

Selective Catalytic Reduction after treatment device for NO_x emission reduction in diesel trucks and buses poses new enforcement challenges. To keep the SCR function working as designed, vehicle operators need to regularly replenish urea – a reductant used by the SCR device to convert NO_x into nitrogen and oxygen, else NO_x emission could be much higher than earlier models.

One of the issues, which need to be resolved, is the issue of availability of Urea Charing Facilities for vehicles using Selective Catalytic Reduction (SCR) Technology to meet Euro IV equivalent Bharat Stage – IV emission norms for NO_x solution such as 'AdBlue' to transform nitrogen oxides (NO_x) passing through the exhaust system, into nitrogen and water.

There are areas of concern on use of Urea for this purpose:

- There is a Fertiliser Control Order in place, which restricts the use of urea to agriculture. Urea cannot be sold to industries other than specified. This is a problem for sourcing urea for this use;

- Therefore urea producers cannot sell the product in the open market and import licence for urea for industrial application is also restricted;

- The Department of Fertilisers needs to make change in its regulations permitting urea to be sold for the purpose of use in after treatment devices at the full price which excludes all element of subsidy. At the present time, urea manufacture is virtually exempt from the application of central excise duty on account of the agricultural use of the product. For sale to non-agriculture use, central excise duty may be levied at the general rate of 12% *ad valorem*. Likewise import permission should also be provided on payment of a general basic customs duty and the additional duty in lieu of excise duty at the general rate of 12% *ad valorem*.

11.7.3 Retrofitting of Particulate Emission Control Devices

There are four primary PM exhaust after treatment technologies, namely, crankcase filters, diesel oxidation catalysts, partial flow filters and diesel particulate filters (DPFs). All four may be used in both new and retrofit applications. However, DPFs is considered to be the best available control technology for heavy duty diesel PM control.

11.7.4 Time-bound Retro Fitting Requirement for Commercial Vehicles

Retro-fitting is a particular area of concern for the existing stock of BS III medium and heavy duty commercial vehicles which run on diesel. BS III vehicles do not have adequate after treatment devices and particulate filters. It is recommended, that once a geography is fully converted to BS IV grade fuel, commercial vehicles are required by law to get the retro-fitting of catalytic converters and particulate filters done within a period of two years for the extension of their operating licence under the Motor Vehicles rules.

11.7.5 Manufacturing Specification for Motor Gasoline and Diesel

Motor Gasoline and Diesel are sold at retail outlets, at BIS specifications (BS III and BS IV). Marketing companies require refineries to produce better quality compared to BIS specs – called manufacturing specifications. This is to ensure BIS specs at retail outlets, even with certain quality deterioration during product movement from refinery to retail outlets.

The above issue was deliberated in the 71st Meeting of the Scientific Advisory Committee (SAC) on Hydrocarbons of Ministry of Petroleum & Natural Gas held in June, 2012. As advised by SAC, a Working Group constituted by SAC under the Chairmanship of Director (R), IOC had detailed deliberations on the issue of Refinery Manufacturing Specifications for dispatch of products through Tank Truck/Tank Wagons/Tanker and Pipelines

a) For movements through rail, road and dedicated pipelines, the BIS specifications will be the Refinery Manufacturing Specifications.

b) In the case of transfers through Multi-product Pipelines, the Group has recommended appropriate Refinery Manufacturing Specification in line with the report published on 10 May 2011 by Task Force No. 3 on Pipeline Quality Giveaway.

c) PPAC has been requested to incorporate the recommendations of the Working Group I in the Industry Quality Manual for compliance.

CHAPTER 12

CONCLUSIONS AND RECOMMENDATIONS

12.1 Approach

The report has discussed in detail, the present and prospective availability of BS IV and BS V gasoline and diesel from refineries. There is not enough BS IV fuel to meet the entire needs of the country, but this objective can be achieved by timely completion of ongoing projects and initiating and completing some others. However, in order to be capable of meeting the country-wide needs for BS V automotive fuel, significant additional investment are needed to be initiated and completed to a tight time line. The total investment that has been made and will have to be made in the future in order to achieve the requisite BS V production capability is in the region of **Rs 80,000 crore.**

The vehicle technology – present and prospective – is expected to be able to meet the stated emission norms in the context of availability of BS IV/BS V fuels in the time frame that is being recommended. The geography wise and block wise transition is also expected to ease the transition for the automobile industry. The emission norms for passenger cars, light & heavy commercial and goods vehicles have been adapted from European emission norms for these categories.

In the case of emission norms for 2 and 3 wheelers, there is a sizeable difference between the extant Euro IV and BS IV proposed norms in this report. However, the latter is tighter than what has been proposed by the industry and notified for public comment, vide Gazette notification, 14 March 2014. The hiatus between the notified Euro IV emission norms and that being proposed in this report is still large. However, given the status of technology and economic dynamics of the industry which so far has been conforming to

BS III emission norms, it is felt that the industry perhaps needs some time to be able to come into line with Euro IV norms with convergence to Euro IV being possible only at the time of roll out of BS V emission norms in April 2020.

A roadmap for the transition to BS IV in the entire country has been laid out in detail beginning April 2015 and completion with effect from April 2017. The transition to BS V is slated to take place and completed by 1 April 2020 in the entire country. The BS VI emission norms are expected to come into effect from April 2024.

This is an undoubtedly ambitious transition trajectory. If all of the constraints were to be preserved as presently perceived, this trajectory would not have been possible.

The "**Business as Usual**" path would have meant a roll out beginning 2019 for BS IV and to BS V five years after that, that is, by 2024.

The Committee has sought to relax many of the constraints, particularly the financial compulsions, evaluated the entire logistics chain for severe tightening in defining what has been called "**Accelerated Transition Path**".

While the "**Business As Usual**" trajectory may have been a more comfortable path for both refinery and automobile stakeholders, it would have failed the test of public interest. The objective of the Committee (as it sees it) is primarily to deliver to the citizens of this country the best possible solution in terms of emission norms in the shortest possible time frame. After all, the primary objective that is sought to be protected is public health.

The report has also proposed encouraging the use of alternative fuels, including CNG, Auto LPG, Bio-diesel, and electric/hybrid vehicles. It is felt that provisions of fiscal support is critical to the success of urban mass transit systems which in the longer run is one of the most powerful instruments for protecting the quality of ambient air. Mass transit systems also have the greatest ability to use electricity as the source of energy – both in rail cars and in electric bus trolleys/trams.

12.2 KEY ISSUES

Some key issues including fuels availability discussed in earlier chapters and which are relevant in formulating the recommendations are:

1. In India after 2000 differential norms were made applicable in metros and in the rest of the country because of limited domestic availability of higher quality automotive fuel in the country.

2. The trend globally in the area of fuel quality improvement suggests that about half of gasoline and one third of diesel will be equivalent to Euro V by 2020[21]. The region wise projections are at **Table 6.1** of this report.

3. Government of India plans to cover additional 50 cities with BS IV grade fuel supply by 2015 over and above the 13 cities covered in 2010. Out of the planned 50 cities 26 cities have already been expanded.

4. Individual countries have different quality parameters for diesel in respect of density, distillation recovery, viscosity etc.

5. India is consuming proportionately more diesel relative to gasoline that could be normally derived from crude oil. This results in a need to maximise diesel production. In view of this, diesel quality in respect of density, recovery and viscosity in line with South Korea, Japan, China and USA is being proposed.

6. Government should iron out the anomalies in tax treatment that has been discussed in the previous chapter and develop appropriate fiscal provision for assisting in the funding of investment needs for transition to BS IV and BS V emission regimes in the case of North East refineries and for the purpose of Urban Mass Transit systems.

[21] Tables 5.3 and 5.4, ***World Oil Outlook 2013***, pp. 204-205

7. It must deregulate the retail prices of diesel such that the refineries are able to fully recover their costs and service the huge capital investments that have been made and will have to be made in order to bring their products in line with the BS IV and BS V regimes being recommended.

12.3 Proposed Roadmap for Auto Fuel Quality Upgradation in Refineries

With the completion of on-going, new refinery commissioning and quality upgradation projects of different refineries, gasoline and diesel production during 2016, 2017 and 2020 is expected to be as under:

2016

- BS IV gasoline production will increase to 28.0 MMT in 2016 (incl. 9.3 MMT from RIL-SEZ).
- Likewise, BS IV diesel production will increase to 81.8 MMT in 2016 (incl. 16 MMT from RIL-SEZ).

2017

- In 2017, gasoline output will be 18.6 and 15.0 MMT of BS IV and BS V grade respectively (incl. 9.3 MMT BS V gasoline from RIL-SEZ).
- As against this, the demand is expected to be 21.2 and 22.7 MMT in 2016 and 2017 respectively.
- In 2017, diesel output is expected to be 54.4 and 41.0 MMT BS IV and BS V grade (incl. 16 MMT BS V diesel from RIL-SEZ).
- **Full output of BS IV fuels by the end of December 2016**

2020

- **Full Output of BS V grade automotive fuel**

12.4 Major Issues for Refineries

- In order to supply 100% BS IV fuels throughout the country, refineries as a whole will need up to 3 years' time after notification.
- However for implementing BS V fuels across all of India, up to 7 years' time will be required to carry out techno-economic studies, find cost

effective solutions with a focus on refinery profitability issues such as processing of more high sulphur and heavier crudes, minimisation of low value stranded products, obtain investment approvals, land identification for new facilities in existing refineries, statutory clearances and implementation.

- The order of magnitude investment requirement for gasoline works out to be about Rs 20,000 crore and for diesel, it is estimated to be Rs 60,000 crore. Thus, the total capital expenditure requirement for 100% BS IV/V supply is expected to be in the region of **Rs 80,000** crore.
- Reducing the sulphur content of auto fuel, especially diesel, opens up greater options for emission control by way of after treatment devices.

12.4.1 Specifications for Assam Refineries

The refineries in the North Eastern Region of India, namely at Guwahati, Numaligarh, Digboi and Bongaigaon which process Assam crude suffer problems of vintage, small scale and lack in the necessary equipment to produce fuels exactly conforming to BS IV and BS V standards. The Committee recommends continuance with existing relaxation by maintaining Cetane Number limit to 48. However, it ought to be made clear that these refineries will be able to meet the sulphur limit of 50 ppm for BS IV diesel.

Assam refineries produces gasoline with an aromatic content in excess of the prescribed limit of 35% on account of higher aromatics in its gasoline pool owing to Assam crude oil processing. Specific relaxation along the lines of Cetane Number will need to be extended to Assam refineries for sale of its gasoline in the North East Region. The relaxation (for both BS IV and BS V) will stipulate a maximum aromatics content of 40% for gasoline produced by Assam refineries.

Since the facilities for meeting aromatic specification of 35% at BORL will come up by September 2016, it is proposed to extend the relaxation in aromatic content from 35% to 40% to BORL till such time only for supplies to be made to Uttarakhand.

12.5 ROADMAP FOR ROLLOUT OF BS IV GASOLINE DIESEL THROUGHOUT INDIA

It is necessary to transit in a way which provides geographical integrity to the fuel and hence emission regimes in the country. The transition period would be 2015 to 2017. By 1 April 2017, all across the country, the retail outlets would sell only BS IV gasoline and diesel, with the relaxations as already described for the North East refineries *viz.* Guwahati, Digboi, Bongaigaon and NRL in respect of Cetane, and Aromatics. The relaxation for aromatics shall also be applicable for BORL till September 2016.

Considering the availability across refineries and the logistics for positioning of product, the intermediate milestones (in addition to already converted cities), taking the geographical blocks is proposed at the retail outlet from 1 April of the year (**Maps 9.1 to 9.6**):

2015 The whole of Northern India covering Jammu & Kashmir, (except Leh/Kargil[22]), Punjab, Haryana, Himachal Pradesh, Uttarakhand, Delhi and the bordering districts of and parts of Rajasthan and Western Uttar Pradesh.

Where part of the State is being covered, the relevant districts will be listed. This will be the case with Rajasthan and Uttar Pradesh at this stage. The selected districts of Rajasthan are Bharatpur, Alwar, Hanumangarh and Sriganganagar. The districts of West Uttar Pradesh to be covered are Saharanpur,

[22] Supplies to Leh and Kargil can be made only by road when the passes are open (Rohtang and Zozilla passes). These passes are only in the months of April to September. Therefore, the process of moving BS IV gasoline and diesel to these areas will begin from April 2015 and the retail outlets will be converted by September 2015. Thus BS IV MS and HSD will be available at the retail level in Leh and Kargil with effect from 1 September 2015.

Muzaffarnagar, Baghpat, Meerut, Bijnor, Ghaziabad, Gautam Buddh Nagar, Bulandshar, Jyotiba Phule Nagar, Rampur, Moradabad, Aligarh, Badaun, Bareilly, Mathura, Mahamaya Nagar, Etah, Agra, Ferozabad, Etawah and Mainpuri.

2016 All of Goa will be covered. All of Kerala, Karnataka, the newly formed State of Telangana (formerly part of Andhra Pradesh), Odisha, and the Union Territories of Daman & Diu, Dadra-Nagar-Haveli and Andaman & Nicobar. Parts of Maharashtra (Mumbai, Thane and Pune districts) will be covered. Parts of Gujarat (Surat, Valsad, Dangs and Tapi districts) will also be converted. In addition a corridor spanning the highway link through Gujarat and Rajasthan linking Northern India to the ports on the West Coast will also be sought to be covered.

2017 The rest of the country

12.6 INTRODUCTION OF BS V GASOLINE/DIESEL

While the investment for the transition to BS IV gasoline and diesel is for the most part under execution or approved or likely to be approved, that is not the case with the investments that will be required to shift to BS V.

The investments that will be needed to convert the older refineries of the OMCs to 100% BS V fuel will be quite large and at the existing level of depressed profitability it may be hard for them to justify raising the large resources to fund the capital expenditure. This is the "**Business as Usual**" scenario where they feel that it may be possible for them to upgrade their refineries to become fully compliant with BS V by 2024. Hence, the retail level transition can become effective from **1 April 2025**.

However, the OMCs have submitted that if the funding sources are assured to them then it will be technically possible for them to accelerate the changeover such that the refineries become fully BS V compliant by the end of 2019. In that event the complete transition to BS V will become possible at the retail outlet by **1 April 2020**.

The rollout plan of BS V fuels will begin with the Northern Region and part of Gujarat and Rajasthan from 2019 as is being proposed for BS IV and all of Gujarat and Rajasthan if logistics and supply conditions permit, and will be completed in the entire country by April 2020.

This is the "**Accelerated Transition Scenario**" which from the public policy point of view would be the desirable one.

This is however no reason for BS V fuels to await launch before the complete transition to BS V. It can be introduced along with BS IV in retail outlets as a premium fuel to the extent that BS V fuel is available at the refineries for domestic sale. Considering that the catalyst life will be considerably extended by the use of 10 ppm sulphur fuel, appropriate education will surely create a significant demand for 10 ppm sulphur fuels especially in larger cities.

It could also be ensured that across the country, specified outlets on the highways stock BS V auto fuels so that vehicle owners/operators who choose to use BS V do not have to switch back to BS IV in the normal course of events.

12.7 EMISSION NORMS FOR DIFFERENT VEHICLES CATEGORIES

12.7.1 Two Wheelers

BS IV emission norms

- For gasoline two wheelers other than mopeds, as per WMTC cycle, the proposed emission norms are given at **Tables 8.3 & 8.4.** For Mopeds the extant IDC test cycle will be used for BS IV and BS V emission norms.

- A sub-limit for NO_x is proposed within the overall limit of $HC + NO_x$.

- BS IV emission norms for two wheelers will be applicable for vehicles manufactured from 1 April 2016.

BS V emission norms

- BS V Emission norms for two wheelers will be applicable for new models with effect from 1 April 2020 for new models and for continuing models within one year thereafter. Norms are at **Table 8.5**.

- A sub-limit for NO_x is proposed within the overall limit of HC + NO_x.

12.7.2 Three Wheelers

BS IV Emission Norms

- Emission norms for BS IV have been proposed for both gasoline/ CNG/Auto LPG and diesel fuelled three wheelers. They are given at **Table 8.7**.

- These emission norms will become applicable with effect from 1 April 2016.

BS V Emission Norms

- Emission norms for gasoline/CNG/Auto LPG and diesel fuelled three wheelers for BS V regime are given at **Table 8.8**. They will come into effect from 1 April 2020 for new models and for continuing models within one year thereafter.

- Vehicle manufacturers have stated that deep change in technology are involved, which do not have ready parallels elsewhere, in this phase of the transition and a review be taken of the status in about four years' time in case there are problems of successfully completing the technological transition.

12.7.3 Four Wheelers

BS IV Emission Norms

- The emission norms for all classes of four wheelers will be as per extant notification.

- However, the applicability of BS IV will be rolled in as the fuel becomes progressively available across the country and nationwide by April 2017.

BS V Emission Norms

- Emission norms for all categories of four wheelers have been proposed in line with Euro V and are placed at **Tables 8.10 & 8.11** for vehicles of less than 3.5 tonnes. Emission norms for heavy duty vehicles (>3.5 tonnes) are at **Tables 8.14 & 8.15**.

- BS V emission norms will become applicable for new models with effect from 1 April 2020 and for continuing models within one year of that, that is, before 1 April 2021.

12.7.4 BS VI Emission Norms with effect from 1 April 2024

BS V fuel quality and emission norms are proposed to be implemented in the entire country from 1 April 2020. There is no change expected in the fuel quality as between BS V and BS VI fuels. Thus, it is only emission norms that will have to be made more stringent.

No emission norms have been developed for BS VI by this Committee. This higher level of emission norms have yet to be firmed across the world, including the EU, North America and Japan.

Thus, at the time of the proposed review that has been suggested in five years' time, say 2019, the BS VI emission norms may be finalised.

However, conceptually the BS VI emission regime can become applicable with effect from 1 April 2024 for all classes of vehicles. This will give a gap of four years to the automobile manufacture, as has been desired by the latter, for upgrading and adjusting their technology, design and standards.

12.8 Fiscal Support Sought

The most suitable remedy in this case is that Government should permit full costs to be passed on to the customer. In the case of alternative fuels, several requests have come up on account of incentives or equitable treatment. There are some issues relating to tax treatment and these too are discussed on merits. Details are at **Chapter 11**.

12.8.1 Price Differentials for BS III and BS IV

It is recommended that the premium/discount as between BS III and BS IV fuel (primarily due to the difference in sulphur content) be taken to be 75 paise per litre for both gasoline and diesel and that this difference be reflected in the computed price. Use of premium or discount will depend on what the base price is – 350/500 ppm sulphur fuel or 50 ppm sulphur fuel – premium if the former is the base and discount if the latter is the base. The differential should be put in place immediately.

12.8.2 Equalisation of BS III retail price with BS IV & High Sulphur Cess

It is recommended that the retail price of BS III fuel should be the same as that for BS IV. This will eliminate the incentive to use BS III fuel, when BS IV fuel is also available. However, the additional charge on BS III fuel will not accrue to the oil companies but will be in the form of a **High Sulphur Cess** which will accrue to OIDB and can be utilised to finance the capital investment required for refineries to upgrade themselves to move to full BS V automotive fuels by 2020. It is estimated that if this is done with effect from 1 July 2014, the collection assuming a graduated increase in BS IV penetration will be about **Rs 10,000** crore in the course of 2014-15, 2015-16 and 2016-17.

12.8.3 Special Fuel Upgradation Cess

As previously noted, the capital cost of changeover in the refineries from the present scenario to 100% BS V is estimated to be of the order of **Rs 80,000 crore**. The oil companies are already in a stretched financial condition and will not be able to generate the necessary resources in a financially sustainable fashion in the normal course of events.

It has also been seen that if things are left to their existing course, including financial resources, this improvement will take many, many more years to be completed than is contemplated in the **Accelerated Transition Path**.

If the slower course were to be adopted five or more number of years will be required for the transition away from BS III to BS IV and finally to BS V. This would entail a **large cost in terms of public health**.

Had it been technically possible this Committee would have opted for an even earlier roll out of BS V automotive fuel and corresponding BS V emission norms. However, financial constraints are inherently different from technical ones in so far as that easing financial constraints are often within the scope of public policy decision making.

The best way to ease the financial constraint is the imposition of a special cess that will accrue to the OIDB and be made available to the refineries to fund the investment needed for upgrading to BS IV and finally to full BS V automotive fuel production.

It is hence recommended that a **Special Fuel Upgradation Cess of 75 paise per litre** on all gasoline and diesel sold in India be imposed and this cess accrue to the OIDB. The estimated collection starting from 2014-15 and going up to 2021-22 (seven years) will be **Rs 64,000 crore** assuming modest growth in sales volumes.

The accumulated OIDB cess can be deployed to finance the modernisation and upgradation of refineries so as to enable them to produce BS IV and BS V grade fuels in a manner that is consistent with the charter and regulations of the OIDB.

It is likely that most or all of the funding from OIDB to the refineries will be in the form of term loans. It is recommended, that keeping in mind the financially stretched conditions of the refineries and oil marketing companies, concessional sub-market rates of interest may be extended for loans made for the purpose of installation of new plant or for upgrading of existing equipment for the purpose of meeting BS IV and then BS V fuel standards. The tenor of the loan could also be extended to more than 10 years so as to incentivise the refineries to travel on the path of **accelerated transition**.

12.8.4 Rationalisation of Rates of Central Excise Duty

There are two separate and **widely different** rates of each excise duty applicable for motor spirit or gasoline and for high speed diesel. For "unbranded" or regular gasoline the applicable central excise duty (before 3% education cess) is Rs 9.20/litre and that for "branded" or premium gasoline is Rs 15.50/litre. For unbranded or regular high speed diesel the applicable central excise duty (before 3% education cess) is Rs 3.46/litre and that for "branded" HSD is Rs 5.75/litre.

The premium fuels are designed for longer and more efficient engine life and long term fuel efficiency. The separate treatment for the purpose of excise duty was introduced from March 2008 and is actively discouraging the demand for premium fuels.

It is recommended that the Department of Revenue make immediate changes in this situation and bring the duty rates of gasoline and diesel on par, irrespective of whether they are regular or premium, *i.e.* branded.

The rates of excise duty on gasoline and diesel are fixed rates, not *ad valorem*. The argument can be made that a higher priced product – which premium fuels indeed are – should be taxed at a higher rate. This legitimate concern can be taken care of by imposing a small differential in the excise duty of **50 paise per litre**, which will more or less maintain the *inter se* tax proportionality as between regular and premium automotive fuels, as long as the duty rates remain fixed and do not change to *ad valorem*.

12.9 Actions Required for Ensuring Inspection and Maintenance of Vehicles Related Issues

Inspection and Maintenance (I&M) is one of the areas that need to be improved to reach the goal of improved ambient air quality. Vehicle pollution strategy consists of four components *i.e.* increasingly stringent new vehicles standards, specifications for clean fuel, proper inspection and maintenance of in used vehicles and transport and travel management.

Best practices for I&M include:

- Centralised I&M system where inspection and maintenance are carried out independently.
- Accelerated replacement of old vehicles or retrofitting them with after treatment devices.
- Frequency of inspection should vary for vehicles with different mileage accumulation rates.
- Linkage of I&M with registration data so that failure to present proof of inspection leads to denial of registration.
- Raise public awareness of health benefits that can result from successful I&M programme.
- Making vehicle fitness mandatory for vehicle above 10 years.
- Strengthening of PUC norms.

12.10 Phasing out of In-use Vehicles

There should be a policy for the phasing out of older commercial vehicles (15 years subject to MoRT&H judgement). Vehicles that are used as personal transport cover progressively less and less distance with age. This is not the case with commercial vehicles. It is therefore necessary to have a clear process through which older commercial vehicles, especially those which are clearly unable to meet extant emission norms be phased out of service.

12.10.1 Retrofitting NO_x Control Devices – Selective Catalytic Reduction

Selective Catalytic Reduction after treatment device for NO_x emission reduction in diesel trucks and buses poses new enforcement challenges. To keep the SCR function working as designed, vehicle operators need to regularly replenish urea – a reductant to convert NO_x into nitrogen and oxygen. For this, the urea availability is to be ensured.

In India there are certain areas of regulatory concern on the use of Urea for purposes other than agriculture.

- There is a Fertiliser Control Order by Government of India in place.
- As per the order, Urea cannot be sold to industries other than specified. Therefore, marketing, trading and retailing of Urea is restricted.
- Urea manufacturers in India cannot sell the same in open market.
- Proper license for import and/or handling of urea would be required.

The main concern of the Department of Fertilisers is that subsidised urea should not find its way into non-agricultural use. There is no reason why Government will not permit the sale of urea for the purpose of use in after treatment devices at full cost and without one paise of subsidy. This matter needs to be taken up with the Ministry concerned and a satisfactory solution to the problem can be found. Given that at the margin India is a net importer of Urea, the import restrictions ought to be used for this end use or domestic sales transactions should be permitted.

12.10.2 Retrofitting of Particulate Emission Control Devices

There are four primary PM exhaust after treatment technologies, namely, crankcase filters, diesel oxidation catalysts, partial flow filters and diesel particulate filters (DPFs). All four may be used in both new and retrofit applications. However, DPFs is considered to be the best available control technology for heavy duty diesel PM control.

12.10.3 Time-bound Retro Fitting Requirement for Commercial Vehicles

Retro-fitting is a particular area of concern for the existing stock of BS III medium and heavy duty commercial vehicles which run on diesel. BS III vehicles do not have adequate after treatment devices and particulate filters. It is recommended, that once a geography is fully converted to BS IV grade fuel, commercial vehicles are required by law to get the retro-fitting of catalytic converters and particulate filters done within a period of two years for the extension of their operating licence under the Motor Vehicles rules.

12.11 Vapour Recovery System

OMCs will be encouraged to implement vapour recovery system for gasoline to minimise benzene emission in larger cities where sales are high and the cost can be recovered. This can be gradually expanded.

12.12 Studies to be Carried Out and Other Recommendations

The Committee also recommends following studies to be carried out in 2018 after implementation of BS IV norms in the entire country:

- Environmental impact, health impact and toxicology related periodic source apportionment studies in various cities and regions, assessment of background pollution, studying effect of certain kinds of pollution amongst various cohort groups, developing and implementing statistical tools for analysis and mining of such data, etc.
- Establish an Empowered Monitoring & Evaluation Committee with the Secretariat being provided by CPCB and with members drawn from all the stakeholders as well as independent experts knowledgeable in various aspects (including technical, financial, health, social, environmental and institutional), to define the studies and analysis that would be undertaken for effective implementation of the AFV&P.
- Assessment of impact of increasing octane number on fuel efficiency of gasoline vehicles and financial/operational impact on refineries.
- Assess the effect of enhancing T_{95} point of diesel fuel on emissions of vehicles. There is considerable debate in literature over this, however it is worth assessing this impact since if the emissions are controllable, then this can add considerably to the diesel pool in the country.
- Assessment of "on-road performance" of the after-treatment devices (which is known to be distinct from testing on-chassis in well-defined laboratory conditions).
- Process innovations in after-treatment devices, such as partial filter DPFs, lean NO_x traps etc. However, such projects should be undertaken in association with interested automobile industry partners.
- Auditing of inspection and maintenance facilities including calibration of the analysers used.
- Development of calibration protocol for PM_{10}/ $PM_{2.5}$ sampler.
- Accreditation of suppliers of PM_{10}/$PM_{2.5}$ sampler by national institute like NEERI/CPCB/CSIO/NPL etc.

- 95 RON gasoline should be made widely available in the larger cities which are likely to be the main markets for high compression fuel efficient passenger cars.
- Oil companies and vehicle manufacturers must see how to strive for better lubricity as the sulphur content in diesel is progressively brought down and what additives – both naturally occurring, like biodiesel and synthetic – can be used in this pursuit.

12.13 INTERIM REVIEW

The Committee recommends that an interim review be undertaken in 2019 which can take stock of the progress of various recommendations of this Committee and to finalise BS VI emission norms taking into account the latest technological developments.

ANNEXURE 1

CONSTITUTION OF 4 WORKING GROUPS BY THE CHAIRMAN, EXPERT COMMITTEE, AUTO FUEL VISION & POLICY 2025

During the 1st meeting of the Expert Committee held in Yojana Bhawan, New Delhi on 22nd January 2013, following four Working Groups were constituted to deliberate and recommend roadmap for fuel quality and its implementation:

1. **Air Quality & Vehicular Emission Norms for all types of Vehicles, Vehicle Technology and Fuel Quality**:

    i. Dr R.K. Malhotra, Director, IOC (R&D) – Convenor
    ii. Representative of Ministry of Heavy Industries
    iii. Dr B. Sengupta, Former Member Secretary, CPCB
    iv. Shri Shrikant R. Marathe, Director, ARAI
    v. Shri K.K. Gandhi, ED (Technical), SIAM
    vi. Shri Ashok Dhar, President, Industrial Marketing, RIL
    vii. Prof. Shantanu Roy, IIT, Delhi
    viii. Shri I.V. Rao, Executive Adviser, Maruti Suzuki Ltd.
    ix. Ms Chitra Gupta, BIS
    x. Shri B.D. Ghosh, ED, CHT

2. **Automobile exhaust on Ambient Air Quality & Public Health, Emission reduction programme, fuel economy, warranty of in-use vehicles**:

    i. Dr B. Sengupta, Former Member Secretary, CPCB–Convenor
    ii. Dr Leena Srivastava, ED, TERI
    iii. Dr N.S. Dharmshaktu, Ministry of Health
    iv. Representative from Ministry of RT&H
    v. Dr Rashid Hasan, Ministry of E&F
    vi. Shri Shrikant R. Marathe, Director, ARAI
    vii. Shri K.K. Gandhi, ED (Technical), SIAM
    viii. Shri Abhay Bakre, ED, PCRA
    ix. Prof. L.M. Das, Centre for Energy Studies, IIT, Delhi
    x. Shri B.D. Ghosh, ED, CHT

3. **Refinery Upgradation, Technology and Logistics, Funding & Fiscal Measures**:

    i. Shri R.K. Ghosh, Director, IOC (R) - Convenor
    ii. Prof. Shantanu Roy, IIT, Delhi
    iii. Shri S.S. Saini/K. Balachandran, Site President, RIL
    iv. Shri L.K. Gupta/C. Manoharan, Essar
    v. Shri B.D. Ghosh, ED, CHT
    vi. Shri S.K. Handa, ED, EIL
    vii. Shri B.K. Datta, Director (R), BPCL
    viii. Shri B.K. Namdeo, Director (R), HPCL

4. **Suitable mix of auto fuels including gas, logistics, road transport**:

    i. Shri Prabhat Singh, Director (M), GAIL - Convenor
    ii. Representative of MNRE
    iii. Shri Balasubramanian, ED, IOC
    iv. Prof. L.M. Das, Centre for Energy Studies, IIT, Delhi
    v. Shri K.K. Gandhi, ED (Technical), SIAM
    vi. Shri B.D. Ghosh, ED, CHT
    vii. Shri S.P. Gupta, Director, PPAC

The Centre for High Technology would provide technical and secretarial support to the Expert Committee.

ANNEXURE 2

Trend in Air Quality Parameters (SO_2, NO_2 and PM_{10}) in 50 Cities during 2008 to 2012

State	City	2008			2009			2010			2011			2012		
		SO_2	NO_2	PM_{10}	SO_2	NO_2	PM_{10}	SO_2	NO_2	PM_{10}	SO_2	NO_2	PM_{10}	SO_2	NO_2	PM_{10}
Andhra Pradesh	Hyderabad	5	26	**85**	5	23	**81**	5	24	**79**	5	28	**74**	4	28	**83**
	Visakhapatnam	10	30	**81**	11	26	**93**	7	16	**71**	13	21	**80**	12	13	**65**
	Vijayawada	5	28	**96**	6	15	**87**	6	14	**93**	6	11	**90**	6	12	**67**
Bihar	Patna	7	39	**120**	5	37	**146**	7	40	**181**	4	36	**158**	6	34	**162**
Chandigarh	Chandigarh	2	15	**95**	2	15	**81**	2	16	**92**	2	16	**102**	2	19	**106**
Chhattisgarh	Raipur	19	43	**192**	18	46	**263**	15	43	**289**	15	42	**310**	14	41	**284**
	Durg-Bhilainagar	17	25	**109**	15	25	**112**	9	22	**109**	8	22	**104**	8	22	**105**
Delhi	Delhi	6	57	**214**	6	50	**252**	5	55	**261**	6	61	**222**	6	61	**252**
Gujarat	Ahmedabad	12	20	**88**	16	21	**94**	15	21	**95**	14	25	**83**	12	23	**79**
	Surat	17	24	**87**	19	26	**90**	16	24	**76**	20	29	**106**	16	26	**97**
	Vadodara	14	28	**77**	16	30	**86**	17	29	**93**	18	30	**92**	16	31	**99**
	Rajkot	11	14	**105**	11	15	**105**	13	17	**96**	13	18	**98**	13	17	**97**
Haryana	Faridabad	13	24	**150**	15	23	**154**	18	29	**164**	20	43	**174**	12	39	**190**
Jharkhand	Jamshedpur	37	51	**172**	36	49	**172**	35	48	**153**	36	48	**152**	37	49	**149**
	Dhanbad	19	44	**131**	17	41	**164**	15	36	**184**	35	36	**207**	17	40	**175**
	Ranchi	18	33	**173**	18	32	**179**	19	35	**172**	18	35	**165**	18	35	**202**

ANNEXURE 2 (Cont'd)

State	City	2008			2009			2010			2011			2012		
		SO_2	NO_2	PM_{10}	SO_2	NO_2	PM_{10}	SO_2	NO_2	PM_{10}	SO_2	NO_2	PM_{10}	SO_2	NO_2	PM_{10}
Karnataka	Bangalore	15	41	**100**	14	37	**112**	14	31	**89**	4	28	**91**	14	28	**117**
Kerala	Kochi	4	12	43	4	12	42	4	11	36	3	13	38	3	8	**70**
	Kozhikhode	2	7	34	2	9	32	2	9	42	2	8	46	2	8	55
	Thrissur	-	-	-	-	-	-	2	7	31	2	14	33	2	15	**73**
	Mallapuram	-	-	-	-	-	-	2	5	30	2	5	30	2	5	36
	Thiru' puram	10	26	**67**	9	21	**61**	9	24	**56**	10	23	**58**	9	22	54
	Kollam	-	-	-	-	-	-	3	15	47	4	20	53	4	19	41
Madhya Pradesh	Indore	10	19	**196**	9	17	**183**	14	18	**120**	12	14	**132**	12	20	**143**
	Bhopal	6	20	**102**	7	17	**119**	9	18	**133**	4	16	**170**	3	21	**172**
	Jabalpur	2	25	**136**	2	24	**136**	2	25	**135**	2	25	**73**	2	24	**75**
	Gwalior	9	16	**163**	10	18	**187**	12	20	**308**	12	20	**311**	13	27	**327**
Maharashtra	Mumbai	9	40	**127**	6	41	**117**	4	19	**97**	5	33	**116**	5	21	**117**
	Pune	22	37	**103**	25	40	**88**	29	39	**82**	32	58	**113**	22	45	**91**
	Nagpur	8	33	**114**	6	31	**101**	7	33	**113**	8	35	**108**	10	34	**82**
	Nashik	30	25	**79**	23	29	**89**	21	26	**77**	25	27	**96**	24	27	**95**
	Aurangabad	8	20	**75**	7	25	**86**	6	21	**75**	8	31	**83**	9	32	**79**
Punjab	Ludhiana	10	40	**271**	9	38	**253**	9	32	**214**	11	28	**221**	11	27	**229**
	Amritsar	-	-	-	15	35	**190**	14	36	**219**	14	26	**210**	13	38	**195**

ANNEXURE 2 (Cont'd)

State	City	2008			2009			2010			2011			2012		
		SO_2	NO_2	PM_{10}	SO_2	NO_2	PM_{10}	SO_2	NO_2	PM_{10}	SO_2	NO_2	PM_{10}	SO_2	NO_2	PM_{10}
Rajasthan	Jaipur	6	35	**127**	6	36	**151**	6	37	**164**	6	37	**139**	9	51	**184**
	Jodhpur	6	24	**176**	6	23	**140**	6	22	**181**	5	23	**168**	6	24	**191**
	Kota	9	25	**125**	6	24	**91**	10	29	**132**	7	31	**139**	8	31	**155**
Tamil Nadu	Chennai	9	14	**63**	9	17	**73**	9	15	59	9	24	**92**	12	21	57
	Coimbatore	6	30	**75**	6	27	**77**	5	27	**78**	4	26	**102**	5	27	**68**
	Madurai	10	24	42	10	25	42	11	25	47	11	24	44	10	23	48
	Tiruchirappalli	-	-	-	-	-	-	-	-	-	-	-	-	11	17	**78**
Uttar Pradesh	Kanpur	7	24	**212**	8	31	**212**	7	34	**203**	10	31	**183**	8	25	**221**
	Ghaziabad	20	16	**236**	29	31	**239**	30	37	**290**	31	39	**231**	29	33	**236**
	Agra	6	23	**198**	6	21	**185**	5	20	**185**	3	23	**155**	4	22	**181**
	Varanasi	16	19	**106**	17	20	**125**	18	20	**127**	17	20	**127**	18	21	**138**
	Meerut	10	42	**115**	8	44	**119**	8	47	**166**	5	45	**123**	4	43	**129**
	Allahabad	8	37	**181**	3	24	**160**	4	24	**218**	5	20	**258**	4	32	**318**
	Lucknow	8	36	**190**	8	36	**197**	8	34	**204**	8	33	**189**	8	32	**204**
West Bengal	Kolkata	8	64	**103**	11	68	**126**	11	62	**99**	12	65	**113**	9	59	**125**
	Asansol	7	74	**135**	8	55	**154**	8	66	**141**	7	56	**145**	13	48	**117**

Note: '–' Data not available. BDL – Below Detection Limit (*i.e.,* less than 4 micrograms per cubic meter for SO_2 and less than 9 micrograms per cubic metre for NO_2). Data of Agra city is of Taj Mahal which has been identified as sensitive Area. National Ambient Air Quality Standard for Residential, Industrial, Rural and others Areas (Annual average) for SO_2 = 50 micro-gram per cubic metre, NO_2 = 40 micro-gram per cubic metre and PM_{10} = 60 micro-gram per cubic metre.

Source: Air Quality Data as reported by CPCB/SPCBs/PCCs/NEERI in monthly summary sheet/environmental data bank/hard copy calculations for 2012 as per data available on 31st March 2013.

ANNEXURE 3.1

Gasoline BS III & BS IV Specification

S. No.	Attribute	Unit	BS III		BS IV	
			Regular	Premium	Regular	Premium
1.	Density@15°C	kg/m3	720-775	720-775	720-775	720-775
2.	Distillation					
	E-70	% vol.	10-45	10-45	10-45	10-45
	E-100	% vol.	40-70	40-70	40-70	40-70
	E-150	% vol. min	75	75	75	75
	FBP	°C max	210	210	210	210
	Residue	% vol. max	2	2	2	2
3.	Sulphur	ppm max	150	150	50	50
4.	RON	min	91	95	91	95
	MON	min	81	85	81	85
5.	RVP @ 38°C	kPa max	60	60	60	60
6.	VLI					
	Summer	max	750	750	750	750
	Other months	max	950	950	950	950
7.	Benzene	% vol. max	1	1	1	1
8.	Aromatics	% vol. max	42	42	35	35
9.	Olefin	% vol. max	21	18	21	18
10.	Gum content (solv washed)	mg/100 ml max	5	5	5	5
11.	Oxidation stability	Minutes, min	360	360	360	360
12.	Lead as Pb	g/l max	0.005	0.005	0.005	0.005
13.	Oxygen	% wt. max	2.7	2.7	2.7	2.7
14.	Oxygenate	% vol. max				
	Methanol		3	3	3	3
	Ethanol		5	5	5	5
	Iso-propyl alcohol		10	10	10	10
	Iso-butyl alcohol		10	10	10	10
	Tertiary-butyl alcohol		7	7	7	7
	Ethers with ≥5 C atoms/molecule		15	15	15	15
	Other oxygenates		8	8	8	8
15.	Copper strip corrosion for 3 hrs. @ 50°C, max	Rating	Class 1	Class 1	Class 1	Class 1

Note: For gasoline processed from Assam crude, relaxation of Aromatics content for these Assam units as provided in the present BIS specification.

ANNEXURE 3.2

Diesel BS III & BS IV Specification

S. No.	Attribute	Unit	BS III	BS IV
1.	Density @ 15°C	kg/m3	820–845	820–845
2.	Distillation: 95% vol. Recovery @ °C, max	°C	360	360
3.	Sulphur	ppm max	350	50
4.	Cetane Number	Min	51	51
5.	Cetane Index	Min	46	46
6.	Flash Point, Abel, min	°C	35	35
7.	KV @ 40°C	cSt	2.0–4.5	2.0–4.5
8.	Carbon residue (Ramsbottom) on 10% residue, max (without additive)	% wt max	0.3	0.3
9.	Water content	mg/kg max	200	200
10.	Lubricity corrected Wear Scar Diameter @ 60°C, max	Microns	460	460
11.	Ash	% wt. max	0.01	0.01
12.	Cold Filter Plugging Point:			
	a) Summer	°C	18	18
	b) Winter	°C	6	6
13.	Total contamination, max	mg/kg	24	24
14.	Oxidation stability, max	g/m3	25	25
15.	Polycyclic Aromatic Hydrocarbon (PAH), max	% wt.	11	11
16.	Copper strip corrosion for 3 hrs. @ 50°C, max	Rating	Class-1	Class-1

Note: For diesel processed from Assam crude, relaxation of Cetane Number & Cetane Index by these Assam units and density shall be applicable as provided in the present BIS specification.

ANNEXURE 4.1

Gasoline BS V Specification

Sl.No	Attribute	Unit	Proposed BS V	
			Regular	Premium
1	Density @15 deg C	kg/m3	720–775	720–775
2	Distillation			
	E-70	% vol.	10–45	10–45
	E-100	% vol.	40–70	40–70
	E-150	% vol. min	75	75
	FBP	°C max	210	210
	Residue	% vol. max	2	2
3	Sulphur	ppm max	10	10
4	RON	min.	91	95
	MON	min.	81	85
5	RVP @ 38^{0}C, max	kPa	60	60
6	VLI (10RVP+7E70) Summer (May to July)	max	750	750
	Other months	max	950	950
7	Benzene	% vol. max	1	1
8	Aromatics	% vol. max	35	35
9	Olefin	% vol. max	21	18
10	Gum (solvent washed)	mg/100 ml max	5	5
13	Oxidation Stability	Minutes, min	360	360
11	Lead as Pb	g/litre max	0.005	0.005
12	Oxygen	% wt. max	2.7	2.7
13	Oxygenates	% vol. max		
	Methanol		3	3
	Ethanol		5	5
	Iso Propyl Alcohol		10	10
	Iso Butyl Alcohol		10	10
	Tertiary Butyl Alcohol		7	7
	Ethers with 5 or more C atoms per molecule		15	15
	Other Oxygenates		8	8
14	Copper strip corrosion for 3 hrs @ 50°C, max	Rating	Class 1	Class 1

ANNEXURE 4.2

Diesel BS V Specification

S. No	Attribute	Unit	Proposed BS V
1.	Density @15°C	kg/m^3, max	820–845
2.	Distillation T_{95}	°C max	360
3.	Sulphur	Ppm max	10
4.	Cetane No	min.	51
5.	Cetane Index	min.	46
6.	Flash Point	°C min.	42
7.	Viscosity @ 40°C	cSt	2.0–4.5
8.	PAH	% wt. max	11
9.	Total Contaminants	mg/kg max	24
10.	RCR on 10% Residue	% wt. max	0.3
11.	Water Content	mg/kg max	200
12.	Lubricity, Corrected Wear Scar Diameter (WSD) @ 60°C	Microns, max	460
13.	Ash	% wt. max	0.01
14.	Cold Filter Plugging Point a) summer, max b) winter, max	°C °C	18 6
15.	Oxidation stability	g/m3, max	25
16.	Copper strip corrosion for 3 hrs @ 50°C, max	Rating	Class 1

ANNEXURE 5

Gasoline (Motor Spirit) Specifications in Different Countries

S. No	Attribute		India	Europe	USA	Japan	South Korea	China	
			BS IV	EN 228: 2008	Conventional	JIS K 2202		Nation wide	Beijing
			Apr 10	Jan 09	Nov 11	Jan 08	Jan 09	Dec 09	Jan08
1	Density @ 15°C	kg/m3	720-775	720-775		783 max			
2	Distillation								
	E-70	% vol.	10-45	20-48					
	E-100	% vol.	40-70	46-71					
	E-150	% vol. min	75	75					
	T-10	°C max				70	70	70	70
	T-50	°C max				75-110	125	120	120
	T-90	°C max				180	170	190	190
	FBP	°C max	210	210		220	225	205	205
	Residue	% vol max	2	2		2	2	2	2
3	Sulphur	ppm max	50	10	80	10	10	150	50
4	RON	Min	91	91		89	91	90/93	90/93
5	MON	Min	81	81					
6	AKI	min						85/88	85/88
7	RVP @ 38°C	kPa max	60	45-60	44-75	44-65(s) 44-43(w)	44-82		
8	VLI	max		1050					
	Summer	max	750						
	Others	max	950						
9	Benzene	% vol. max	1.0	1.0	0.62	1.0	0.7	1.0	1.0
10	Aromatics	% vol. max	35	35			24	40	
11	Olefin	% vol. max	21	18			16	30	25
12.	Existent Gum	g/m3 max	50						
13	Oxidation stability	Minutes, min	360	360		240	480	480	480
14.	Lead as Pb	g/l max	0.005	0.005	0.013	0.001	0.013	0.005	0.005
15	Phosphorous	g/l max			0.0013		0.0013	0.0013	
16	Manganese	g/l max			0.0083			0.016	0.016
17	Oxygen	% wt. max	2.7	2.7	2.7	1.3	0.5-2.3(s) 1-2.3(w)	2.7	2.7
18	Oxygenate	% vol max							
	Methanol		3	3		0.5	0.1% wt	0.3% wt	0.3% wt
	Ethanol		5	5		3			
	Iso-propyl alcohol		10						
	Iso-butyl alcohol		10						
	Tertiary-butyl alcohol		7						
	Ethers with ≥5 C atoms/molecule		15	15		7			
	Other oxygenates		8						

ANNEXURE 6

Diesel Specifications in Different Countries

S. No.	Attribute		India	Europe	USA	Japan	South Korea	China	
			BS IV	EN 590:2009	ASTM D 975-11 No.2	JIS K 2204-2007		Nation wide	Beijing
			April 10	Oct 09	April 11	Jan 07	Jan 09	Jan 10	Jan 08
1.	Density @ 15°C	kg/m3	820-845	820-845	--	860 max	815-835	810-850$^{\$}$	820-845$^{\$}$
2.	Distillation								
	T-50	°C max	--	--	--	--	--	300	300
	T-85	°C max	--	350	--	--	--	--	--
	T-90	°C max	--	--	282-338	360	360	355	355
	T-95	°C max	--	360	--	--	--	365	365
	FBP	°C max	--	--	--	--	--	--	--
	Recovery @ 360°C	% vol. min	95	--	--	--	--	--	--
3.	Sulphur	ppm max	50	10	15	10	10	350	50
4.	Cetane Number	min	51	51	40	50	52	49	51
5.	Cetane Index	min	46	46	40	50	52	46	46
6.	Flash Point	°C min	35	55	52	50	40	55	55
7.	KV @ 40°C	cSt	2.0-4.5	2.0-4.5	1.9-4.1	1.7-2.7	1.9-5.5	3-8$^{\$}$	3-8$^{\$}$
8.	Total Aromatics	% wt max	--	--	35	--	30	--	3-8$^{\$}$
9.	PAH	% wt max	11	11	--	--	5	11	11
10.	Total sediments	mg/100 ml max	--	--	--	--	--	None	None
11.	Total contamination	mg/kg max	24	--	--	--	--	--	--
12.	Oxidation stability	g/m3 max	25	--	--	--	--	--	--
13.	RCR on 10% residue	% wt max	0.3	--	--	--	--	--	--
14.	CCR on 10% residue	% wt max	--	0.3	0.35	0.1	0.15	0.3	0.3
15.	Water content	mg/kg max	200	0.02	--	--	--	Trace	Trace
16.	Water + sediment	% vol. max	--	--	0.05	--	0.02	--	--
17.	Lubricity corrected WSD	Microns max	460	460	520	--	400	460	460
18.	Ash	% wt. max	0.01	0.01	0.01	--	0.02	0.01	0.01
19.	Oxygen	% wt. max	0.6*	--		--	--	--	--
20.	FAME	% vol max	--	7	5	--	5	0.05	--

Note: * Applicable only for diesel with 5% v/v bio-diesel at 20°C
$^{\$}$ At 20°C

ANNEXURE 7

Process Units Installed for Fuel Quality Improvements

Sl No	Attribute	Process units/Operational changes
	Fuel – Gasoline	
1	Lead free	CRU/CCRU and MTBE units
2	Benzene reduction	Feed management and operational changes besides putting up facilities like Bensat and Isomerisation units, pre & post reformate and FCC gasoline splitters
3	Sulphur reduction	FCC Gasoline Desulphurisation unit
4	Octane Number Enhancement	CRU/CCRU/Alkylation
5	Olefins and Aromatic management	BENSAT & FCC Gasoline Desulphurisation unit
	Fuel – Diesel	
1	Sulphur reduction	DHDS, DHDT, VGO HDT and Hydrocracker units
2	Cetane Number improvement	DHDT and Hydrocracker units
3	Distillation recovery	DHDT and cut point management in VDU
4	Limiting Polycyclic Aromatic Hydrocarbon (PAH)	Hydrocracker unit

ANNEXURE 8

Gasoline Production Numbers

(Figs in TMT)

	Co	Refinery Location	01.04.16			01.04.17				01.04.20				01.04.25				Invest. Rs Crore	Remarks
			BS III	BS IV	Total	BS III	BS IV	BS V	Total	BS III	BS IV	BS V	Total	BS III	BS IV	BS V	Total		
1		Digboi	104		104	110			110	110			110	110			110		Aromatics of 42% cannot be reduced
2		Guwahati	154		154		154		154		154		154		154		154	400	BS III being made thru stream sharing. BS IV after IndAdaptG and new CRU commissioning
3		Barauni	1045	77	1122	1045	77		1122		1100		1100		1100		1100	500	BS IV subject to successful trials being done. CRU block and Prime G units revamp is considered for 2018
4		Gujarat	935	550	1485	935	550		1485		1600		1600		1600		1600	500	Prime G+ in 2017; Post J-18 in 2020
5	IOC	Haldia	60	420	480	60	420		480		830		830		830		830		Reformate ex Paradip
6		Mathura		960	960		960		960		1150		1150		1150		1150	8630	Production based on 8 MMTPA. Capacity expansion to 11 MMTPA @ 2018-19
7		Panipat		1485	1485		1485		1485		1700		1700		1700		1700		Post CCRU, catalyst change in 2014. Post P-20.2 @ 2020
8		Bongaigaon	206		206	69	446		515	69	446		515	69	446		515	1830	Considering INDMAX from 1.4.2017. Without INDMAX, only 206 TMTPA of BS III MS will be available.
9		Paradip		3900	3900		3900		3900			3900	3900			3900	3900		PDRP commissioning in 2015. Production No. based on MS mode operation of FCCU.
10	CPCL	Manali	636	324	960		960		960		780	180	960		780	180	960	200	Gasoline desulphurisation required
11		CBR			0				0				0				0		No gasoline production

	Co	Refinery Location	01.04.16			01.04.17				01.04.20				01.04.25				Invest. Rs Crore	Remarks
			BS III	BS IV	Total	BS III	BS IV	BS V	Total	BS III	BS IV	BS V	Total	BS III	BS IV	BS V	Total		
12	BPCL	Mumbai	900	900	1800		1840	460	2300		1840	460	2300		1840	460	2300	3352	CCR stabilisation @ July 2014. Isom stabilisation @ July 2016
13		Kochi		1894	1894		947	947	1894		947	947	1894		947	947	1894		IREP completion in Dec 2015
14	HPCL	Mumbai	672	588	1260		1260		1260			1700	1700			1700	1700	180	
15		Vizag	1200	480	1680		1680		1680			1390	1390			1390	1390	180	
16	NRL	Numali-garh	264	60	324	264	60		324		662	662	1324		662	662	1324		Capacity expansion from 3 to 9 MMTPA @ 1.04.2020
17	MRPL	Mangalore		805	805		855		855		805	220	1025		805	220	1025	1500	New NHT, CCRU & 18.FCC gasoline tre19.ating unit and revam20.p of Isom unit21.
18	HMEL	Bhatinda		1000	1000		1000		1000			1400	1400			1400	1400	500	
19	BORL	Bina	385	400	785	385		400	785			785	785			785	785	250	Facilities would be required for BS IV and BS V
20	RIL	DTA		3500	3500		2000	1500	3500		2000	1500	3500		2000	1500	3500	660	
21	RIL	SEZ		9300	9300			9300	9300			9300	9300			9300	9300		Product availability from SEZ if duty is same as at DTA
22	Essar	Jamnagar		1440	1440			2400	2400			2400	2400			2400	2400	380	BS III gasoline being exported. Investment to be firmed up.
	Associated facilities																	938	For all the refineries
	Total		6561	28083	34644	2868	18594	15007	36469	179	14014	24844	39037	179	14014	24844	39037	20000	
	% demand			132.47 %			81.91%	66.11%			49.35 %	87.48%			34.10 %	60.45%			
	Excl. RIL-SEZ		6561	18783	25344	2868	18594	5707	27169	179	14014	15544	29737	179	14014	15544	29737	20000	
	% demand			88.6%			81.91%	25.14%			49.35 %	54.73%			34.10 %	37.82%			
	Demand		21.2 MMT			22.7 MMT				28.4 MMT				41.1 MMT					

ANNEXURE 9

Diesel Production Numbers

(Figs in TMT)

	Co	**Refinery Location**	**01.04.16**			**01.04.17**				**01.04.20**				**01.04.25**				**Invest Rs Crore**	**Remarks**
			BS III	BS IV	Total	BS III	BS IV	BS V	Total	BS III	BS IV	BS V	Total	BS III	BS IV	BS V	Total		
1		Digboi		340	340		350		350		350		350		350		350	0	
2		Guwahati		600	600		600		600		600		600		600		600	0	BS III/IV diesel thru stream sharing of industrial kero from other refineries
3		Barauni		2820	2820		3080		3080		3080		3080			3080	3080	40	100% BS IV in 2016 subject to crude restriction to 5.8 MMTPA due to DHDT limitation. 100% BS IV @ 2017 with DHDT revamp to 3.3 MMTPA.
4	**IOCL**	Gujarat	5280	550	5830	5280	550		550		7300		7300		7300		7300	800	New DHDT considered. Post J-18 @ 2020
5		Haldia	2500	500	500		3050		3050		1510	1540	3050		1970	730	2700	450	New DHDT @ 2016. New CGO-HDT under coker @ 2017 AT 8 MMTPA
6		Mathura		2650	2650		2650		2650		5000		5000		5000		5000	8668	Production No. based on 8 MMTPA processing. Presently, 50% BS III & 50% BS IV being produced. Capacity expansion to 11 MMTPA @ 2018

	Co	Refinery Location	01.04.16			01.04.17				01.04.20				01.04.25				Invest Rs Crore	Remarks
7	IOC	Panipat		6800	6800		6800		6800		10300		10300		10300		10300	50	DHDS catalyst replacement in 2014. Gasoline Merox to ATF Merox. Expansion to 20.2 @ 2020
8		Bongaigaon	1108	200	1308		1092		1092		1092		1092		1092		1092	1848	Limited BS IV from 2016. Crude capacity of 2.7 MMTPA @ 2018
9		Paradip		6200	6200		6200		6200			6000	6000			6000	6000	240	Change of catalyst in VGO-HDT considered after 2 cycle operation in 2020-21 for BS V diesel
10	CPCL	Manali	2900	1000	3900		4500		4500		3600	900	4500		3600	900	4500	565	Higher diesel production from 01.04.17 after coker commissioning and OHCU revamp + new SRU. 3600 TMT BS IV diesel with DHDS catalyst replacement. 900 TMT BS V diesel after DHDT catalyst replacement
11		CBR	220		220	220			220	220			220	220			220	500	
12	BPCL	Mumbai	4200	950	5150	4200	950		5150		4560	1140	5700		4560	1140	5700	1993	Based on EIL study for 80% BS IV and 20% BS V diesel production. New DHDT is considered under the study. BS IV and BS V would be possible only after DHDT from April 2019.
13		Kochi		7882	7882		5159	2707	7866		5159	2707	7866		5159	2707	7866	14225	IREP completion in Dec 2015. New DHDT is required

	Co	Refinery Location	01.04.16			01.04.17				01.04.20				01.04.25				Invest Rs Crore	Remarks
14	HPCL	Mumbai		2196	2196		3504		3504			3000	3000			3000	3000	2424	
15		Vizag		3800	3800		3800		3800			3500	3500			3500	3500	3880	
16	NRL	Numaligarh	1650	300	1950	1590	360		1950		3051	3050	6101		3051	3050	6101	15050	Capacity expansion from 3 to 9 MMTPA @ 1.04.2020. Capex Rs15000/- Crore
17	MRPL	Mang-alore	5216	1261	6477		6339	300	6639		7942	600	8542		7942	600	8542	3375	Revamp of DHDT & SRUs and new DHDT & associated facilities
18	HMEL	Bhatinda		4300	4300		4000		4000			4000	4000			4000	4000	300	
19	BORL	Bina		2800	2800		1400	1400	2800			2800	2800			2800	2800	270	
20	RIL	DTA		11150	11150			11150	11150			11150	11150			11150	11150	360	
21	RIL	SEZ		16000	16000			16000	16000			16000	16000			16000	16000	0	Product availability from SEZ if duty is same as at DTA
22	Essar	Jamnagar		9540	9540			9420	9420			9420	9420			9420	9420	280	
	Associated facilities																	4682	For all the refineries
		Total	20574	81839	102413	6010	54384	40977	101371	220	53544	65807	119571	220	50924	68077	119221	60000	
	% of demand			95.72%			60.03%	45.23%			50.18%	61.67%			36.35%	48.59%			
	Excl. RIL-SEZ		20574	65839	86413	6010	54384	24977	85371	220	53544	49807	103571	220	50924	52077	103221	60000	
	% of demand			77.00%			60.03%	27.57%			50.18%	46.68%			36.35%	37.17%			
	Demand in MMT				85.5				90.6				106.7				140.1		

ANNEXURE 10

Gazette Notification of Fuel Efficiency Norms

रजिस्ट्री सं० डी० एल०-33004/99 REGD. NO. D. L.-33004/99

भारत का राजपत्र
The Gazette of India

असाधारण
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विद्युत मंत्रालय

अधिसूचना

नई दिल्ली, 30 जनवरी, 2014

का.आ. 290 (अ).— केन्द्रीय सरकार, ऊर्जा संरक्षण अधिनियम, 2001 (2001 का 52) की धारा 14 के खंड (क) और (ख) और धारा 18 के अधीन प्रदत्त शक्तियों का प्रयोग करते हुए, ऊर्जा दक्षता ब्यूरो के परामर्श से, पेट्रोल या डीजल या द्रवित पेट्रोलियम गैस (एलपीजी) या सम्पीड़ित प्राकृतिक गैस (सीएनजी) के मोटर यान (जिसे इसमें इसके पश्चात् उक्त मोटर यान कहा गया है), जो यात्रियों और उनके सामान को ढोने के लिए प्रयुक्त होता है और जिसमें ड्राईवर की सीट को मिलाकर नौ सीट से अधिक नहीं हैं, और यान का कुल भार चेसिस डायनमोमीटर पर जांचने पर 3,500 किलोग्राम से अधिक नहीं है के लिए तद्द्वारा ऊर्जा खपत मानक उक्त प्रवर्ग के मोटर यानों के विक्रय के लिए विनिर्माण या आयात करने के प्रयोजन के लिए विनिर्दिष्ट करती है, अर्थात्

2. (1) उक्त मोटर यानों का प्रत्येक विनिर्माता नीचे उपबंधित अनुसार औसत ऊर्जा खपत मानकों के निबंधनों के अनुसार ऊर्जा खपत मानक का पालन करेगा : —

(i) "औसत ईंधन खपत मानक = ए x (डब्ल्यू–बी) + सी

जहां,

ए = स्थिरांक गुणक

औसत ईंधन खपत मानक = विनिर्माता का प्रति 100 किलोमीटर पेट्रोल के समतुल्य लीटर में औसत ईंधन खपत मानक;

बी = नियत स्थिरांक;

सी = नियत स्थिरांक;

डब्ल्यू = विनिर्माता द्वारा विक्रय के लिए विनिर्मित या आयातित उक्त सभी नए मोटर यान का किलोग्राम (कि.ग्रा.) के लदान के बिना भारित औसत;

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(ii) गुणक स्थिरांक और नियत स्थिरांक भारत में उक्त मोटर यान के विनिर्माण या आयात के वर्ष पर निर्भर करते हुए निम्नलिखित सारणी 1.1 और सारणी 1.2 से अवधारित किए जाएंगे, अर्थात्:—

सारणी 1.1

(वित्तीय वर्ष 2016—17 से 2020—21 के लिए)

ए	0.0024
बी	1037
सी	5.4922
विनिर्माता के लिए औसत ईंधन खपत मानक	0.0024 x (डब्ल्यू—1037) + 5.4922

सारणी 1.2

(वित्तीय वर्ष 2021—22 से आगे के लिए)

ए	0.002
बी	1145
सी	4.7694
विनिर्माता के लिए औसत ईंधन खपत मानक	0.002 x (डब्ल्यू—1145) + 4.7694

(iii) जहां किसी विनिर्माता के लिए लदान के बिना भार का भारित औसत (डब्ल्यू) निम्नलिखित फार्मूला के अनुसार संगणित किया जाएगा :—

$$\text{डब्ल्यू} \sum \text{एन}_{\text{आई}}\text{डब्ल्यू}_{\text{आई}} / \sum \text{एन}_{\text{आई}}$$

जहां,

$\text{एन}_{\text{आई}}$ = भारत से संबंधित वित्तीय वर्ष में विक्रय के लिए विनिर्मित या आयात उक्त मोटर यानों के किसी मॉडल आई की संख्या;

$\text{डब्ल्यू}_{\text{आई}}$ = संबंधित वित्तीय वर्ष में किसी मॉडल आई का किलोग्राम में लदान के बिना भार।''

(2) केन्द्रीय सरकार, ऊर्जा दक्षता ब्यूरो से परामर्श करके, अधिसूचना द्वारा सारणी 1.2 में यथा विनिर्दिष्ट 'बी' का मूल्य संशोधित कर सकेगी, परंतु कलैण्डर वर्ष 01 जनवरी, 2016 से 31 दिसम्बर, 2016 के दौरान विनिर्मित या आयातित सभी यानों का लदान के बिना औसत भार 1145 किलोग्राम से कम है, जिस दशा में उक्त अवधि में सभी यानों का लगान रहित औसत भार 'बी' का मूल्य होगा।

(3) वास्तविक ईंधन खपत का औसत निम्नलिखित प्रक्रिया के अनुसार अवधारित किया जाएगा:—

(i) विनिर्माता के लिए प्रति 100 किलोमीटर, लीटर के समतुल्य पेट्रोल में वास्तविक ईंधन खपत का औसत किसी वित्तीय वर्ष में विनिर्मित या आयातित उक्त सभी मोटर यानों की भारित औसत ईंधन खपत है और उसका अवधारण निम्नलिखित फार्मूला के अनुसार किया जाएगा:—

$$\text{वास्तविक ईंधन खपत का औसत} = \sum \text{एन}_{\text{आई}}\text{एफसी}_{\text{आई}} / \sum \text{एन}_{\text{आई}}$$

जहां,

$\text{एन}_{\text{आई}}$ = किसी मॉडल आई के विक्रय के लिए विनिर्मित या आयातित यानों की संख्या,

$\text{एफसी}_{\text{आई}}$ = किसी मॉडल आई की प्रति 100 किलोमीटर, लीटर में पेट्रोल के समतुल्य ईंधन खपत,

(ii) प्रत्येक मॉडल की लीटर में प्रति 100 किलोमीटर ईंधन खपत (एफसी), पेट्रोल, डीजल, द्रवित पेट्रोलियम गैस (एलपीजी) और सम्पीड़ित प्राकृतिक गैस (सीएनजी) इंजन यान से तेलपाइप उत्सर्जन के लिए मानकों के ब्यौरों की प्रक्रिया और केन्द्रीय मोटर यान नियम, 1989 के अधीन यथा विनिर्दिष्ट परीक्षण प्रक्रिया से व्युत्पन निम्नलिखित फार्मूला के अनुसार अवधारित की जाएगी :–

(क) प्रत्येक मॉडल में प्रति 100 किलोमीटर (पेट्रोल, एलपीजी या डीजल के मामले में) लीटर के रूप में तथा सीएनजी के मामले में प्रति 100 किलोमीटर घन मीटर में वास्तविक ईंधन खपत निम्नलिखित फार्मूला के अनुसार संगणित की जाएगी :

$एफसी_{पेट्रोल}$ = 0.0423 x $सीओ_2$

$एफसी_{डीजल}$ = 0.0373 x $सीओ_2$

$एफसी_{एलपीजी}$ = 0.0615 x $सीओ_2$

$एफसी_{सीएनजी}$ = 0.0558 x $सीओ_2$

जहां,

$सीओ_2$ = प्रति किलोमीटर, ग्राम में, कार्बन डाईऑक्साइड का मापित उत्सर्जन,

(ख) डीजल, एलपीजी और सीएनजी मोटर यानों में पेट्रोल के समकक्ष वास्तविक ईंधन खपत उपरोक्त (क) में निर्दिष्ट वास्तविक ईंधन खपत से नीचे विनिर्दिष्ट परिवर्तित गुणनखंडों के साथ गुणा करके अभिप्राप्त की जाएगी :–

ईंधन का प्रकार	पेट्रोल के समकक्ष परिवर्तित गुणनखंड
डीजल	1.1340
एलपीजी	0.6878
सीएनजी	0.7581

3. 01 अप्रैल, 2016 से आरंभ, अगले किसी वित्तीय वर्ष में, पैरा 2 के उप–पैरा (2) में यथा विनिर्दिष्ट वास्तविक ईंधन खपत संबंधित वित्तीय वर्ष के पैरा 2 के उप–पैरा (1) में यथा विनिर्दिष्ट औसत ईंधन खपत मानक से कम या उसके समान होगी।

4. (1) अनुपालन और प्रवर्तन – भारत में उक्त मोटर यानों के विक्रय करने वाले सभी विनिर्माता या आयातकर्ता ऊपर विनिर्दिष्ट ऊर्जा खपत मानकों का पालन करेंगे।

(2) सड़क परिवहन और राजमार्ग मंत्रालय, केन्द्रीय मोटर यान नियम, 1989 के अधीन इन मानकों का प्रवर्तन करेगा।

[फा. स. 10/7/2008–ईसी]

ज्योति अरोड़ा, संयुक्त सचिव

MINISTRY OF POWER

NOTIFICATION

New Delhi, the 30th January, 2014

S. O. 290 (E). —In exercise of the powers conferred by clause (a) and (b) of section 14 and section 18 of the Energy Conservation Act, 2001 (52 of 2001), the Central Government in consultation with the Bureau of Energy Efficiency, hereby specifies energy consumption standard for the motor vehicle of petrol or diesel or liquefied petroleum gas or compressed natural gas, used for the carriage of passengers and their luggage and comprising not more than nine seats including driver's seat, and of Gross Vehicle Weight not exceeding 3,500 kilogram tested on chassis dynamometer (hereinafter referred to as the said motor vehicle) for the purpose of manufacturing or importing for sale of the said category of motor vehicles, namely:—

2. (1) Each manufacturer of the said motor vehicles shall comply with energy consumption standard in terms of Average Fuel Consumption Standards as provided below:—

(i) "The Average Fuel Consumption Standard = **a x (W-b) + c**

Where,

a = Constant Multiplier

Average Fuel Consumption Standard = Average Fuel Consumption Standard of manufacturer in petrol equivalent liter per 100 kilometer;

b = Fixed Constant;

c = Fixed Constant;

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

(ii) the constant multiplier and the fixed constants shall be determined from the following Table 1.1 and Table 1.2 depending upon the year of manufacturing or import of the said motor vehicle in India, namely:—

Table 1.1

(for fiscal years 2016-17 to 2020-21)

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

Table 1.2

(fiscal year 2021-22 onwards)

a	0.002
b	1145
c	4.7694
Average Fuel Consumption Standard for Manufacturer	= 0.002 x (W – 1145) + 4.7694

(iii) where weighted average Unladen Mass (W) for a manufacturer is calculated as per the following formula:-

$$W = \sum N_i W_i / \sum N_i$$

Where,

N_i = Number of the said motor manufactured or imported for sale in India of a model i in the respective fiscal year;

W_i = Unladen mass in kilogram of a model i in the respective fiscal year."

(2) The Central Government may, by notification, in consultation with the Bureau of Energy Efficiency revise the value of 'b' as specified in Table 1.2 provided the average unladen mass of all the vehicles manufactured or imported during the calendar year 1st January, 2016 to 31st December, 2016 is less than 1145 kilogram, in which case the average unladen mass of all the vehicles in the said period will be the value of 'b'.

(3) The Average of Actual Fuel Consumption shall be determined as per the following procedure:—

(i) Average of Actual Fuel Consumption in petrol equivalent liter per 100 kilometer for a manufacturer is the weighted average fuel consumption of all the said motor vehicles , manufactured or imported in a fiscal year and shall be determined as per the following formula:—

$$\text{Average of Actual Fuel Consumption} = \sum N_i FC_i / \sum N_i$$

Where,

N_i = Number of vehicles manufactured or imported for sale of a model i,

FC_i = Petrol equivalent fuel consumption in liter per 100 kilometer of a model i;

(ii) the Fuel Consumption (FC) in liter per 100 kilometer of every model shall be determined as per the following formula derived from the procedure for Details of Standards for Tailpipe Emissions from Petrol, Diesel, Liquefied Petroleum Gas (LPG) and Compressed Natural Gas (CNG) Engine Vehicles and Test Procedure as specified under the Central Motor Vehicle Rules, 1989.

(a) the actual fuel consumption of every model in terms of the liter per 100 kilometer (in the case of petrol, LPG or diesel) and in cubic meter per 100 kilometer in the case of CNG shall be calculated by the following formulae:

$$FC_{petrol} = 0.0423 \times CO_2$$
$$FC_{diesel} = 0.0373 \times CO_2$$
$$FC_{LPG} = 0.0615 \times CO_2$$
$$FC_{CNG} = 0.0558 \times CO_2$$

Where,

CO_2 = the measured emission of carbon dioxide in gram per kilometer;

(b) the actual fuel consumption in petrol equivalent for diesel, LPG and CNG motor vehicles shall be obtained by multiplying the actual fuel consumption referred to in (a) above with the conversion factors specified below:—

Fuel Type	Conversion Factor to Petrol equivalent
Diesel	1.1340
LPG	0.6878
CNG	0.7581

3. In any fiscal year commencing from1st April, 2016 onwards, the Average of Actual Fuel Consumption as specified in sub-para (2) of para 2 shall be less than or equal to Average Fuel Consumption Standard as specified in sub-para (1) of para 2 of the respective fiscal year.

4. (1) Compliance and enforcement.- All the manufacturers or importers selling the said motor vehicles in India shall comply with the energy consumption standards specified above.

(2) The Ministry of Road Transport and Highways shall enforce the same under the Central Motor Vehicle Rules, 1989.

[F. No – 10/7/2008-EC]

JYOTI ARORA, Jt. Secy.

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ANNEXURE 11

Order Constituting Expert Committee for Preparing a Draft Auto Fuel Vision & Policy 2025

R-29011/23/2012-OR
Government of India
Ministry of Petroleum & Natural Gas

19th December, 2012

OFFICE MEMORANDUM

Subject : Constitution of an Expert Committee for preparing a Draft Auto Fuel Vision & Policy 2025.

Government had constituted an Expert Committee in 2001, under the Chairmanship of Dr. R A Mashelkar, the then Director General, CSIR, which recommended the last Auto Fuel Policy for the country. The policy also envisaged that the Auto Fuel Policy must undergo periodic revisions. The technological and other changes that have taken place during this period have necessitated formulation of an Auto Fuel Vision and Policy for the whole country clearly laying the roadmap for the year 2025. Accordingly, it has been decided to constitute an Expert Committee to draft Auto Fuel Policy 2025 with the following terms of reference:

(i) Recommend road map for auto fuel quality till 2025 for the country, taking into account the achievement under the last Auto Fuel Policy, emission reduction of in-use vehicles, growth of vehicles and supply and availability of fuels.

(ii) Recommend suitable mix of auto fuels including gas and its specifications, considering the following:
   a) Availability of infrastructure and logistics of fuel supplies,
   b) The processing economics of auto fuels, and
   c) Improvement in the quality of fuel vis-à-vis improvement in vehicle engine technology.

(iii) Recommend vehicular emission norms for various categories of vehicles and roadmap for their implementation.

(iv) Recommend use of alternate fuels to minimize impact on environment.

(v) Recommend fiscal measures for funding requisite upgradation of Oil Refineries, logistics and removal of inter-fuel pricing distortions.

2. The constitution of the Expert Committee will be as under:-

(i)	Shri Saumitra Chaudhuri, Member, Planning Commission	Chairman
(ii)	Shri S.Sundareshan, Ex-Secretary, M/o Petroleum & Natural Gas and Ex-Secretary, D/o Heavy Industry	Member
(iii)	Prof L.M Das, Centre for Energy Studies, IIT, Delhi	Member
(iv)	Prof Shantanu Roy, Dept. of Chemical Engineering, IIT, Delhi	Member
(v)	Dr. R.K. Malhotra, Director(R&D), IOCL	Member
(vi)	Shri Shrikant R.Marathe, Director, ARAI, Pune	Member
(vii)	Dr. B. Sengupta, former Member Secretary, Central Pollution Control Board	Member
(viii)	Dr. Leena Srivastava, ED, TERI	Member
(ix)	Shri Ashok Dhar, President, Industrial Marketing , RIL	Member
(x)	Shri I.V.Rao, Executive Adviser, Maruti Suzuki India Ltd.	Member
(xi)	Shri K.K. Gandhi, ED(Technical), SIAM	Member
(xii)	Shri B.D Ghosh, ED CHT (For Technical and Secretarial Support)	Member
(xiii)	Shri L.N.Gupta, Jt. Secretary, M/o Petroleum & Natural Gas	Member Secretary

3. Representatives from the following Ministries/ Departments not below the rank of Joint Secretary will be Ex- Officio members of the Committee.

i. Ministry of Environment & Forests
ii. Department of Heavy Industry
iii. Ministry of Road Transport & Highways
iv. Department of Health and Family Welfare
v. Department of Consumer Affairs

4. The Committee may hold formal consultations with the different stakeholders and co-opt any Expert for technical assistance in their deliberations.

5. The technical and secretarial assistance to the Committee will be provided by the Centre for High Technology (CHT).

6. Outstation Non Official Members will be entitled for to and fro economy class air-fare, conveyance and accommodation. Local Non-Official Members will be provided with conveyance for attending the meetings. A sitting fee of Rs. 5000/- per meeting would be provided to all Non-official Members. The expenditure on the above including any incidental expenses will be borne by CHT out of its budget.

7. The Committee will submit its interim report to the Government by 15th March 2013 and the final Report by 31st May 2013.

27.12.12
(Pawan Kumar)
Under Secretary to the Govt. of India

Copy to :-

i. Shri Saumitra Chaudhuri, Member, Planning Commission
ii. Shri S.Sundareshan, Ex-Secretary, D/o Heavy Industry
iii. Professor L.M Das, Centre for Energy Studies, IIT, DELHI
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xii. Secretary, Ministry of Environment & Forests
xiii. Secretary, Department of Heavy Industry
xiv. Secretary, Ministry of Road Transport & Highways
xv. Secretary, Department of Health and Family Welfare
xvi. Secretary, Department of Consumer Affairs
xvii. Shri L.N Gupta, Joint Secretary, MOP&NG and Member Secretary
xviii. Shri B.D Ghosh, ED, CHT
xix. PS to Minister(P&NG)/PPS to Secretary(P&NG)/Sr PPS to Addl Secy(P&NG)
xx. Guard File