Chapter 6

LAWS RELATING TO CONTROL AND REGULATION OF FUEL AND TECHNOLOGY

Vehicles are undoubtedly the most rapidly growing source of urban air pollution in India and Asia. Michael P. Walsh, a US-based vehicle technology expert says, "While 60 percent of the world's population lives in Asia, it owns only about 20 percent of the world's vehicles excluding two-wheelers. On a per capita basis, the US and Europe still tends to dominate, with the highest in the US. Most of the Asian countries have a very low per capita vehicle population. This scenario will change as experts forecast a substantial additional growth in the vehicle population in the Asian Cities. The Asian region, especially India and China, is urbanising at a very rapid rate with a high per capita gross domestic product (GDP), a measure of economic growth. This implies that the cities experiencing economic growth are destined to face choking congestion and pollution.[1]

Fuel and Technology: Its Growing Importance

The solution, though not absolute, may be surveyed and can possibly be found in the improvement in the fuel consumed by the different modes of transportation, especially motor vehicles and corresponding engine technology to be compatible to such fuels.

All over the world, initiatives have been taken to improve the quality of diesel and petrol and make use of less polluting short chain hydrocarbon fuels like compressed natural gas (CNG), liquified petroleum gas (LPG) and propane. Improvement in fuel quality is also achieved through removal/reduction of emission related constituents in the fuels such as sulphur and polycyclic aromatic hydrocarbons (PAH) in diesel and sulphur, lead, benzene and other aromatics in petrol. Further reduction of emissions is

[1] Anumita Roychowdhury, Vivek Chattopadhyaya, Chirag Shah & Priyanka Chandola, *A Technology Roadmap* in Ajit Chak & Souparno Banerjee (ed.), *The Leapfrog Factor: Clearing the Air in Asian Cities,* Centre for Science and Environment (CSE), 2006, at p. 129.

obtained through improved engine technology and exhaust treatment systems.[2]

Until the end of the 19th Century the horse was the most efficient form of transport, whether you rode on its back or used it to pull some form of carriage. The word 'car' is a shortening of 'carriage of course, and the first cars were in fact little more than horseless carriages.[3]

The early car designer, to replace the horse, had a choice of a steam, electric or an internal combustion engine to power his vehicle.

Steam was a known quantity to the early car designers, and had been used successfully on the railways for years. But the requirement for road and rail are different. The preparation for a single drive propelled by steam was time consuming.[4] That is no problem for a locomotive where you can build the delay into the timetable, but it is not much good if you just want to pop out for a quick drive.

Electric engines in those days were heavy and only had short range. Those problems were still under research and development even though all the main car manufacturers had pumped enormous amount of time and money into finding some sustainable solution.

The choice finally had to fall on the Internal Combustion Engine.[5]The petrol-burning, internal combustion engine that is used today eventually established its superiority.[6]

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[2] *Report on Clean Fuels,* a Report prepared and submitted by the "Environment pollution (Prevention and Control) Authority [EPCA]" in response to the Supreme Court Order dated *March 26, 2001 & April 27, 2001* [arising out of W.P.(C) No.13029 of 1985; *M.C.Mehta v Union of India and others*].

[3] John Fletcher, *Cars and Trucks: A Piccolo Factbook*, Piper Books Limited (1982), p. 8.

[4] Cars such as the 1904 American 'Stanley Steamer', for example, could travel 45 km per hour but took 30 minutes to build up a head of steam. The 1892 French Scotte Steam Wagonette performed well, but the time it took to 'warm up' was a big disadvantage.

[5] An *Internal Combustion Engine* conducts a process of burning fuel and is an oxidation process that yields heat and light. It involves a mixture of fuel and air, which is thermodynamically unstable. The fuel is then converted to stable products, usually water and carbon dioxide, with the large amount of energy and heat.

[6] The 1885 *German Benz Motorwagon,* a three wheeler whose rear wheels were driven by a toothed belt powered by a single-cylinder, set the pace and others soon followed.

In its simplest form, an automobile is a heat engine, which transforms the chemical energy of a fuel into thermal energy and uses this energy to produce mechanical work. The development of this engine is a product of great research and development extending over a period of atleast a hundred years.

Most of the basic research in engine technology was accomplished in the first half of the twentieth century – the period linked with great research and development. However, in the second half of the twentieth century, the work done in the automobile industry revolved around only beautifying the physical appearance of the product rather than developing the engine technology further. The first attempts to build cars were little more than design exercises. Once the basic principles were established, however, it wasn't long before cars began to look like the sophisticated vehicles we know today.

It was only after air quality in urban areas started to deteriorate rapidly and public pressure along with environmental regulations forced the industry to clean up their act to survive the market, that they realised the importance of modifying the current engine design to reduce pollution.

However, so far in their bid to reduce air pollution, a majority of the automobile companies have not moved beyond the use of some pollution control systems on the same engine design. A lot more needs to be done to achieve even the minimum acceptable levels of air quality. Considering that transportation is the life line of the modern economy, it better happen soon or otherwise the automobile industry will go down in history as a victim of its own success.[7]

In the early days of vehicle manufacturing an important factor that had been overlooked and never bothered by the policy makers and the people advising such policy makers was fuel consumption. From the time the first cars appeared on the road until the 1970s, no one bothered very much about mileage. In some countries,

[7] *Green Rating of Indian Industry: Environmental Rating of Indian Automobile Sector,* Green Rating Project, A civil society initiative by the Centre for Science and Environment (CSE), New Delhi, supported by United Nations Development programme (UNDP) and the Ministry of Environment and Forests (MoEF), Government of India, (2001), p.1

various taxes were charged on petrol made it expensive to buy, so car manufacturers there emphasized the fuel economy of their cars, but no one as such was worried about the oil supply running out.

Then, following the war in the Middle East in 1973 where much of the oil and petrol came from, a shortage of the same occurred. Such shortage was not due to natural causes but by the blockade of the Suez Canal. Throughout Europe and North America there were massive queues at petrol stations as drivers waited to feed their fuel-guzzling machines. And when the taps were turned back on again and petrol was generally available again, its price had risen sharply. The days of plentiful, fairly cheap fuel was over.

The initial reaction of the aforementioned situation (war of the Gulf) in history was panic. For a year of so it seemed that the manufacturers thought the oil would run out for good at any minute. They spent money like waster on research projects to find an alternative to petrol and other fuels. Alcohol and various gases were considered as possible alternatives, and much time and money were spent to see if there was any way that electric cars could be made remotely practical.

The answer in the short term and early years was 'No'. But research continued in the alternative power sources although the pace was less hectic in the middle period when instead of devoting more time on discovering and inventing alternative sources, the focus was to use the available fuel more efficiently.

It was found, as a result of searching ways of establishing fuel efficiency in vehicles that the two great wasters of fuel in a car or a truck are weight and aerodynamic drag. The less weight you have and the more efficiently you cut through the air, the less power you need for a given level of performance. In one vehicle, the emphasis might be put on saving weight, in another bit could be on aerodynamics, depending on its use. For instance, saving weight is more important in a town vehicle where journeys are short, while aero dynamics play a larger part in long distance running vehicles.

This was the initial stages were technology for the efficiency of fuel stepped into the domain of vehicle manufacturers. This was a result of the scare arising out of the Middle East crisis in 1973. But later the problems of air pollution, where the transport sector (especially the automobiles) made substantial contribution; and its impact on public health was apparent in the aftermath of the above crisis. Such technological advancement in achieving fuel efficiency and use of alternative fuels was guided towards achieving ambient air quality and defeating air pollution related diseases.

The Growing Menace of Vehicular Pollution

After international consciousness of environmental degradation and its impact on economic growth dawned on the world community, a flurry of international instruments in the form conventions and declarations came into existence. This exercise of global integration of minds to face and counter the challenges thrown by the late twentieth century consumerism and its 'positive' effect on economic growth gave rise to the practice of a robust development with a sound environment maintained simultaneously. The term coined for such a venture was 'sustainable development'.[8]

Emissions from vehicles are growing more rapidly in Asia than its capacity to mitigate them. Reprieve lies in leapfrogging to cleaner vehicular technologies. A climb-down in local air pollution levels is possible despite economic growth, as has been amply demonstrated in the North. In the US, for instance, while the economy and energy consumption increased manifold in three decades, aggregate emissions could still be reduced significantly. Europe had a similar experience. Asia, in its turn, can avoid the polluting pathways of the North and follow a clean technology roadmap.

The injurious effect of vehicular pollution can be scientifically controlled by adopting improved technologies such as fixing to cheap gadgets in the existing vehicles and the use of safe fuel like

[8] Please *refer* 'Chapter 3 and 4' for more information on the concept of 'Sustainable development'.

CNG, USLD, and lead-free petrol. Automobile manufacturers should also extend their cooperation by imposing and adopting advance technology by which vehicles will be more eco-friendly. [9]

The mass emission standards were notified for the manufacturers of both petrol and diesel driven vehicles for the first time in 1991.[10] Mass emission tests are conducted on a stimulated driving cycle consisting of a pattern of acceleration, cruising, deceleration and idling time and exhaust from each stage is tested for gaseous emission during the operating cycle. Mass emission standards refer to gm/km of pollutants emitted by the vehicle as determined by the chassis dynamometer test using the Indian driving cycle. The composited pollutant is the emitted gases should be within the prescribed limits under the law.

It is submitted that despite that spate of revised exhaust emission rules, the emission regulations are still weak and lag behind as per international standards. India is still adopting those standards which Europe had enforced way back in 1992-93.[11]

Automotive manufacturers from around the world have determined that the need exists to update our 'Worldwide Fuel Charter' to address emerging requirements more stringent vehicle emission control and reduced fuel consumption. These new requirements are now being planned and implemented in the regions of Asia, Europe and North America. Automotive manufacturers have reviewed existing data and concluded that additional reductions in both gasoline and diesel fuel sulphur levels will be essential to enable future vehicle technologies to meet these new requirements.[12]

Unfortunately, the Indian regulators are only obsessed with incremental gains that can barely help reverse the pollution trend. Small gains are easily offset by growing traffic volumes. Indian regulations instead of pushing the automobile industry to catch up

[9] S. A. K. Azad (Dr.), *Automobile Pollution: Environment and the law,* Indian Bar Review, Vol. XXX (2 & 3) 2003, p. 303 (310)].

[10] Schedule IV, *Environment Protection Rules, 1986.*

[11] Gitanjali Nain Gill, *Unheard Screams: Vehicular pollution in Delhi,* Delhi Bar Review, 2001, p. 131 (137-39).

[12] *World-Wide Fuel Charter (Proposed),* A report prepared by "Alliance of Automobile Manufacturers" in consultation with other international auto manufacturers, January 2000,

with their global best standards, even fall short of what the industry is capable of achieving.

As the vehicle technology is slow to improve there is increased concern about the public health impacts of uncontrolled dieselisation of the car fleet. The European regulations that India follows worsens this impact. The current European standards allow diesel vehicles to emit several times more nitrogen oxides (NO_x) than petrol vehicles and are lenient on particulate standards.

Blocking the road map are also the countries refineries that are holding back on enabling fuels needed to speed up the technology roadmap. Without the ultra low sulphur fuel India – like many other Asian Countries – cannot take advantage of the advanced emissions control technologies that can achieve significantly low emissions cart reasonable rates. India – where more than half of the existing refinery capacities have been created in recent years – has not been driven by an aggressive roadmap. The longer India delays in addressing these issues, the longer its citizens will suffer the adverse consequences of the toxic pollution.

Countries round the world are coming under increasing pressure to address the combine goals of clean emissions, fuel economy improvement and greenhouse gas emissions reduction. Without an integrated approach there can be adverse trade-offs as already noticed in the North. Europe, while aggressive about greenhouse gas reduction has not tightened the emissions standards adequately, undermining the public health goals. The U.S. while on the fore front with very stringent fuel neutral emissions standards is unconcerned about the fuel economy and greenhouse gas impacts of its lenient policies on gas guzzling. This foreshadows the future challenge in India and Asia.

The solution is to leapfrog. The key countries, including China have quickened pace and are expected to narrow down the gap with the Northern emissions regulations in the near-term. Global experience demonstrates that it is cheaper to leapfrog and fiscal solutions exist to mitigate the costs of technology transformation.[13]

China and India are the emerging giants of the world economy and international markets. Energy developments in China and India are transforming the global energy system because of the size of the two countries and their growing weight in international fossil-fuel trade. Similarly both countries are increasingly exposed to changes in world economy markets. The staggering pace of Chinese and Indian economic growth in the past few years, outstripping that of all other major countries, has pushed up sharply their energy needs, a growing share of which has to be imported. The momentum of economic development their energy needs has to be met by imports, as demand is outstripping indigenous supply. Increasing fossil-energy consumption has serious implications for the environment, both in terms of local pollution and through rising emissions of greenhouse gases. That these trends will continue is scarcely in doubt. How rapidly the two countries' energy needs develop and how they are met will have far reaching consequences for them and the rest of the world.[14]

The importance of China and India in the world's energy outlook is set to continue to grow steadily over the coming decades. Rapid economic development, industrialisation, urbanisation and improved lifestyles will undoubtedly drive energy demand yet higher, though at a less rapid rate than in the recent past.

If there is a status quo in government policies, described and referred in this study as the 'Reference Scenario', the trend of growth and simultaneously, and of course consequentially, the energy needs of China and India would account for 45 percent of the total increase in the world energy demand in the end of the second decade of this century, the twenty first century. China's

[13] Anumita Roychowdhury, Vivek Chattopadhyaya, Chirag Shah & Priyanka Chandola, *A Technology roadmap* in Ajit Chak & Souparno Banerjee (ed.), *The Leapfrog Factor: Clearing the Air in Asian Cities*, Centre for Science and Environment (CSE), (2006), at p. 129.

[14] Maria Argiri, *Energy trends in China and India*, International Journal of Environmental Consumerism, 2008, p.27.

primary energy needs expand from 537 million tonnes of oil equivalent (Mtoe) in 2005 to 3,819 Mtoe in 2030, an average annual increase of 3.2 percent. India needs to grow even faster, by 3.6 percent per year, from 537 Mtoe to 1,299 Mtoe. Their energy needs grow much faster than in the rest of the world. Today, the two countries together account for 20 percent of the world's primary energy use. By 2030, this share increases to 29 percent. Their share of energy-relisted emissions of carbon dioxide also increases

(Table 6.1)

PRIMARY ENERGY DEMAND IN CHINA & INDIA IN THE REFERENCE SCENARIO[15] [Million tonnes of oil equivalent (Mtoe)]

	1990	2000	2005	2015	2030	2005-2030
CHINA	**874**	**1, 121**	**1, 742**	**2, 851**	**3, 819**	**3.2%**
Coal	534	629	1,094	1,869	2,399	3.2%
Oil	116	230	327	543	808	3.7%
Gas	13	23	423	109	199	6.4%
Nuclear	0	4	14	32	67	6.5%
Hydro	11	19	34	62	86	3.8%
Biomass & waste	200	214	227	225	227	0.0%
Other renewables	0	0	3	12	33	9.9%
INDIA	**320**	**459**	**537**	**770**	**1,299**	**3.6%**
Coal	106	164	208	330	620	4.5%
Oil	63	114	129	188	328	3.8%
Gas	10	21	29	48	93	4.8%
Nuclear	2	4	5	16	33	8.3%
Hydro	6	6	9	13	22	3.9%
Biomass & waste	133	149	158	171	194	0.8%
Other renewables	0	0	1	4	9	11.7%

Year	**1990**	**2000**	**2005**	**2015**	**2030**	**2005-2030**
TOTAL	**1,194**	**1,580**	**2,279**	**3,622**	**5,119**	**3.3%**
Coal	640	794	1,302	2,199	3,018	3.4%
Oil	178	345	456	730	1,136	3.7%
Gas	23	44	71	157	292	5.8%
Nuclear	2	9	18	48	100	7.0%
Hydro	17	26	43	75	109	3.8%
Biomass & waste	334	363	385	396	422	0.4%

[15] *World Energy Outlook 2007: China and India Insights*, p. 118 (International Energy Agency, OECD, Paris, France, 2007).

Other renewables	0	0	4	16	41	10.2%

In both these countries, the pace of growth in energy demands slows progressively over the projection period in line with economic growth. Primary energy intensity – the amount of energy needed to produce a unit of Gross Domestic product (GDP) – continues to fall in India. Intensity is projected to fall more quickly in the Alternative Policy Scenario, which assumes that additional policies aiming to at improving security of supply and reducing CO2 emissions and air pollution are implemented. Per capita demand grows sharply: from 1.3 toe in 2005 to 2.2 toe in 2030 in China, and from 0.5 toe to 0.9 toe in India. Wide disparities among provinces in China and between the urban and rural areas in India remain.

All primary fuels except biomass and waste see continuing growth in demand in both countries over the next two decades. In the absence of a new government policy action, both China and India will remain heavily dependent on coal, mostly produced indigenously, to energise their economies. Compared to China, where the demand would be constant, India's share of coal actually increases. By the end of the projection period, i.e. at the end of the second decade, namely, 2030, coal makes up 59 percent of the two countries' combined energy needs: 63 percent in China and 48 percent in India. In both countries, power generators remain the main consumers of coal, accounting for almost 68 percent of China's incremental coal needs between 2005 and 2030 and 70 percent of India's.

China's and India's combined oil consumption increases from 9.3 million barrels per day (mb/d) in 2005 to 23.1 mb/d in 2030 – growth of 3.7 percent per year. The two countries together account for 42 percent of the global increase in oil demand between 2005 and 2030. Almost two-thirds of the increase in oil use between 2005 and 2030 comes from the transport sector. As a result, the share of transport in total oil demand rises sharply, from 33 percent in 2005 to 52 percent in 2030. Oil continues to play a more important role in meeting energy needs in India than in China. It accounts for 25 percent of India's primary fuel demand in 2030, up from 24 percent in 2005, while in China it rises from 19 percent to 21 percent in the same impending period. The reason is because of the relatively greater importance of energy intensive industry, which depends heavily on coal, in China. Per-capita oil demand nonetheless remains higher in China than in India, largely because incomes are higher.

(Table 6.2)

OIL PRODUCTION IN CHINA AND INDIA IN THE REFERENCE SCENARIO[16]
[Million barrels per day (mb/d)]

	CHINA			INDIA		
	2006	**2015**	**2030**	**2006**	**2015**	**2030**
Crude oil	3.67	3.84	2.70	0.69	0.62	0.39
Natural gas liquids	-	-	-	0.11	0.11	0.12
Coal-to-liquids	-	0.18	0.75	-	-	-
Total	**3.67**	**4.02**	**3.45**	**0.79**	**0.73**	**0.52**

Natural gas use grows rapidly from current low levels in both countries, boosting its share in the overall primary energy mix. The governments of China and India are keen to see gas play a bigger role, in order to reduce reliance on dirtier coal. But gas remains a marginal fuel – largely consumed in power generation and industry – as it struggles to compete with oil, which is more competitively priced. Its share of primary energy demand rises from 2 percent in 2005 to 5 percent in 2030 in china, and from 5 percent to 7 percent in India. The shares of other energy sources such as nuclear, hydropower, etc are also on the rise while that of biomass drops. Biomass consumption increases by almost a quarter in India, though its share in the residential energy mix falls with rising use of modern fuels.

The power sector alone accounts for 53 percent of the increase in primary energy demand in China over the relevant

[16] *Ibid* at p. 125.

period[17] and for just over half (around 28-30 percent) in India. Its share of primary demand reaches 46 percent in 2030 in China and 45 percent in India. The growth in power-sector energy demand would be even faster were it not for the expected improvement in the thermal efficiency of power stations. In both countries, power stations remain the main source of air pollution and of energy-related carbon-dioxide emissions since coal continues to be the dominate fuel input for generation which is expected to fall in the projected period, i.e. by 2030.

(Table 6.3)

SECTORAL SHARES IN FINAL ENERGY CONSUMPTION IN CHINA AND INDIA IN REFERENCE SCENARIO[18] (%)

	2005	2015	2030	2005	2015	2030
Industry	42	46	44	28	32	34
Transport	11	13	19	10	14	20
Residential	30	22	19	44	37	29
Services	04	05	06	03	03	04
Other	13	14	12	14	14	13

Among final sector, transport sees the fastest growth in energy demand, though the industry is the single biggest contributor to the growth in the final energy demand over the projection period and remains the single largest consumer in both countries.

Road transport – freight and passenger cars – accounts for the bulk of the increase in transport fuel use. As people get richer, their demand for mobility takes off, especially once average per-capita GDP (in purchasing power parity terms) reaches a level between 3,000 and 10,000 US dollars, the point at which a large portion of the population can afford to own a motor vehicle. Vehicle sales are already booming in China and India, and the total number of light-duty vehicles on the roads is projected to soar from about 22 million in 2005 to more than 200 million in 2030 in China and from 11 million to 115 million in India. The two countries, China followed by

[17] Between the years 2005 and 2030.

[18] *Supra* note 15, (*World Energy Outlook 2007: China and India insights*), at p. 123

India, have the biggest markets for new cars worldwide well before 2030. The share of road transport in total primary oil demand rises from 24 percent in 2005 to 40 percent in 2030 in China and from 23 percent to 41 percent in India.

Neither China nor India currently produces enough crude oil of natural gas to meet its needs. These shortfalls grow substantially as the economic growth starts to heat up. Most of China's fields already in production have reached or passed their peak and discovered fields awaiting development do not have large enough reserves to make good the decline. The projected fall in China's crude oil production id offset to a large degree by increased from coal-to-liquids (CTL) plants, such that overall oil output falls by just 0.2 mb/d between 2006 and 2030. Nonetheless, the rapid increase in oil demand means that imports rise sharply, from 3.5 mb/d in 2006 to 7.1 mb/d in 2015 and 13.1 mb/d in 2030.[19] Most of this oil is in the form of crude oil, as China's refining capacity is expected to grow in line with the inland demand for oil products.

India is also facing the prospects of increasing dependence on oil imports. Despite some major discoveries since late 1990s, India is a mature oil producing country. Most major oilfields in production today were discovered in the 1970s and 1980s and have passed their production peak. In the coming years as a result of a steady economic growth in a status quo situation,[20] India's oil production is projected to increase from just under 790 thousand barrels per day (kb/d) in 2006 to 870 kb/d in 2010 and then to fall back to 730 kb/d in 2015 and 520 kb/d in 2030. Higher natural gas liquids (NGL) production tempers the decline in oil output through to 2020, when it too starts to fall. There are no plans to develop CTL production, as it is commercially not viable. As in China, demand for oil outpaces output over the projection period (2006-2030). Net oil imports increase steadily from 1.9 mb/d in 2006 to 2.3 mb/d in 2010, 3 mb/d in 2015 and 6.0 mb/d in

[19] World Energy Outlook 2007: China and India Insights, p. 118 (International Energy Agency, OECD, Paris, France, 2007).

[20] An assumed situation where the policies of the Government remain the same.

2030. Gross oil imports – crude oil and other types of refinery feedstock – are projected to be even higher in order to supply India's export-oriented refineries as well as its domestic needs, reaching 7.6 mb/d in 2030. Net products exports reach close to 1.6 mb/d by 2015 and then stabilise. India's overall dependence on imports net of exports rises from 70 percent today to 92 percent by ther end of the projection period (2030).

For both India and China, the story is similar for natural gas. China's gas production is projected to rise from 57 billion cubic metres (bcm) in 2006 to 103 bcm in 2015 and 118 bcm in 2020, falling back to 111bcm by 2030. In India, demand also outstrips gas production, which rises from 29 bcm in 2006 to 51 bcm in 2030. Most of the increase comes from the recently discovered fields in the Krishna-Godavari basin. Gas imports – entirely as LNG – jump by about 30 percent between 2006 and 2010, reaching about 12 bcm. Imports remain stable up to 2010 or so and quadrupling between 2020 and 2030, reaching 61 bcm at the end of the projection period. However, the prospects for imports are highly uncertain, as they depend critically on the balance of production and demand, which in turn is very sensitive to the relative prices of coal and gas, and the affordability and availability of imported gas.

The Indian government plans to expand significantly the role of nuclear power and modern renewable energy technologies to buttress its energy demand for the future. The signing of the 123 Agreement, a civilian nuclear deal with the USA in July 2009[21] which benefits India of importing nuclear technology (which gives the facility to use reprocessed nuclear fuel) for peaceful use, a term used for using nuclear material for producing power. India already has a similar deal in place with Russia and France, Australia and Canada are

[21] The signing of the now popularly known 123 Agreement - Nuclear Deal - almost led to the downfall of the Congress headed United Progressive Alliance (UPA) government with Prime Minister Dr. Manmohan Singh at the helm after the Left Parties withdrew support for signing a deal with what they call the imperialist United States of America.

already in the loop for exporting reprocessed fuel and the works.

In India, nuclear power capacity is projected to surge from 3 GW in 2005 to 17 GW by 2030, with the share of nuclear power in electricity generation rising from 2.5 percent in 2005 to 4.6 in 2030.

Energy from renewable sources in total expands slowly, with traditional biomass continuing to dominate consumption. Hydropower output more than doubles, yet its share of power generation falls from 14 percent in 2005 to 9 percent in 2030. Among power-generation technologies wind power sees the fastest growth, with capacity raising from just over 6 GW in 2006 – the fourth largest in the world – to 27 GW by 2030, so that its share of total electricity generation raises from just under 1 percent to 2.5 percent.

Biomass use for bio fuels, which has only started recently in India, is expected to grow to almost 2 Mtoe in 2030, though this represents little more than 1 percent of road-transport fuel demand.

The projected energy supply in India and China in the reference scenario where the policies of the governments are unchanged calls for a cumulative infrastructure investment of 5 trillion[22] US dollars (according to 2006 dollar valuation) or 200 billion US dollars per year, over the period 2006-2030. India's overall investment would be a little more than one third of China's. India accounts for 6 percent of projected world energy investment and China 17 percent.

The oil sector requires $169 billion of investment in India equal to 14 percent of total energy-investment needs and China $547 billion (15percent). In China, the upstream accounts for 48 percent of total oil investment. Of downstream investment, India's share is higher at 77 percent because of more rapid expansion of refining capacity relative to demand (to supply export markets). The gas-supply projections call for

[22] A trillion is 1,000,000,000,000 (One thousand billion or one million millions)

cumulative investment of $ 168 billion in china and $ 63 billion in India. Around 55 percent of this investment is needed upstream in both countries. The rest goes to Liquified natural gas (LNG) terminals, transmission and distribution networks and storage facilities.

In The High Growth Scenario which assumes higher rates of Gross Domestic product (GDP) growth – 1.5 percentage points than in the above mentioned reference Scenario – in both China and India. These higher rates, unsurprisingly, result in faster growth in energy demand in both countries. As these countries account for a significant rising share of global energy demand - and higher demand in the rest of the world as a whole – drives up international prices, which tempers the overall growth in consumption. In India, total primary energy demand in 2030 will be 16 percent higher than in the Reference scenario and China 23 percent. Together India and China account for 54 percent of the increase in the world primary energy demand between 2005 and Reference Scenario.

Although India's oil imports are 27 percent higher in 2030, import dependence is roughly stable at 92 percent due to rise in domestic production. For the same reason, China's dependence increases by only one percentage point at 80 percent even though imports are 31 percent higher than in the 'Reference Scenario'.

Oil and coal account for most of the increase in both countries' primary energy demand. Oil demand reaches 8.3 mb/d in 2030 in India – 1.8 mb/d or 27 percent higher than in the Reference Scenario. In China it is 4.9 mb/d or 30 percent higher at 21.4 mb/d. In India, about three-fourths of this increase comes from the transport sector and two-thirds in China.

In the 'Alternative Policy Scenario'[23] India and China can move to a more economically and environmentally sustainable

[23] An *Alternative Policy Scenario,* which assumes that additional policies aiming at improving security of supply and reducing CO2 emissions and air pollution are implemented.

development path by enforcing existing government policies more strictly and introducing new policies that they are under discussion with an aim to implement the same. These action result in a significant reduction in energy demand and switching to less polluting, low and zero carbon fuels and technologies. Importantly, these outcomes produce a net financial benefit for energy consumers and lower costs to the economy as whole – even without putting a monetary value on the energy-security and environmental benefits.

(Table 6.4)

PRIMARY ENERGY DEMAND IN CHINA & INDIA IN THE ALTERNATIVE POLICY SCENARIO[24] (Mtoe)

	2005	2015	2030	2005	Mtoe[25]	%
CHINA	**1,742**	**2,743**	**3,256**	**2.5%**	**-563**	**-14.7**
Coal	1,094	1,743	1,842	2.1%	-556	-23.2
Oil	327	518	653	2.8%	-155	-19.2
Gas	42	126	225	6.9%	25	12.6
Nuclear	14	44	120	9.0%	53	79.4
Hydro	34	75	109	4.8%	23	26.4
Biomass & waste	227	223	255	0.5%	28	12.4
Other renewables	3	14	52	11.9%	19	57.4
INDIA	**537**	**719**	**1,082**	**2.8%**	**-217**	**-16.7**
Coal	208	289	411	2.8%	-209	-33.7
Oil	129	173	272	3.0%	-56	-17.1
Gas	29	47	89	4.6%	-4	-4.3
Nuclear	5	19	47	9.9%	14	41.9
Hydro	9	17	32	5.3%	9	42.3
Biomass & waste	158	168	211	1.2%	17	8.5
Other renewables	1	6	21	15.8%	12	145.5
TOTAL	**2,279**	**3,462**	**4,339**	**2.6%**	**-780**	**-15.2**
Coal	1,302	2,032	2,253	2.2%	-765	-25.3
Oil	456	692	925	2.9%	-211	-18.6
Gas	71	173	313	6.1%	21	7.3
Nuclear	18	62	167	9.2%	67	66.9
Hydro	43	92	141	4.9%	32	29.6
Biomass & waste	385	392	466	0.8%	45	10.6
Other renewables	4	20	73	12.7%	31	75.5

[24] *Supra* note 19, *World Energy Outlook 2007*, at p. 132.
[25] Difference from the Reference scenario in 2030 (Refer Table 1)).

Primary energy demand grows markedly less quickly in this scenario, by 2.8 percent per year on average in India (0.8 percentage points less than in the reference scenario) and 2.5 percent in China (0.7 points less). Demand for oil is 1.1 mb/d or 17 percent lower in India and 3.2 mb/d or 19 percent lower in China in 2030. Most of the oil savings in – 69 percent in India and 68 percent in China – come from the transport sector, with the introduction of more fuel-efficient vehicles and the expanded use of alternative fuels, notably bio fuels. Consumption of natural gas is slightly reduced in India. Transport demand is reduced most in percentage terms, with new policies to promote public transport and the faster introduction of fuel-efficient vehicles.

Most of the measures analysed in the 'Alternative Policy Scenario' have very short payback periods. The higher initial cost to energy end users of improved motor in industry and more efficient appliances and cars is paid back more quickly in China than in India where payback periods for more efficient appliances are significantly longer for households because of subsidised electricity prices. Introducing economically efficient electricity pricing would result in much shorter paybacks and much faster gains in efficiency improvements.

Indigenous output of conventional oil and gas is no different in the 'Alternative Policy Scenario', as oil and gas prices are assumed to be unchanged. Output of bio fuels, however, increases as a result of government policies to boost their role in transport demand.

In all the three scenarios, most of the global increase in energy related CO2 emissions comes from India, China and other developing countries, though local pollution will remain the primary environmental concern for these countries. India and China together account for 56 percent of the increase in emissions between 2005 and 2030 in the 'Reference Scenario', 69 percent in the 'Alternative Policy Scenario' and 65 percent in the 'Higher Growth Scenario'.

(Table 6.5)

ENERGY-RELATED CO2 EMISSIONS BY REGION AND SCENARIO (Billion tonnes)[26]

	Reference*			Alternative#		High Growth@	
	2005	**2015**	**2030**	**2015**	**2030**	**2015**	**2030**
OECD	**12.8**	**14.1**	**15.1**	**13.2**	**12.5**	**13.9**	**14.6**
North America	6.7	7.5	8.3	7.2	7.1	7.5	8.1
United States (US)	5.8	6.4	6.9	6.2	6.0	6.3	6.7
Europe	4.0	4.2	4.5	3.8	3.5	4.3	4.4
Pacific	2.1	2.3	2.3	2.2	1.9	2.2	2.1
TRANSITION ECONOMIES	**2.5**	**3.0**	**3.2**	**2.9**	**2.8**	**3.0**	**3.2**
Russia	1.5	1.8	2.0	1.7	1.7	1.8	2.0
DEVELOPING COUNTRIES	**10.7**	**16.4**	**22.9**	**15.2**	**17.9**	**17.4**	**26.3**
China	5.1	8.6	11.4	8.1	8.9	9.5	14.1
India	1.1	1.8	3.3	1.6	2.4	1.9	3.9
Other Asia	1.4	2.0	2.7	1.8	2.1	2.0	2.6
Middle East	1.2	1.8	2.5	1.7	2.0	1.8	2.7
Africa	0.8	1.0	1.4	0.9	1.1	1.0	1.3
Latin America	0.9	1.2	1.6	1.1	1.3	1.2	1.6
WORLD	**26.6**	**34.1**	**41.9**	**31.9**	**33.9**	**34.9**	**44.8**
European Union	3.9	4.0	4.2	3.6	3.2	4.1	4.2

*Reference Scenario.
#Alternative Policy Scenario.
@High growth Scenario.

(Table 6.6)

TOP FIVE COUNTRIES FOR ENERGY-RELATED CO2 EMISSIONS IN THE REFERENCE SCENARIO[27]

	2005		**2015**		**2030**	
	Gt	**Rank**	**Gt**	**Rank**	**Gt**	**Rank**
US	5.8	1	6.4	2	6.9	2
China	5.1	2	8.6	1	11.4	1
Russia	1.5	3	1.8	4	2.0	4
Japan	1.2	4	1.3	5	1.2	5
India	1.1	5	1.8	3	3.3	3

[26]Supra Note 24 at p. 199.
[27] *Ibid* at p. 200.

Despite the strong increase in emissions in both India and China over the past few years, their historical share in cumulative emissions, measured over a period 1990 to 2005, amounted to only 2 percent for India and 8 percent for China. By comparison, the United States and the European Union (EU) countries combined for more just over half of all cumulative emissions. This pattern changes radically over the outlook period.

In the 'Reference Scenario' China's share of cumulative emissions from 1990 to 2030 rises to 16 percent, approaching that of United States at 23 percent and the European Union at 18 percent. In the same period India's cumulative emissions approach that of Japan hovering around 1 to 2 percent, in the 'Reference Scenario' In the 'High Growth Scenario' India's cumulative emissions exceeds that of Japan in 2030 and China's are the same as those of the European Union. India's per-capita emission are projected to remain far lower than those of both the OECD countries and the transition economies (Russia being one of the prime example) in 2030, even though they grow faster than in almost any other region. Whereas China's per-capita emissions are projected to approach those of OECD Europe in the end of projection period (2030) in the 'Reference Scenario', but less than half of those of the United States in the same period. Per-capita emissions are markedly lower in all regions in the 'Alternative policy Scenario' than in the 'Reference Scenario'. In the 'High Growth Scenario', both India's and China's per-capita emissions are about one-fifth higher than in the 'Reference Scenario', while they are broadly the same in the rest of the world.

Table 6.7)

PER-CAPITA ENERGY-RELATED CO2 EMISSIONS BY REGION AND SCENARIO[28]

(Tonnes)

	Base	Reference		Alternative		High Growth	
	2005	**2015**	**2030**	**2015**	**2030**	**2015**	**2030**

[28] *Ibid* at p. 202.

OECD	**11.0**	**11.4**	**11.6**	**10.7**	**9.7**	**11.3**	**11.3**
North America	15.5	15.8	15.6	15.2	13.5	15.6	15.2
United States	19.5	19.6	19.0	18.9	16.5	19.4	18.5
Europe	7.5	7.6	7.9	6.8	6.1	7.7	7.8
Pacific	10.3	11.4	11.8	10.9	9.8	10.8	10.7
TRANSITION ECONOMIES	**7.5**	**8.9**	**10.1**	**8.5**	**8.7**	**8.9**	**9.9**
Russia	10.7	13.3	16.0	12.6	14.1	13.3	16.0
DEVELOPING COUNTRIES	**2.2**	**2.9**	**3.5**	**2.7**	**2.7**	**3.1**	**4.0**
China	3.9	6.2	7.9	5.8	6.1	6.8	9.7
India	1.0	1.4	2.3	1.3	1.7	1.5	2.7
Other Asia	1.5	1.8	2.0	1.6	1.6	1.7	1.9
Middle east	6.7	8.0	8.7	7.3	7.2	8.1	9.6
Africa	0.9	0.9	0.9	0.9	0.8	0.9	0.9
Latin America	2.1	2.3	2.8	2.2	2.3	2.3	2.8
WORLD	**4.1**	**4.7**	**5.1**	**4.4**	**4.1**	**4.8**	**5.5**
European Union	*8.0*	*8.0*	*8.4*	*7.2*	*6.5*	*8.2*	*8.3*

In 2006 there were in India around 17 million four wheel motor vehicles, cars, buses and trucks. The fuel consumption of these vehicles was around 30 mt. The number of vehicles is growing rapidly and by 2020 if the acceleration continues we may have around 70 million vehicles. Consuming at the same rate and efficiency, the fuel consumption would be more than 125 mt in 2020. A 20 per cent increase in efficiency will save 25 mt of petrol and diesel and reduce emissions of CO2 by 75 mt.

In 2008 a little more than 100000 buses served some 1150 million people in India providing public transport. Some 500 billion passenger kilo metres (pkm) were provided by these buses, which consumed some 1.85 mt of diesel. With a projected population of about 1400 million in 2020 and the same bus/person ratio we can expect 125000 buses consuming 2.25 mt of diesel and serving 600 billion pkm. Doubling the availability of buses per person we can attract more people to travel by bus rather than private vehicles. If we can double the travel by bus to 1200 billion pkm, and if we assume that travel by private vehicle would consume 0.025 litres per pkm, the net saving of petroleum products (petrol saved - additional diesel consumed by buses) would be 19 mt per year and reduction in emission of CO2 of some 55 mt per year.

Transport used 2 231 Mtoe of energy worldwide in 2006 □□ 95% from carbon□intensive fossil fuels. These fuels are uniquely suited to the needs of the sector but they are the principal source of transport's GHG emissions. Furthermore, they are available in finite quantities and though sufficient resources remain to cover projected growth in demand, they will come from increasingly expensive sources – some of which may be more carbon□intensive than current fossil fuels. Reducing emissions in the transport sector will eventually require decarbonising transport energy. In the meantime, transport will remain vulnerable to short□term price spikes of fuels.

Increasing the efficiency of fossil fuel use and early decarbonisation has the potential to alleviate the impacts of these disruptions on households and industry. At the same time, rising fossil fuel prices make investments in efficiency and alternative energy sources more attractive. There is scope for government action to facilitate early decarbonisation.

Most of Europe and North America are past that peak and are now sliding back to more tolerable levels of pollution. Countries in Asia, like India and China, are still scaling the peak. The challenge to avoid the peak and tunnel through the curve (Kuznet's curve)[29]to keep its pollution level low even as it grows economically lies in following the cleanest possible technological path that is both precautionary and preventive.

The industrial countries have come full circle. They have followed the toxic model of economic growth, introduced a huge amount of toxins in the atmosphere and introduced stern pollution abatement measures for environmental recovery. A comparison of growth measures like GDP and vehicle miles

[29]The famous environmental *Kuznets's curve* shows the relationship between pollution and per capita gross domestic product (GDP). This concept was originally developed by economists to demonstrate how pollution load increase over time with increasing per capita GDP, reaches a peak and starts to decline.

travelled by the US environmental Protection Agency (EPA), the federal government agency in the US, for a period between 1970 and 2001, reveals that the GDP has increased by 161 percent, and the 'vehicle-miles travelled' increased by 149 percent. But despite the steep levels of economic and vehicular growth, the US has been able to reduce the aggregate emission of criteria pollutants by 25 percent. The improvement in emissions of criteria pollutants in the US has taken place despite an increase in the population from 203 million to more than 280 million (a 39 percent rise) and a 42 percent increase in energy consumption.[30]

Europe witnessed the same trend. Between 1980 and 2000, the GFDP increased by 57 percent, the passenger-kilometre by 62 percent and the population went up by five percent. Conversely, key urban air pollutants like sulphur dioxide (SO2) reduced by 60 percent, particulate matter (PM) precursors by 37.9 percent, ozone (O3) precursors by 28 percent and nitrogen oxides (NO2) by 14 to 25 percent.[31] The enormous health and environment benefits from this improvement far outweigh the added cost of clean-up.

Regulatory pressures are cleaning up cars, buses and trucks in Europe and the US. The future challenges would even be more severe for these countries as they gear up to address multiple problems of urban toxins, greenhouse gas (GHG) emissions and fuel economy. Even after stringent efforts, the West might still not be able to meet the clean air target as burgeoning vehicle numbers threaten to overwhelm these efforts. Eventually, the transition curve will have to cross over to achieve zero emissions levels.

Asia can beat pollution from the rapidly growing vehicular fleet if new vehicles emit as little as possible, and therefore technology improves as fast as possible. The longer Asia

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[30] Anon, *Draft report on the Environment*, US Environment protection Agency (2003), Washington DC,p.1.

[31] Steinar Larssen, *Comprehensive Approaches to Air Quality Management in Asia, Europe, Japan and Australia,* paper presented at the conference, "Better Air Quality 2003", Manila, the Philippines, December 17-18 (2003), p.13.

delays a decision to leapfrog to clean technology, the longer it is going to suffer the adverse impacts of pollution.

The challenge is, therefore, to define economic and environmental policies that will make early introduction of clean technology possible for long-term gains. In this effort, each of the predominant vehicle technologies, diesel and petrol, and their alternatives present unique challenges and prospects. The 'Alternative Policy Scenario'[32] discussed an analysed above should be the ideal situation of economic growth and the governments of various countries are treading the path of "sustainable development", a development concept which can be aptly applied in the case of sustainable use of automobile.

It is an open fact that vehicles are a necessary evil in the context of development and economic growth. They cannot be absolutely banned from use but should be used in such a manner that the development process and economic growth is not hampered. That is where sustainable use of automobile comes in. The two important and determining factors which automobiles depend on for its existence and where the principles of sustainable development can be included in controlling and curbing the menace of vehicular pollution are fuel and technology.

Vehicular Emission Control: Historical Background

Vehicular Emission Control[33] is the study and practice of reducing the polluting emissions produced by vehicles powered by internal combustion engines.

Throughout the 1950s and 1960s, various federal, state and local governments in the United States conducted studies into the numerous sources of air pollution. These studies ultimately attributed a significant portion of air pollution to the automobile, and concluded air pollution is not bounded by local political boundaries. At that time, such minimal emission

[32] *Supra* note 23.
[33] *http://en.wikipedia.org/wiki/Vehicle_emissions_control* accessed and viewed on July 10, 2010.

control regulations as existed in the U.S. were promulgated at the municipal or, occasionally, the state level. The ineffective local regulations were gradually supplanted by more comprehensive state and federal regulations. By 1967 the state of California created the California Air Resources Board and in 1970, the U.S. Environmental Protection Agency was formed. Both agencies now create and enforce emission regulations for automobiles, as well as for many other sources. Similar agencies and regulations were contemporaneously developed and implemented in Western Europe, Australia, and Japan.[34]

The first effort at controlling pollution from automobiles was the PCV (positive crankcase ventilation) system. This draws crankcase fumes heavy in unburned hydrocarbons — a precursor to photochemical smog — into the engine's intake tract so they are burned rather than released unburned from the crankcase into the atmosphere. Positive crankcase ventilation was first installed on a widespread basis by law on all new 1961-model cars first sold in California. The following year, New York required it. By 1964, most new cars sold in the U.S. were so equipped, and PCV quickly became standard equipment on all vehicles worldwide. [35]

The first legislated exhaust (tailpipe) emission standards were promulgated by the State of California for 1966 model year for cars sold in that state, followed by the United States as a whole in model year 1968. The standards were progressively tightened year by year, as mandated by the U.S.EPA.[36]

By the 1974 model year, the emission standards had tightened such that the de-tuning techniques used to meet them were seriously reducing engine efficiency and thus increasing fuel usage. The new emission standards for 1975 model year, as well as the increase in fuel usage, forced the invention of the catalytic converter for after-treatment of the

[34] *Ibid.*
[35] *Ibid.*
[36] *Ibid*

exhaust gas. This was not possible with existing leaded gasoline, because the lead residue contaminated the platinum catalyst. In 1972, General Motors proposed to the American Petroleum Institute the elimination of leaded fuels for 1975 and later model year cars. The production and distribution of unleaded fuel was a major challenge, but it was completed successfully in time for the 1975 model year cars. All modern cars are now equipped with catalytic converters and unleaded fuel can now be found almost everywhere.[37]

The first ever step to control emissions was taken in California in 1964, by specifying minimum emission system control systems on cars on 1966 model cars. In 1970, the US Congress adopted the first major Clean Air Act and established the US Environmental Protection Agency (EPA).[38]

In the same year, emission control norms were being set up in Europe and Japan. The subsequent two decades norms became more comprehensive, the implementation procedure got fine -tuned and the structural framework created.[39]

The current decade has seen these norms being tightened, and also the adoption of a long-term agenda. Europe introduced the Euro series of norms.

Motor vehicles produce many different pollutants. The principal pollutants of concern—those that have been demonstrated to have significant effects on human, animal, plant, and environmental health and welfare—include:[40]

- *Hydrocarbons (HCs):*[41] this class is made up of unburned or partially burned fuel, and is a major contributor to urban smog, as well as being toxic. They can cause liver damage and even cancer. The regulations regarding hydrocarbons vary according to the engine regulated, as well as the jurisdiction. In some cases, "non-methane hydrocarbons" are

[37] *Ibid*
[38] *Ibid*
[39] *Ibid.*
[40] *http://en.wikipedia.org/wiki/Vehicle_emissions_control* visited and accessed on 11th July 2010
[41] *Ibid.*

regulated, while in other cases, "total hydrocarbons" are regulated. Technology for one application (to meet a non-methane hydrocarbon standard) may not be suitable for use in an application that has to meet a total hydrocarbon standard. Methane is not toxic, but is more difficult to break down in a catalytic converter, so in effect a "non-methane hydrocarbon" standard can be considered to be looser. Since methane is a greenhouse gas, interest is rising in how to eliminate emissions of it.

- *Carbon monoxide (CO):*[42] a product of incomplete combustion, carbon monoxide reduces the blood's ability to carry oxygen; overexposure may be fatal.
- *Nitrogen oxides (NO_x):*[43] These are generated when nitrogen in the air reacts with oxygen at the high temperature and pressure inside the engine. NO_x is a precursor to smog and acid rain. NO_x is a mixture of NO and NO_2. NO_2 destroys resistance to respiratory infection. For dogs most of the nitrogen dioxide is removed in the nasal cavity. Jumbo vehicles and delivery trucks blow hot exhaust, containing life dangerous quantities of NO_2 into the atmosphere.
- *Particulates* (PM)*:*[44] soot or smoke made up of particles in the micrometre size range: Particulate matter causes respiratory health effects in humans and animals.
- *Sulphur oxides (SO_x):* A general term for oxides of sulphur, which are emitted from motor vehicles burning fuel containing a high concentration of sulphur.[45]

[42] *Ibid.*
[43] *Ibid.*
[44] *Ibid.*
[45] *Ibid.*

The Scenario in the United States of America

The importance of the car as air polluter has been recognised in federal and State legislation for more than forty-five years. In 1955 the Congress undertook the initial action in this area by authorising the Department of health, Education and Welfare to conduct a research on the subject of air pollution control.[46] Five years later Congress enacted the first federal legislation focussing solely upon automobile exhaust emissions – The Motor Vehicle Exhaust Study act. The first effort to continue research activities and to regulate auto emissions on the federal level began with the Motor Vehicle Air Pollution Control Act, 1965.[47]

In 1964, the Senate Public Works Committee Special Sub-Committee on Air and Water Pollution released a report entitled "Steps Towards Cleaner Act". It recommended legislation to deal with automobile exhaust, including minimum standards for limiting exhaust emissions, similar limits for diesel exhaust, grants for solid-waste disposal, and establishment of a technical committee to investigate ways to reduce sulphur oxide. The full committee estimated that approximately 82.5 million automobiles, trucks and buses in the United States emitted more than 14 million tonnes of hydrocarbons, 4 million tonnes of nitrogen oxides and 75 million tonnes of carbon dioxide per year.. Concluding that automobile emissions "constitute a major proportion of the community air pollution problem in large cities" and that the technological skills and equipment needed to reduce pollution had passed the research stage, the committee found no reason to delay more serious control measures.

The United States Congress passed the Vehicle Air Pollution and Control Act in 1965[48] in an effort to control automobile emissions. It was passed during the presidency of Lyndon Johnson, the thirty-sixth president of the US. The chief

[46] See *Pub. L. No.84-159, 69 Stat. 322 (1955).*
[47] See *Pub. L. No.89-272, 79 Stat. 992 (1965).*
[48] The Act, principally an effort to control air pollution caused by automobile exhaust, also authorized a national research programme to dispose of solid waste.

proponent of the bill was Ralph Nader, a consumer activist who attacked prevailing standards of automobile safety and vehicle pollution. The new law authorised the Secretary of health, education and welfare to establish standards that limited the amount of carbon monoxide, hydrocarbons, or other air pollutants emitted from gasoline or diesel fuels in automobiles, trucks and buses. Specifically, that section of the law only affected new motor vehicles or engines and prohibited the domestic sale, manufacture for domestic sale, or importation of any vehicle not in conformity with the standardised limits.[49] Fines of upto $1,000 per automobile or per engine could be levied upon manufacturers who did not comply. Manufacturers had to submit sample vehicles to the HEW Secretary, who oversaw the tests for compliance. Other sections of the legislation made provisions for actions against US companies by foreign nations for air pollution.

The Vehicle Air Pollution and Control Act was one in the series of pollution-control Acts that included the Clean Air Act, 1965 and the Clean Air Amendment Act, 1977.[50] The act complemented a series of regulations ranging from safety standards to fuel-efficiency standards that changed the face of the American Automobile Industry. The effort to clean up air affected by automobile emissions involved an after-the-fact strategy that relied on the establishment of government standards and a mandate to force industry to meet those standards.[51]

Petroleum–related automobile engine exhausts, identified as potential atmospheric problem as early as 1915, did not emerge as a serious problem until 1945. Frequently attempts were made to reduce emissions focussed not on making combustion inside the engines more efficient – which had actually been accomplished by racers and was epitomised in the often maligned "muscle cars" – but rather on cleaning up

[49] Frank N.Magill (ed.), *Chronology of Twentieth-Century History: ECOLOGY AND THE ENVIRONMENT, Vol-I,* Fitzron Debroy Publishers, 1997, p. 575.
[50] *See* Chapter 2.
[51] Frank N.Magill (ed.), *Chronology of Twentieth-Century History: ECOLOGY AND THE ENVIRONMENT, Vol-I,* Fitzron Debroy Publishers, 1997, p. 576.

the exhaust after it left the combustion chamber. In 1970, for example, the Detroit automobile makers had achieved considerable success with "hemi" engine designs actually associated with race cars; however regulators, however, focussed their efforts on the installation of catalytic convertors in engines to recycle exhaust.

The relationship between automobile exhausts and air pollution generated broader attacks on the on the automobile itself as an enemy of the environment. Virtually all the critics[52] agreed automobile emissions were increasing and that the vehicles themselves were dangerous.

In fact, though, air-quality trends in major US cities had dramatically improved since the boom of the automobile ownership. Carbon monoxide levels in the United States in 1975 were only 94 million tonnes, an amount well below the 1950 level and closer to that of 1940. Suspended particulate levels in five major US cities dropped or remained constant between 1967 and 1974.

Most of the trends indicated that the most dramatic improvements in air quality occurred in the 1970s, extremely late to be correlated with the Clean Air Act. Overall, air quality has remained relatively constant in the United States since 1958, a situation that mirrors trends in major European cities.

However, it was Subchapter II of the Clean Air Act of 1970 that set in motion the federal scheme of automobile emissions regulation that exists today. The Congressional Approach to pollution from newly constructed automobiles has been described as one of the "technology-forcing" applying to newly-manufactured vehicles. Under this theory, the statute established (1) stringent performance standard of 90 percent emissions reduction from existing levels and (2) a five or six

[52]Activist Ralph Nader attacked the integrity of safety components of automobiles in his "*Unsafe at Any Speed" (1965);* Urban specialist Lewis Mumford characterized automobiles as "*The American Way of Death*"; Kenneth Scneider more bluntly stated his position in his 1971 book *Autokind Versus Mankind;* Anti-automobile activists speculated about industry-sponsored plots to destroy fuel-efficient vehicles or engines.

year deadline for the automobile manufacturing companies to achieve this standard in practice.[53]

At the same time, natural factors affected the environment much more significantly, for example, lead concentrations at uninhabited Camp century, Greenland, soared between 1900 and 1950. Similarly the state of Washington continued to experience side effects from 1980 Mount Saint Helens eruption years after the event. Such occurrences demonstrated that any improvements government could mandate for air quality paled in comparison to natural effects and, indeed, could be reversed in a few minutes by a natural disaster.[54]

Certainly there were successes directly attributable to the Clean Air Act. From 1967 to 1976, hydrocarbon emissions in San Francisco area was reduced 25 percent. Carbon monoxide levels in New York dropped more quickly than projected. Moreover, a major effect of the legislation was to expand the role of the federal government in supervising and mandating air-quality improvement. Amendments to the Clean Air Act of 1977, for example, required the federal government to provide information to States to control motor-vehicle emissions and the imposition of catalytic converters in 1974 shifted the nation away from the use of leaded gasoline.[55]

In 1967, the federal government assumed responsibility for establishing clean-air standards with the Air Quality Act but allowed individual states to have more stringent requirements. The 1967 law sets emissions limits in grams per million of hydrocarbons, which discriminated against smaller automobiles that had less room with which to work. A four-cylinder engine might produce less overall pollutant than an eight-cylinder engine but would emit more grams of hydrocarbons per million. Moreover, pollution-control devices

[53] Thomas J. Schoenbaum & Ronald H. Rosenberg, *Environmental policy Law: Problems, Cases and Readings (2nd edn.),* [*Chapter4- A Brief History of Federal Automobile Emission Control.*], The Foundation Press, Inc. (1991), p. 695.

[54] *Ibid*

[55] *Ibid*

added weight to vehicles, requiring slightly larger engines to achieve the same horsepower.[56]

Critics complained that the government regulations had other negative side effects. Some critics argues that the government should have developed an incentive programme approach to pollution control, allowing companies to exceed pollution levels at a price and rewarding companies that achieved lower emission levels with tax and other incentives. According to such critics, it was as a result of ill-designed government regulation that the catalytic converter became the standard pollution-control device, even though many engineers concluded that it was one of the least effective means of controlling engine emissions. The adoption of the catalytic converter also illustrates how government mandate could conflict. In 1978, the Energy Tax Act (the so-called gas guzzler tax) on large automobiles passed to conserve petroleum. Yet among the items that added weight to automobiles and reduced fuel efficiency were the catalytic converter and other safety equipment mandated by the government.[57]

By the mid-1970s, other ramifications of various pollution-control requirements also became apparent. One source estimated that Gross National Product (GNP) reductions resulting from regulatory effects in the automobile industry cost the nation 5 percent annually by the 1980s, and another source estimated that pollution and safety requirements had cost US business $100 billion by 1980.[58]

One the other hand environmentalists and consumer activists argued that an air-pollution crisis existed and that the Clean Air Act and other anti-pollution legislations had been ineffective. Some of the urgency was removed from the debate by the energy crisis of 1970-'s, which resulted in the dramatic penetration of the US automobile market by smaller, more fuel-efficient Japanese cars that generated a response by

[56] *Ibid*
[57] *Ibid*
[58] *Ibid*

US automakers. Improvements in engine design, weight reduction, and aerodynamics contributed to vastly improved engine performance and fuel efficiency. Ironically, many of the modifications that became standard on engine in the 1980 had been common in race cars of the 1960s and 1970s. Fuel injectors replace spark plugs, for example and overhead cam engines took the place of centrally located cams. In addition, new variations in chamber design and electronic ignition promised to burn fuel far more thoroughly than earlier designs that relied on the catalytic converters, although it seemed unlikely that the nation would ever return to leaded gasoline.[59]

California pioneered the regulation of automobile emissions. Its regulatory regime dates back to 1960, when the State enacted its motor vehicle pollution control program. In developing regulations, even the federal government often simply followed the lead of the State of California. The first emission control requirements on automobile registered in California took place in 1965. The first set of federal controls became effective in the 1968 model year.[60]

The automobile industry feared that inconsistent State regulation would compromise the economies of scale of automobile manufacturing. Congress prompted atleast in part by automobile industry lobbying, provided in the 1967 Air Quality Act that federal automobile emissions limitations would pre-empt not only any less stringent State standards, but also any more stringent State standards. There was one exception, however, California was authorised to have more stringent standards.[61]

This basic structure of the federal regulatory programme survived the enactments of the Act's comprehensive amendments in 1970 and 1990. The federal automobile emissions standards continue to require uniformity, a departure from the standard approach under the Clean Air Act and most federal environmental regulatory provisions, which is

[59] *Ibid*
[60] *Ibid*
[61] *Ibid*

to pre-empt less stringent State standards but to allow States to impose more stringent standards.

Continuing an approach initially adopted in 1977, the 1990 amendments authorise other States to choose between the federal standards and the more stringent California standards if they have non-attainment areas. – areas that do not meet the National Ambient Air Quality Standards (NAAQS). No State however, may adopt any other automobile emissions standards other than the California or federal ones. The resulting two-standard strategy reflects a compromise between two interests: the desire to protect the economies of scale in automobile production and the desire to accelerate the process for attainment of the NAAQS.[62]

The 1990 amendments prescribe the emissions standards for four pollutants beginning with the 1994 model year and specify that in each subsequent year a progressively increasing percentage of each manufacturer's sales must meet these standards. The emission reductions resulting from this regulatory programme are considerable. The permissible emissions of nitrogen oxides, for example, in some cases are 69 percent lower than under the prior regulatory requirements and 90 percent lower than uncontrolled levels.[63]

But in 1988, before Congress even began to consider these limitations seriously, California substantially strengthened its emissions standards. To implement these new standards, in September 1990 the California Air Resources Board (CARB) adopted a low emission vehicle (LEV) programme for automobiles sold in California. Under the LEV programme, automobile manufacturers must meet a fleet average requirement for emissions that become stricter each year.[64]

California's standards are considerably more stringent than the federal standards established in the Clean Air Act's

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[62] *Ibid*
[63] *Ibid*
[64] *Ibid*

1990 amendments. Environment protection Agency (EPA) estimated that under the national LEV programme which is not as stringent as California's, emissions would be approximately 70 percent lower than the under statutory standards prescribed in the Clean Air Act.[65]

Actions by other States and the emergence of the national LEV programme: After the Congress enacted the 1990 Clean Air Act amendments and California adopted its LEV programme, other states began to consider the choice between California standards and the less stringent federal requirements. These States included Texas, Michigan, Illinois and Wisconsin, as well as twelve other north-eastern States and the District of Columbia, which comprised the Ozone Transport Commission (OTC) an organisation established under the 1990 amendments to combat the interstate ozone pollution.

In October 1991, the OTC states signed a memorandum of understanding providing that each State would take steps to adopt the California LEV standards. Over the next two years, several States made effort in this regard, but only Massachusetts and New York adopted the standards. Some of the States delayed action pending challenges to the legality of the Massachusetts and New York programmes, while others made their adoption of the California LEV standards contingent on the adoption of those standards by other States in the region.[66]

By a majority vote of the member States' governors, the OTC can recommend to the EPA additional measures to control ozone pollution. The Clean Air act provides that if the EPA Administrator approves such recommendation, he must require each OTC member (even members opposed to the recommendation) to adopt these additional controls. In August 1993, three OTC members – Maine, Maryland and Massachusetts – petitioned the OTC to recommend the

[65] *Ibid*
[66] *Ibid*

application of California LEV standards to all States within the OTC. The OTC approved this petition by a 9-4 vote. In January 1995, EPA approved the OTC's recommendation, thereby requiring all OTC members to adopt California LEV standards beginning in model year 1999.[67]

At the same time however, EPA indicated that it would attempt to broker an agreement between the OTC States and the automobile manufacturers to enable the adoption of a national LEV programme. The agency hoped to facilitate the creation of a mutually acceptable set of national automobile emission standards. EPA acknowledged that the Clean Air Act precluded it from requiring manufacturers to meet more stringent standards before model year 2004, it therefore sought the voluntary agreement of the automobile manufacturers., Throughout the regulatory proceedings, however, EPA stressed that once a manufacturer opted into the programme, the agency could enforce the national standard against the manufacturer like any other binding automobile emissions standard. In its approval to the OTC's recommendation, EPA indicated that its order requiring the OTC States to adopt the California standards would become effective only if the national LEV programme failed.[68]

This dual strategy suffered a significant setback in 1997 when the D.C. Circuit held that EPA lacked authority to require OTC States to adopt California's LEV standards. Despite losing this trump card, the EPA succeeded in fashioning a national LEV programme that shared important features with the California's LEV programme. In two major respects the national LEV programme is less restrictive than its California counterpart. First, the average emissions for one of the pollutants – nonmethane organic matter – are 19 percent higher in the national programme: 0.075 grams per mile

[67] *Ibid*
[68] *Ibid*

instead of 0.063 grams per mile. Second, the national LEV programme does not require Zero Emission Vehicles (ZEV).[69]

In March 1998, the EPA declared the national LEV programme binding and effective, and announced that manufacturers must meet the programme's emissions standards in the north-eastern States in model year 1999 and nationally in the year 2001. All twenty-three automobile manufacturers that sell cars in the United States entered into an agreement, as did the nine OTC States. The four remaining OTC States – Main and Vermont in addition to Massachusetts and New York – adopted the California standards instead. EPA has estimated that for 2001 and subsequent model years, emissions of volatile organic compounds and nitrogen oxides will be upto 66 percent and 73 percent lower, respectively, under the national LEV programme than the federal standards otherwise would have required.[70]

More recently, thirteen States announced a joint plan in November 2000 to adopt emission limits for truck and bus engines that are far stricter than the current federal standards. The group includes not only California and the north-eastern States – the leaders in automobile emission standards – but also Georgia, Nevada, North Carolina and Texas. Because these States represents approximately 40 percent of the market for new trucks, manufacturers might respond by adopting more restrictive standards nationwide, as they eventually did in the case of automobiles. In this regard, the executive directors of both the State and /territorial Air Pollution Programme Administrators and the Association of Local Air Pollution Control Officials stated: "Our hope is [that] with these States joining California, we will create the critical mass that will result in the engine manufacturers deciding to manufacture just one truck model, and it would be a much cleaner truck.[71]

[69] *Ibid*
[70] *Ibid*
[71] *Ibid*

It can be difficult to determine whether States enact environmental regulations in response to actual environmental concerns or out of the desire to externalise costs or to comply with federal mandates. The case of automobile emission standards poses particular difficulties because the prominent role of the EPA in approving the OTC recommendations and brokering the national LEV programme. Nonetheless, a careful analysis of these regulatory developments indicates that several States were the primary catalyst for the establishment of stringent national LEV standards. Moreover, these States' actions do not fit the paradigm of jurisdictions' externalising pollution costs outside their borders, and for the most part of their actions did not result from federal requirements.[72]

THE HISTORY OF MOBILE SOURCE CONTROLS: The 1970 CAA forced technological innovations on the foreign and domestic automobile industry. It required the EPA to set tailpipe standards that reduced hydrocarbons (HCs), nitrogen oxide (NOx) and CO pollution in automobile exhaust by at least 90 percent from 1970 baseline which includes some controls on HC and Co emissions. No technology existed at the time to meet the 90 percent standards. EPA by rule set an exhaust standard of 0.41 grams per mile (gpm) for HC emissions. It set a standard of 0.4 gpm for NOx, which was subsequently relaxed in 1977 CAA amendments to 1.0 gpm. And it set a standard of 3.4 gpm for CO2. The theory was that the 1970 standards would force the development of brand-new technology.[73]

The theory worked. The industry responded by developing the "catalytic converter", which fits on the end of the tailpipe and converts HC, NOx, and CO into carbon dioxide, water vapour and nitrogen gas. The original standards, amended in 1977, remain in effect today. However these specific standards and technology have not as yet achieved the 90 percent (pollution reduction required by the CCA) of 1970 in all cases and the number of recalls annually by foreign and domestic

[72] *Ibid*

[73] *http://www.implats.co.za/market/emission_standards.asp* visited and accessed on 13th July 2010

companies indicates some of the difficulty in meeting even current standards in use. On the other hand, there is testimony that the standards can easily be met.[74]

The Act gave EPA a rule making mandate to set specific numerical standards for trucks and buses. They vary according to the weight of the vehicle and are phased in for some vehicles classes as provided in the Act.

The federal standards must be met at "certification", when the vehicle comes of the assembly line, and "in-use" for the "useful life" of the vehicle. The current Act defines the useful life of a car as five years or 50,000 miles in use, whichever comes first. EPA has defined eleven years or 120,000 miles in the case of light-duty trucks and even longer (upto 285,000miles) in the case of heavy-duty trucks.[75]

As a practical matter, compliance with the standard in-use is controlling. In order to meet the applicable standards in-use and avoid recall, new vehicles regularly certify at levels well below such standards.

In general, EPA has not regulated emission of toxic substances by motor vehicles or fuels directly, but monitors the emissions and many of the toxics are reduced principally as a direct consequence of the HC standard. For instance, benzene, butadiene and formaldehyde are types of hydrocarbons. As a result, they are controlled, at least in part, by tailpipe standard limiting exhaust emissions of hydrocarbons.

Emission Norms

AUTOMOBILE EMISSION STANDARDS UNDER THE CLEAN AIR ACT: Comprehending the statute authorising EPA's program for setting motor vehicle emission standards is no easy task. Title II of the 1990 CAA amendments added enormously to the detail of the mobile source provisions of the Act.

[74] *Ibid*
[75] *Ibid*

In 1974, reacting to the energy crisis and the national economic problems, Congress amended the Clean Air Act to further postpone the HC and CO standards until 1977 and to push back the NOx deadline to 1978. In 1975, EPA extended the HC and CO standards until 1978. Facing this 1978 deadline for all three principal automotive pollutants, the 1977 CAA amendments set new extensions. Beginning in 1980, the HC standard was set at 0.41 grams per mile (gpm). CO emissions were set at 7.0 gpm for 1980 and 3.4 beginning in 1981. The NOx standard was established at 2.gpm in 1980 to be lowered to 1.0 gpm in 1981 (with limited waivers available to small manufacturers dependent upon other manufacturers for emission control technology under sec 202(b) (1) (B). An additional waiver of the NOx standard to 1.5 gpm was authorised until 1985 to permit the development of new technology or for diesel engines.[76]

1990 CLEAN AIR ACT AMENDMENTS: The 1990 CAA amendments revised the mandatory emission standards for new cars and light duty trucks less than 6,000 pounds by adding new section 202(g).

Notice the differences in the statutory structure – a 5year/50,000 mile standard and a 10year/10,000 mile standard. Why would congress create such a system using two levels of certification? Also, notice that the emission standards set for non-methane hydrocarbons (NMHC), CO, NOx and particulate matter. Why set statutory standards only for these substances? These standards become effective with the 1994 model year but are phased in starting with 40 percent of new cars in 1994, 80 percent in 1995 and 100 percent in 1996. For light-duty trucks separate standards were set[77] and for heavy-duty trucks the existing pretesting emission standards are retained unless EPA chooses to revise them in the future.

[76] Thomas J. Schoenbaum & Ronald H. Rosenberg, *Environmental policy Law: Problems, Cases and Readings* (2nd edn.), 1991, the Foundation Press, Inc., [*A Brief History of Federal Automobile Emission Control* (*Chapter4*). p. 698.

[77] Section 202(h)

To address the question could the automobile or truck emission standards be relaxed or revised by the EPA in the future, Congress amended section 207(b) (1) (C) to allow revision to make the emission standards stricter but stated that, "[I]t is the intent of the Congress that the numerical emission standards specified in the Act shall not be modified by the Administrator after the CAA amendments of 1990 for any model year before the model year 2004." In fact, the Congress directed EPA to study the feasibility and necessity of strengthening automobile standards and authorising the agency to act no later than the model year 2004.[78]

What about the emission of toxic air pollutants from automobiles and other transportation sources? The House report on the CAA amendments identified this as a potentially serious problem. By mid-1992 EPA must complete a study of the need for and feasibility of controlling such pollutants from vehicles and motor fuels which the Administrator, determines reflect the greatest degree of emission reduction achievable through the application of technology which will be available, taking into consideration the standards established under subsection (a), the availability and costs of the technology, and the noise, energy, and safety factors, and lead time. Such regulation shall not be inconsistent with the standards under section 202(a). The regulations shall, at minimum, apply to emissions of benzene and formaldehyde.

The 1990 amendments provided EPA a great deal of additional authority to regulate many facets of vehicle use and maintenance including:

1. Controlling of vehicle refuelling emissions;[79]
2. CO emission standards for vehicles operated in cold temperatures;[80]
3. Auto warranties;[81]

[78] *Supra* Note 76.
[79] Section 202(a) (6)
[80] Section 202(j)
[81] Section 202(i)

4. Onboard emission control diagnostic systems;[82]
5. Clean fuel vehicles[83] and
6. Urban buses[84].

The Alternative Fuels Act, 1988

The Alternative Motor Fuels Act of 1988[85] was passed in both to reduce American dependence on foreign oil and to address automobile makers' lack of interest in designing card for nonexistent fuel and the fuel companies' unwillingness to produce fuel for nonexistent cars. The Act encouraged automobile manufacturers to design and build cars that could burn alternative fuels such as methanol and ethanol. The legislation was intended to resolve the problem by giving incentives to automobile makers and by requiring that a part of the federal fleet use alternative fuels. Since Many in The Congress wanted to relieve American dependence on foreign oil but did not want a solution at the expense of the environment, environmental issues became a major part of the legislation.[86]

The search for the efficient alternative-fuelled vehicles began almost simultaneously with the development of the gasoline-powered engine. Because of its efficiency, however, the gasoline-powered engine quickly stymied most attempts to design and commercialise alternative fuelled vehicles.

The problem of dependence on petroleum based engines became acute during the oil embargo of 1973. Most of the United Sates national defence forces were using petroleum-fuelled vehicles; many considered this to be a national security risk. Moreover, 60 percent of the transportation in the United States relied on petroleum-based fuel. The embargo also raised a general awareness that oil is not a renewable and

[82] Section 202(m)
[83] Sections 241-50
[84] Section 219
[85] *Public Law 100-494.*
[86] *Infra* note 96.

alternate source and the Congress, too realised the US needed to shift its reliance oil to some other, more available fuel.[87]

Alternative fuels have existed for some time, primarily in the form of alcohol-based fuel, but in most cases, such fuel could not be used in commonly available vehicles. Most of the commercial transportation and nearly all personal ones in the US used internal combustion engines. Although many alternative fuels, such as alcohol-based are combustible, they act corrosively on most internal combustion engines and severely curtail the engines' longevity.

The problem was twofold: Acceptable fuels needed to be developed, and vehicles that could use the fuels needed to be designed. This represented a major undertaking for both the fuel companies and the automobile manufacturers and involved a major investment in an unknown technology.[88]

The Alternative Motor Fuels Act, 1988 resolved the problem by requiring that a percentage of government vehicles use alternative fuels. A timetable was established that enforced government purchase of vehicles capable of using alternative fuels.[89]

Provisions in the Act also allowed fleet operators to exceed their operational gasoline allowances by counting only the actual amount of gasoline in a gallon of fuel, rather than the total amount of fuel, against their allotment. This provided an incentive to the private sector to develop and use alternative-fuelled vehicles.[90]

Little information was available on these vehicles running on alternative fuels since the technology was new. To solve this problem, the Act required the formation of several agencies to monitor the alternative-fuelled vehicles purchased by the government. The reports of such agencies were to

[87] *Ibid*
[88] *Ibid*
[89] *Ibid*
[90] *Ibid*

provide information on the mileage, overall efficiency, maintenance records and ecological impact of such vehicles.[91]

An equally important aspect of the new legislation was to amend the existing laws to take into consideration the differences between the alternative-fuelled and petroleum-fuelled vehicles. This aspect was to remove the economic obstacles which would have hindered the development of the technologies required to make alternative-fuelled vehicles a reality.[92]

The immediate impact of the legislation was to encourage development of necessary technology. The long-term impact was expected to be that alternative-fuelled vehicles and the fuel to operate them would be available to the public, reducing American dependence on foreign oil, and to provide technology for the use of renewable resources for transportation and other industrial needs.[93]

The Act specifically established the Interagency Commission on Alternative Motor Fuels, responsible for ensuring that all agencies within the government to work together in implementing the law. Further, an Alternative Fuel Council was established and charged with gathering information and filing reports required by the Act. Among the various reports required by the Act, an independent environmental study to analyse the air quality and make comparisons of the air quality of cities where alternative fuels were used and those where it was not.[94]

Laws amended by this legislation include the Motor Vehicle Information and Cost savings Act, which had a minimum mileage provision. The amendment encouraged the manufacture of alternative-fuelled vehicles by changing the previous equation for fuel-economy standards to reflect the

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[91] *Ibid*
[92] *Ibid*
[93] *Ibid*
[94] *Ibid*

lower mileage of oxygenated fuels.[95] The Act also sought to encourage the development of electric and solar-powered vehicles and required that automobiles capable of using alternative fuels be labelled in such a way that the consumer would be aware of the different fuels that could be used and would be able to make a more informed buying decision.

Another significant provision of the act was to establish a national bus-testing programme, wherein mass transit buses were to be developed so that they could either compressed natural gas (CNG) or other alternative fuels.

The Interagency Commission on Alternative Motor Fuels noted in its final report that additional amendments were necessary to ensure alternative-fuelled vehicles would be available. It reported that a significant market for alternative-fuelled vehicles developed within government and commercial fleet in three years of the passage of the said Act. Because of this success, the commission urged the passage of the National Energy Strategy which was proposed in 1994. With the passage of that legislation, the commission estimated that sales of alternative-fuelled vehicles would increase dramatically; projecting that more than a million such vehicles would be sold by 2000 and more than a million would be sold to business fleet alone by the year 2010. That would save an estimated 200,000 barrels per day.[96]

The Alternative Motor Fuels Act of 1988 was the key legislation in the attempt to shift from petroleum-based to more renewable, ecologically friendly fuels in the United States of America.[97]

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[95] Fuels made with alcohol-based components such as ethanol, methanol and other grain-based substances.

[96] Frank N. Magill (ed.), *Chronology of the Twentieth-Century History: ECOLOGY AND THE ENVIRONMENT Vol II* (*The Alternative Motor Fuels Act is Passed*), Fitzroy Dearborn Publishers (1997), p.1335 (1337).

[97] *Ibid*

India: Emission Norms

Bharat Stage emissions standards[98] are emissions standards instituted by the Government of the Republic of India (Bharat) that regulate the output of air pollutants (such as nitrogen oxides (NO_x), carbon monoxide (CO), hydrocarbons (HC), particulate matter (PM), soot and, where applicable, sulphur oxides (SO_x)) by internal combustion engine powered equipment, including motor vehicles, or other air polluting facilities or equipment. In many cases they are similar to European emissions standards

BACKGROUND:[99] The first Indian emission regulations were idle emission limits which became effective in 1989. These idle emission regulations were soon replaced by mass emission limits for both petrol (1991) and diesel (1992) vehicles, which were gradually tightened during the 1990's. Since the year 2000, India started adopting European emission and fuel regulations for four-wheeled light-duty and for heavy-dc. Indian own emission regulations still apply to two- and three-wheeled vehicles.

Current requirement is that all transport vehicles carry a fitness certificate that is renewed each year after the first two years of new vehicle registration.

On October 6, 2003, the National Auto Fuel Policy has been announced, which envisages a phased program for introducing Euro II - IV emissions standards and fuel regulations by 2010. The implementation schedule of EU emission standards in India is summarized in Table 8.

(Table 6.8)

Indian Emission Standards (4-Wheel Vehicles)[100]

Standard	Reference	Date	Region
India 2000	Euro 1	2000	Nationwide

[98] *http://en.wikipedia.org/w/index.php?title=Talk:Bharat_Stage_emission_standards&action=edit&redlink=1* accessed and viewed on 12th July 2010.

[99] *http://en.wikipedia.org/w/index.php?title=Bharat_Stage_emission_standards&action=history* accessed and viewed on 13th July 2010.

[100] *Ibid*

Bharat Stage II	Euro 2	2001	NCR*, Mumbai, Kolkata, Chennai
		April 2003	NCR*, 12 Cities†
		April 2005	Nationwide
Bharat Stage III	Euro 3	April 2005	NCR*, 12 Cities†
		April 2010	Nationwide
Bharat Stage IV	Euro 4	April 2010	NCR*, 12 Cities†

*National Capital Region (Delhi)

†Mumbai, Kolkata, Chennai, Bengaluru, Hyderabad, Ahmedabad, Pune, Surat, Kanpur, Lucknow, Sholapur, and Agra

The above standards apply to all new 4-wheel vehicles sold and registered in the respective regions. In addition, the National Auto Fuel Policy introduces certain emission requirements for interstate buses with routes originating or terminating in Delhi or the other 10 cities. For 2-and 3-wheelers, Bharat Stage II (Euro 2) will be applicable from April 1, 2005 and Stage III (Euro 3) standards would come in force from April 1, 2010.

HEAVY-DUTY DIESEL ENGINES: Emission standards for new heavy-duty diesel engines—applicable to vehicles of GVW > 3,500 kg—are listed in Table 9.

(Table 6.9)

Emission Standards for Diesel Truck and Bus Engines, g/kWh[101]

Year	Reference	Test	CO	HC	NO_x	PM
1992	-	**ECE R49**	17.3-32.6	2.7-3.7	-	-
1996	-	**ECE R49**	11.20	2.40	14.4	-
2000	**Euro I**	**ECE R49**	4.5	1.1	8.0	0.36*
2005†	**Euro II**	**ECE R49**	4.0	1.1	7.0	0.15
2010†	**Euro III**	**ESC**	2.1	0.66	5.0	0.10
		ETC	5.45	0.78	5.0	0.16
2010‡	**Euro IV**	**ESC**	1.5	0.46	3.5	0.02
		ETC	4.0	0.55	3.5	0.03

* 0.612 for engines below 85 kW

† Earlier introduction in selected regions, see Table 8 ‡ only in selected regions, see Table 8.

LIGHT-DUTY DIESEL VEHICLES: Emission standards for light-duty diesel vehicles (GVW ≤ 3,500 kg) are summarized in Table 10.

101 *Ibid*

Ranges of emission limits refer to different classes (by reference mass) of light commercial vehicles; compare the EU light-duty vehicle emission standards page for details on the Euro 1 and later standards. The lowest limit in each range applies to passenger cars (GVW ≤ 2,500 kg; up to 6 seats).

(Table 6.10)

Emission Standards for Light-Duty Diesel Vehicles, g/km[102]

Year	Reference	CO	HC	Chino	NO_x	PM
1992	-	17.3-32.6	2.7-3.7	-	-	-
1996	-	5.0-9.0	-	2.0-4.0	-	-
2000	Euro 1	2.72-6.90	-	0.97-1.70	0.14-0.25	-
2005†	Euro 2	1.0-1.5	-	0.7-1.2	0.08-0.17	-
2010†	Euro 3	0.64 0.80 0.95	-	0.56 0.72 0.86	0.50 0.65 0.78	0.05 0.07 0.10
2010‡	Euro 4	0.50 0.63 0.74	-	0.30 0.39 0.46	0.25 0.33 0.39	0.025 0.04 0.06

† Earlier introduction in selected regions, see Table 8.
‡ Only in selected regions, see Table 8.

The test cycle has been the ECE + EUDC for low power vehicles (with maximum speed limited to 90 km/h). Before 2000, emissions were measured over an Indian test cycle.

Engines for use in light-duty vehicles can be also emission tested using an engine dynamometer. The respective emission standards are listed in Table 11.

(Table 6.11)

Emission Standards for Light-Duty Diesel Engines, g/kWh[103]

Year	Reference	CO	HC	NO_x	PM
1992	-	14.0	3.5	18.0	-
1996	-	11.20	2.40	14.4	-
2000	Euro I	4.5	1.1	8.0	0.36*
2005†	Euro II	4.0	1.1	7.0	0.15

* 0.612 for engines below 85 kW
† Earlier introduction in selected regions, see Table 8.

[102] *Ibid*
[103] *Ibid*

Emissions standards for gasoline vehicles (GVW ≤ 3,500 kg) are summarized in Table 12. Ranges of emission limits refer to different classes of light commercial vehicles (compare the EU light-duty vehicle emission standards page). The lowest limit in each range applies to passenger cars (GVW ≤ 2,500 kg; up to 6 seats).

(Table 6.12)

Emission Standards for Gasoline Vehicles (GVW ≤ 3,500 kg), g/km[104]

Year	Reference	CO	HC	Chino	NO_x
1991	-	14.3-27.1	2.0-2.9	-	
1996	-	8.68-12.4	-	3.00-4.36	
1998*	-	4.34-6.20	-	1.50-2.18	
2000	**Euro 1**	2.72-6.90	-	0.97-1.70	
2005†	**Euro 2**	2.2-5.0	-	0.5-0.7	
2010†	**Euro 3**	2.3 4.17 5.22	0.20 0.25 0.29	-	0.15 0.18 0.21
2010‡	**Euro 4**	1.0 1.81 2.27	0.1 0.13 0.16	-	0.08 0.10 0.11

* For catalytic converter fitted vehicles.
† Earlier introduction in selected regions, see Table 8.
‡ Only in selected regions, see Table 8.
Gasoline vehicles must also meet an evaporative (SHED) limit of 2 g/test (effective 2000).

THREE AND TWO WHEELER (GASOLINE AND DIESEL VEHICLES: Emission standards for 3- and 2-wheel gasoline & diesel vehicles are listed in the following tables.

(Table 6.13)

Emission Standards for 3-Wheel Gasoline Vehicles, g/km[105]

Year	CO	HC	Chino
1991	12-30	8-12	-
1996	6.75	-	5.40
2000	4.00	-	2.00
2005 (BS II)	2.25	-	2.00
2010.04 (BS III)	1.25	-	1.25

[104] *Ibid*
[105] *Ibid*

(Table 6.14)

Emission Standards for 2-Wheel Gasoline Vehicles, g/km[106]

Year	CO	HC	Chino
1991	12-30	8-12	-
1996	5.50	-	3.60
2000	2.00	-	2.00
2005 (BS II)	1.5	-	1.5
2010.04 (BS III)	1.0	-	1.0

(Table 6.15)

Emission Standards for 2- And 3-Wheel Diesel Vehicles, g/km[107]

Year	CO	Chino	PM
2005.04	1.00	0.85	0.10
2010.04	0.50	0.50	0.05

Overview of the emission norms in India

- 1991 - Idle CO Limits for Gasoline Vehicles and Free Acceleration Smoke for Diesel Vehicles, Mass Emission Norms for Gasoline Vehicles.
- 1992 - Mass Emission Norms for Diesel Vehicles.
- 1996 - Revision of Mass Emission Norms for Gasoline and Diesel Vehicles, mandatory fitment of Catalytic Converter for Cars in Metros on Unleaded Gasoline.
- 1998 - Cold Start Norms Introduced.
- 2000 - India 2000 (Eq. to Euro I) Norms, Modified IDC (Indian Driving Cycle), Bharat Stage II Norms for Delhi.
- 2001 - Bharat Stage II (Eq. to Euro II) Norms for All Metros, Emission Norms for CNG & LPG Vehicles.
- 2003 - Bharat Stage II (Eq. to Euro II) Norms for 13 major cities.
- 2005 - From 1 April Bharat Stage III (Eq. to Euro III) Norms for 13 major cities.

[106] *Ibid*
[107] *Ibid*

- 2010 - Bharat Stage III Emission Norms for 4-wheelers for entire country whereas Bharat Stage - IV (Eq. to Euro IV) for 13 major cities. Bharat Stage IV also has norms on OBD (similar to Euro III but diluted)

FUELS

Fuel Quality plays a very important role in meeting the stringent emission regulation. The fuel specifications of Gasoline and Diesel have, presently, been aligned with the Corresponding European Fuel Specifications for meeting the Euro II, Euro III and Euro IV emission norms. The government has finally decided to implement auto fuel economy standards for the country's automobile sector which will be enforced from 2011. After a year of wrangling between the heavy industries, surface transport and power ministries, the PMO has decided that the Bureau of Energy Efficiency (BEE) will formulate the norms and notify them under the Energy Conservation Act while the surface transport ministry will ensure its implementation. [108]

The norms will be developed on the basis of mileage that petrol and diesel vehicles give, sources in the road transport and highway ministry told The Times of India. With the top office in the government deciding a compromise, BEE is now expected to move fast to implement labelling of vehicles in the first phase which will then be converted into mandatory standards, pushing up the mileage of cars over years just as is done in the case of appliances for energy efficiency.

The use of alternative fuels has been promoted in India both for energy security and emission reduction Delhi and Mumbai have more than 100,000 commercial vehicles running on CNG fuel. Delhi has the largest number of CNG commercial vehicles running anywhere in the World. India is planning to introduce Biodiesel; Ethanol Gasoline blends in a phased manner and has drawn up a road map for the same. The Indian auto Industry is working with the authorities to facilitate for introduction of the alternative fuels. India has also setup a task force for preparing the Hydrogen road

[108] *The Times of India,* September 20, 2009.

map. The use of LPG has also been introduced as an auto fuel and the oil industry has drawn up plans for setting up of Auto LPG dispensing station in major cities.

Conventional Fuels and their Corresponding Engine Technology

DIESEL: Diesel vehicles spew pollutants of most serious concern. While direct emissions of PM and NOx are very high, they also contribute significantly towards the build up of secondary PM and O3. Diesel particulates are largely elemental carbon that absorbs toxic organic compounds. The particulate emissions from uncontrolled diesel engines are six to ten times greater than those from petrol engines[109]

In the atmosphere, some of the SO2 that comes from the vehicles, which is in direct proportion to the sulphur in the fuel, gets converted into sulphates and the impacts on the ambient particulate levels in our cities. Similarly, diesel combustion produces very high amounts of nitric oxide (NO) that forms a major part of the NOx emissions. This contributes to photochemical smog and, through secondary atmospheric transformation, to particulate aerosols.[110]

There are certain inherent factors that make diesel engines attractive worldwide. They are more fuel-efficient than petrol engines of comparable power. Diesel drives greater energy per unit of fuel used. Therefore, it is popular mainly for application in high heavy-duty vehicles including trucks, buses and other commercial vehicles.

Now, however, use of diesel is expanding very rapidly in the personal car segment. The same high score on fuel-efficiency, supported by lower diesel fuel taxes compared to petrol, is luring demand for diesel cars in most countries. This pattern of dieselisation of the light-duty vehicle segment and its pollution impact varies across regions of Asia, Europe and North America,

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[109] Asif Faiz *et al*, *Air Pollution from motor Vehicles: Standards and Technologies for Controlling Emissions* (1996), World Bank, Washington DC, USA, p.63.

[110] Michael Walsh, *Clean Fuel for Asia: Technical Options for Moving Toward Unleaded Petrol and Low Sulphur Diesel (1997)*, Technical Paper No. 377, World Bank, Washington DC, USA.

and is throwing up a wide gamut of pollution and regulatory challenges.

The US, so far, has been able to stave off the overwhelming permeation of diesel cars in the cities. Diesel cars are not popular in the US cities and currently account for less than one percent of the light-duty new vehicle market in North America.[111] There is, however, an upward swing of late with the growing popularity of sports utility vehicles (SUVs), vans and pickups.[112] Though the growth is moderate, the USEPA anticipates, 'increased growth' of diesel light-duty vehicles. By 2015 and later, diesel's share can be nine percent in the sales of light-duty vehicles and 24 percent in light-duty trucks.[113] The US Department of Energy (DoE) forecasts that the share of diesel engines in light-duty vehicles will increase between four to seven percent by 2012.[114] Major automakers are taking a serious look at this segment.[115] The anticipated growth in the US, however, is not as overpowering as is being noticed in other parts of the world.

Europe is swept along on a tide of diesel. In Western Europe, diesel-powered vehicles account for more than half of the new car sales.[116] Diesel car sales have nearly doubled in the major Western European markets. Austria, Belgium and France have recorded the highest share of diesel car sales. In the United Kingdom (UK), the share is 35 percent, while in Italy it is 60 percent. Diesel's share in Germany has touched an all time high of 42 percent. This trend is reflected in all class of vehicles.

In Asia, though the absolute share of diesel vehicles is comparatively small, the rate of increase in many cities is reported to be phenomenal. Diesel penetration is still low in Asia but it is expected to grow in burgeoning vehicles markets of India, China as well as gain momentum in more developed markets such as South

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[111] Michael Walsh, *CAR Line, Virginia*, USA No. 2004-5, October (2004), p. 37.

[112] Michael Walsh, *CAR Line, Virginia*, USA No. 2005-1, February (2005), p. 5.

[113] Anon, "Environmental Impact", *Regulatory impact Analysis – Control of Air Pollution from New Motor Vehicles: Tier 2 Motor Vehicle Emission Standards and Gasoline Sulphur Requirements,* USEPA, Washington DC, p.36.

[114] Michael Walsh, *CAR Line,* Virginia, USA No. 2005-1, February (2005), p. 37.

[115] Tara Baukus Mello, *Diesel, Dirty no more,* Edmunds seen in The Leapfrog Factor: Clearing the air in Asian Cities (2006), A CSE Publication, p.132.

[116] Michael Walsh, *CAR Line,* Virginia, USA No. 2005-1, February (2005), pp. 4-5.

Korea and Japan.[117] Though China is in the midst of a phenomenal increase of in its car fleet, sale of diesel vehicles are still modest due to the nominal difference in diesel and petrol prices. Market forecasters predict significantly higher diesel car sales in Asia. According to JD Power and Associates, a California-based global marketing information firm, global diesel light-duty vehicle sales will increase from 12.5 million in 2003 to 27 million by 2015 with India and South Korea being the drivers behind this growth in Asia.[118]

In India, analysts predict that diesel car sales will grow by almost 45-50 percent by 2010. The increase in diesel car numbers in Delhi mirrors the national crisis. Vehicles registration data from Delhi's state transport authority showed steep rise in the diesel car fleet. Its share in the total car registration has increased from four percent in 1998-1999 to 16 percent in 2002-2003, while petrol car registration has stagnated. What is fuelling the diesel craze is its price. In Delhi when fuel price was revised in June 2010 the price of petrol was around 35 percent more than that of diesel.[119] There price of petrol has been freed from subsidy recently and the price of diesel is on the way to be decontrolled. An auto component major, MICO, is reported to have estimated that during the 2004 the market share of diesel cars were around 31 percent, and is expected to rise to 45 percent by 2010. The present developments points towards that direction.

New marketing strategies are redefining the diesel car market. Some automakers have priced their petrol and diesel vehicles evenly. Tata Motors reversing the trend has priced its petrol version more that the diesel ones. Maruti Udyog Limited (MUL) which had hitherto stayed away from diesel versions has been producing diesel engines from their Gurgaon plant near Delhi since 2005. Similar trends are being followed by various car companies.

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[117] According to the UK-based *World Markets Research Centre Report.*

[118] Anon, *Diesel Surge in India*, Green Car Congress (2004).

[119] The government has decontrolled petrol prices from June 25, 2010 and the decontrolling of diesel prices is in the anvil (The Telegraph, June 26, 2010).

Consider the effect of such a strategy on the consumer, who could now be naturally tempted to go for the latter. Therefore, the future looks bleakly dieselized as the quality of Indian diesel is extremely poor and the Indian government has just started to firm up plans for providing clean diesel.

Paucity of information restricts proper benchmarking of vehicle technology in India. Public access to such information is limited to company brochures and self-professed statements rather than independent regulatory assessment of technological changes expected with the successive changes in emissions regulations. Key public concern is about the quality of technology transformation in India, if it is measuring upto international good practices. In this regard, features related largely to engine performance, power output, fuel economy and emissions performance have begun to draw public attention.[120]

For India, the most obvious reference point is Europe as it follows the European emissions standards, though with considerable time lag.[121] The technologies existing to meet these standards in Europe are well known. However, there is a noticeable variance in the steps taken by India and Europe while graduating through the successive stages of the Euro norms. The technology pattern of improvement undertaken by Indian automobile industries though broadly consistent with those observed in Europe, it is still marred by selective omissions of certain dominant features at a given stage of transition.

The mindset of the Indian automobile industry is to stretch technology to the limit with as much optimization as possible to maintain a competitive price until more fundamental shifts become absolutely necessary. In the absence of strong regulations, industry avoids paths needed to hasten the changeover to more advanced technologies, and this delays the process of meeting clean emissions targets.

[120] Anumita Roychowdhury, Vivek Chattopadhyaya, Chirag Shah & Priyanka Chandola, *A Technology roadmap* in Ajit Chak & Souparno Banerjee (ed.), *The Leapfrog Factor: Clearing the Air in Asian Cities*, Centre for Science and Environment (CSE), 2006, at p. 161.

[121] India adopted Euro I standards as late as 2000 – eight years after Europe. In the absence of strong regulations, the Supreme Court had to intervene in 1999 to enforce *Euro II* standards (1996 European norms) in Delhi in 2000 that reduced the time lag with Europe from 10 to four years.

The early vintage of Euro I diesel cars produced since 2000, witnessed the basic changes in engine parameters that include retarding fuel injection timing, intake, exhaust and combustion organisation and increasing the fuel injection pressure.

The changes in the subsequent Euro II vintage, which came into a few cities since 2000, show that some of the improved features that dominated the Euro II cars in Europe saw very limited application in India. This difference, however, is influenced by the varying emphasis on emissions control and fuel economy improvements.

It is evident, for example, that at the Euro II level, Europe had paid a lot of attention to the fuel injection system and graduated from mechanical injection to electronically-controlled injection systems. Improvement in the fuel injection system plays a significant role in achieving major reduction in pollutants while improving fuel economy. But in the Indian compact car segment, automakers have avoided using electronic controls, till it was time to move to Euro III in a few cities in 2005.

Europe has seen early and consistent development of more advanced direct fuel injection systems – common rail direct injection (CRDi) systems and electronically controlled unit injectors (EUI). Common rail technology for diesels was introduced in the mid to late 1990s; it resembles fuel injection systems for petrol engines with electronic sensors and a computer – but with much high pressure.[122] The common rail system allows control of injection pressure independent of engine speed. The EUI allows high injection pressures to be produced incorporating and individual pump/injector unit per cylinder with electronic timing control. Improved fuel injection systems in diesel vehicles have lowered smoke and PM emissions significantly over time.

Yet another point of divergence is that Europe as seen the early application of the direct injection (DI) system in diesel cars across board, replacing indirect injection (IDI). Primacy attached to fuel economy is responsible for early and wide application of DI

[122]Anon, *Quiet Diesel: Popularity in Europe signals potential for Diesels in US* in *The Weekly*, Georgia, USA, February 1, 2005.

engines in Europe. In DI engines, fuel is injected directly into the combustion chamber that gives higher power output and better fuel economy.[123] In IDI engines, fuel is injected into a separate pre-chamber where ignition occurs and then the combustion spreads to the main combustion chamber. The DI engine is more fuel efficient than the IDI systems. The IDI engine has been mainly used for small, high-speed applications such as passenger cars, where low noise and high performance are important.

However, Indian diesel car models in mini and compact segment have continued with IDI. IDI can be efficient from the emissions reduction point of view. But application of electronically-controlled fuel injection system such as EUI and CRDi can be effective in improving both emissions and fuel economy. In India CRDi has come in some high-end models.

On the whole, until recently[124] the dominant Euro II approach in India is represented by a combination of IDI engines with oxidation catalyst. According to an official of Automotive research Association of India (ARAI), Pune, only design changes in engines would not be adequate to meet Euro norms and tighter emissions standards. It would require exhaust after-treatment devices or some add-on in series.[125] Oxidation catalysts would be more in use beyond Euro II. For additional NOx control, Exhaust gas recirculation (EGR) has also been introduced. EGR routes a part of the exhaust gas into engine air intake and reduces the peak flame temperature that contributes to NOx formation.[126]

The Euro IV norms recently enforced in eleven cities could have been carried out earlier and by now all over India. Such transition would have been possible when Euro III norms were being enforced in 2005, it would have been a critical transition if bolder technology choices could have been made.

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[123] Asif Faiz *et al*, *Air Pollution from motor Vehicles: Standards and Technologies for Controlling Emissions* (1996), World Bank, Washington DC, USA, p.64.

[124] *Euro III* emissions standards have been applicable all over India from *1st April 2010*, whereas *Euro IV* norms have been applicable to a few select cities, the exact number being eleven including the four metros from the same date.

[125] S. Bhattacharya, *Catalysing the Diesel Engines,* paper presented at the "Symposium on International Automotive Technology 2003", ARAI, Pune, January 15-18, 2003.

[126] Asif Faiz *et al*, *Air Pollution from motor Vehicles: Standards and Technologies for Controlling Emissions* (1996), World Bank, Washington DC, USA.

The heavy-duty segment has been the slowest to improve in India. While buses gets an opportunity to meet the one-step-up standards in a few metro cities, trucks lag behind deplorably as they continue to meet the minimum national standards. There is no hope of trucks moving soon to Euro III in India country-wide as they are exempt from standards even in cities that have enforced the latest Euro norms as the matching fuels are not available in the highways.

The Euro I heavy-duty engines are almost entirely aspirated except a few Ashok Leyland trucks that were turbocharged later. ARAI informs that Euro I levels in India were achieved with upgrades that included retarded injection timing, intake, exhaust and combustion optimization, low sac injectors and high swirl.[127]

With the advent of the Euro II standards turbocharging has been applied more extensively as Euro II PM Limit is too severe for conventional naturally-aspirated engine to achieve. Globally, reduction in PM emissions and improvement in fuel efficiency, power and torque output has been achieved by turbocharging the naturally aspirated engines, increasing the boost pressure and improving the match between turbocharger and engine[128] In contrast to naturally aspirated engines smoke emissions from turbocharged engine is lower. According to Ricardo, a global player in engine development, Indian engines would have to be turbocharged and after-cooled to meet Euro emissions standards.

In the heavy-duty commercial vehicle segment application of electronic control and after-treatment devices are mostly absent.

The expert committee report on the Auto Fuel Policy has broadly outlined a wide menu of options for commercial diesel vehicles. These include improvement in fuel injection system using higher injection pressure, common rail system, unit injections instead of multi-cylinder fuel injection pumps. Further improvement in cylinder head design, inlet port, re-entrant combustion chamber and also four-valve system to improve

[127] Anon, *Report of the Expert Committee on Auto Fuel Policy (2002)*, Government of India, New Delhi, p. 162.

[128] Asif Faiz *et al*, *Air Pollution from motor Vehicles: Standards and Technologies for Controlling Emissions* (1996), World Bank, Washington DC, USA.

volumetric efficiency and provide better mixing of air and fuel are other possible options. Further use of turbocharged and turbocharged after-cooled engines would provide higher specific power, better fuel economy and fewer emissions.[129] It is difficult to judge the quality of change from these generalities and very little field information.

In January 2005, Ashok Leyland, one of the two major bus manufacturers, has said in its press communiqué that it is introducing an electronic engine management system (EMS) in its Euro III buses for faster response to operating variables like speed and load.[130]

Indian regulators ignore implications of lingering for too long at the intermediate stages of diesel technology and staying away from the effective solutions emerging globally. The intermediate stage represented by the Euro II, Euro II and Euro IV standards that, apart from engine modifications, predominantly hinge on the using reduced fuel sulphur levels (from 500 ppm to 350 ppm in April 1, 2005 and further lower from April 1, 2010.) in combination with diesel oxidation catalyst (DOC).

The DOCs, the only available after-treatment device available for diesel cars in India today, are not as sulphur sensitive as the particulate traps and can work with sulphur levels of 500 ppm to 350 ppm and are common in cities that have diesel with maximum 500 ppm sulphur. Most of the emission benefits of using oxidation catalysts are in terms of CO and total HC reductions, that is 90 and 70 percent respectively,. Reduction in PM is in the range of 20 to 50 percent.[131].

The DOC is widely used across the world in the lower levels of technologies, emerging evidence signals that countries like India should quickly move out of this phase. India must not encourage the combination of DOC and 500 ppm to 450 ppm sulphur fuels to

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[129] Anon, *Report of the Expert Committee on Auto Fuel Policy (2002)*, Government of India, New Delhi, pp. 160-163.

[130] Detail changes planned still not known.

[131] Anon, Retrofit Emission Control Technologies for Diesel Engines, paper presented at the "World Truck Conference", Manufacturers of Emission Control Association, Monterey, USA, March 2-4, 2003.

persist for too long. Scientific evidence unequivocally shows that DOC oxidizes almost all sulphur and lead to deadlier and more toxic sulphate particles when used with moderately low-sulphur fuels, thereby increasing harmful sulphate emissions. Germany has not opted for DOCs because their use in diesel just reduces the PM mass not the numbers. DOCs make PM smaller so that particulates go down deep into the lungs.[132]

As near-zero sulphur fuels enable enforcement of stringent vehicle standards for new vehicles; they open up the opportunity for reducing emissions from in-use diesel vehicles as well. The same emissions control systems that are used in new vehicles can be retrofitted in in-use diesel vehicles as well – presenting a much bigger opportunity for a cleanup.

Another crucial parameter that has been completely ignored in India is the legal provision for on-board diagnostics (OBD) to check performance of emissions control components in vehicles. The Indian government has avoided introduction of built-in safeguards of the European emissions norms that require the OBD system to monitor pollution control components to detect any malfunction that can increase emissions. The OBD system stores all information related to the emissions control components or the malfunction and alert the driver. They store diagnostic information for repair technicians and also for the enforcement agencies for vehicle inspection programme.

Europe has already implemented OBD requirements for both petrol and diesel vehicles. In 2005 heavy-duty vehicles were also brought into its ambit.

The US has adopted the OBD system in light-duty diesel vehicles and heavy-duty vehicle category of 8,500 to 14,000 pounds (lbs) (approximately 4-6.35 tonnes). The California Air resources Board (CARB) plans to make OBD systems compulsory

[132] This was *explained* by Axel Friedrich, Head of Division, Environment Transport and Noise, Federal Environment Agency of Germany.

on all diesel engines in newly-commissioned vehicles of over 14,000 lbs or 6.35 tonnes from 2010.[133]

However, in 2005, when the Euro III norms were notified from April 1, the Indian industry was not was still not prepared for these applications for checking emission performance of vehicles. It was content with the very basic provision of on-board engine malfunction checks that were already in place. General Motors (GM) and Maruti Udyog Limited (MUL) have offered on-board malfunction indicator light (MIL) which indicates engine malfunction in the car giving the customer an early sign to visit the garage to rectify the problem. The Maruti spokesperson, in this contest, was candid and justified by saying, "None of our models are equipped with OBD system. There is no regulation to this effect. For the OBD system to be effective in principle, there are issues related to servicing habits of users, fuel specifications, adulteration and general lack of infrastructure. However, we have MILs, which give an indication when there is trouble with the sensors, which is also necessary for emissions control." The auto manufacturers say, "Why should we invest in an OBD system when it is not legally mandated?"

Many of these policy issues will have to be sorted out soon in India to enable it to leapfrog to clean diesel technology that has already begun taking place in the West.

PETROL: Petrol cars, powered by spark ignition engines, dominate the global urban market, however, there are regional differences in their market share. With the dynamics for diesel passenger cars changing, petrol cars in many cities have started to face strong competition. The US with one of the highest motorization rates and nominal difference between petrol and diesel prices, remain the largest single petrol consumer in the world. In the European Union (when there were only 15 member countries),[134] petrol usage has declined while diesel demand has grown. In Asian countries, the use of petrol cars is still very high though diesel vehicles are increasing in numbers and the same is reflected in the Indian

[133] Alan Bunting, "CARB Spells out its OBD Proposals for 2010", *Automotive Environment Analyst*, A.W.Knowledge, London, England.

[134] The EU presently has a twenty-four country membership.

trend. Petrol cars also typify the inevitable element of any technology roadmap: solve one set of problems to hurtle into yet another trade-off demanding constant innovation and correction. There is constant threat of new toxic substances entering the fuel streams ostensibly to enhanced desired properties of petrol fuel but adding to toxic emissions instead. There can be other negative trade-offs as well. One example is the risk of increased PM emissions, hitherto, not associated with petrol vehicles, from newer technologies that are emerging to improve fuel economy.

The spark ignition technology has developed quite significantly over the decades compared to diesel technology but now the difference with diesel is narrowing down. While diesel is trying to match up to its cleanliness, petrol is trying to match up with the power and fuel efficiency of the diesel. The combined challenge of stringent emission limits and the tight fuel economy requirements will influence petrol technology significantly in the future.

The limited pollution inventory information available for India shows that petrol vehicles are significant contributors of carbon monoxide (CO) and hydrocarbon (HC). Conventionally, direct emissions of HC, especially volatile organic compounds (VOCs), CO and NOx from petrol driven vehicles have driven regulations worldwide. These are also responsible for the formation of O3. Evaporative losses also add to the overall HC emissions from petrol driven vehicles. In Delhi, their contribution is expected to be as high as 70 percent of the CO emissions from all sources. In recent years, however, the trend in CO emissions has got delinked from the rapidly rising vehicle numbers in Delhi. The CO levels have reduced significantly, showing the impact of technology development.[135]

The dominant regulatory approach in India and worldwide is to set limits for CO, HC and NOx emissions. Petrol is more volatile compared to diesel and results in high evaporative losses. To control this problem evaporative standards are also set. European

[135] Anumita Roychowdhury, Vivek Chattopadhyaya, Chirag Shah & Priyanka Chandola, *A Technology roadmap* in Ajit Chak & Souparno Banerjee (ed.), *The Leapfrog Factor: Clearing the Air in Asian Cities,* Centre for Science and Environment (CSE), 2006, at p. 170.

norms that India follows do not have any special standards for emissions of air toxics, such as benzene, from vehicles which are feared to be at unacceptable levels.

The regulatory approach to control emissions from petrol vehicles is best illustrated by the trends observed in the US. The most stringent regulatory measures adopted to cut petrol emissions in the US has enable nearly 90 percent reduction in petrol emissions from uncontrolled levels.[136]The US Tier 2 standards that are being phased since 2004 are fuel neutral and very tight for all pollutants including CO, NOx, and non-methane organic gases (NMOG).

However unregulated emissions of air toxics from petrol driven vehicles, that are also carcinogen, remains a source of worry. Toxic HCs and benzene among others are highly toxic and strong carcinogens and studies in US have indicated that motor vehicles are responsible for maximum human exposure to these emissions. They still pose nationwide carcinogen risk despite a decline between 1994 and 1999 as found by the National Air toxic Assessment of air toxic inventory data.[137]

The Tier 2 regulations are expected to address this problem to some extent. For the first time new toxic pollutants have been added under the Tier 2 norms and the USEPA has estimated the reduction in exposure to the air toxics for the entire population in 47 States. This kind of detailed risk assessment of petrol emissions is not available in India.

Timely suitable measures like de-regularising fuel prices by the government will help in curbing the rise in the number of vehicles run on conventional fuels in general and diesel-powered vehicles in particular.

Globally, the fundamental transition in petrol technology is marked by death of the carburettor in cars that had heralded the global automobile era. Development of the fuel injection and

[136] Anon, "Environmental Impact", *Regulatory impact Analysis – Control of Air Pollution from New Motor Vehicles: Tier 2 Motor Vehicle Emission Standards and Gasoline Sulphur Requirements, (1999)*, USEPA, Washington DC.

[137] Anon, 'Cleaner Air', *Draft Report on Environment*, USEPA, Washington DC, p. 17, 24.

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[137] Anon, 'Cleaner Air', *Draft Report on Environment,* USEPA, Washington DC, p. 17, 24.

electronic control systems along with three way catalytic converters (TWCs) have significantly lowered petrol emissions – achieving a remarkable 90-95 percent reduction in HC and CO and 80-90 percent in NOx.

Changes in India are in consistent with the global experience. The initial transition from pre-Euro to Euro-I standards followed the predictable route – optimisation of the carburettor that governed the fuel metering in older petrol engines, intake and exhaust combustion optimisation, improved catalytic converters and positive crankcase system.[138]

The advent of the Euro-II standards saw the death of the carburettor technology overnight in passenger cars as it was replace with the superior fuel injection system. By 2000 more than 80 percent of cars changed over to the multi-port fuel engine (MPFI) system. A complete makeover soon followed. Even exhaust gas recirculation (EGR) and multi-valve systems began to feature in these models at this stage. Two-way catalytic converters were replaced with TWCs with closed-loop system. The wide gamut of changes that the MPFI made possible improved driveability, better fuel economy and emissions.

Euro-III has witnessed further progress along the global patterns of technology change covering engine design, combustion conditions and after-treatment systems. Improved TWCs with closed-loop control, exact fuel metering by electronically-controlled fuel injection and ignition, special measures for reducing cold-start and idling emissions and applications of EGR, are among the key features. The focus continues to remain on better injectors and optimising for more precise control of the amount and timing of fuel injection.

Among the major petrol car producers, NMUL, which dominated the market for mini and compact vehicles, informs that its key improvements including redesigning of ther exhaust system with the introduction of closed-couple catalysers, commonly called

[138] Anon, *Report of the Expert Committee on Auto Fuel Policy (2002)*, Government of India, New Delhi; N. Darkar, 'Vehicle Technology', *Urban Transport Journal,* Institute of urban Transport, New Delhi, Vol. 4, No.1.

maniverters.[139] In certain cases an additional maniverter has been added to the under floor catalyser to help in emissions control.[140]

According to company sources, MUL has also introduced the 32-bit microprocessor as part of the electric control module technology in most of the models complying with Euro-III emission standards. In certain models, EGR had been added to improve emission control and also achieve better fuel efficiency. A big thrust was on improving the effectiveness of the catalytic converters. They have further improved the evaporative emissions control systems.

Hyundai, a close competitor in this segment, maintains that the changes in 2005 in the most popular compact model, Santro, were largely incremental and not made solely for the purpose of meeting the Euro-III standards. The company has focussed on modifying the precious metal content of the catalyst. Modifications have also been made in the electronic control units to improve engine, intake and exhaust system.

Increasingly, as is evident from the developments in India, the role of after-treatment devices is assuming great significance in lowering of emissions from petrol cars. Catalytic converters, in use since 1975 in the US, have undergone radical improvements. The original version – the two-way catalysts – could clean only CO and HC by oxidising them. Subsequently, TWCs emerged that are additionally capable of reducing NOx. The catalysts require precise stoichiometric air-to-fuel ratio for the optimum conversion efficiency. The current catalyst technologies can also effectively clean highly reactive HCs. It is estimated that worldwide, 85 percent of new petrol vehicles are equipped with a TWCs. Keeping these emission control devices functional and effective during useful lifetime of the vehicles is important.

As noticed in the case of diesel vehicles as well, the most disappointing and glaring omission in Indian emissions regulations is the absence of a legal mandate for on-board diagnostic control

[139] Anon, Corporate Communications Department, Maruti Udyog Limited, *Personal Communication* (2005).
[140] *Ibid.*

to self-diagnose problems in emissions control systems. Euro III emission standards are already in application in the 13 cities of India since 1st April 2005 without these provisions and Euro IV emission standards are already notified since 1st April 2010 in the major cities whereas Euro III norms have been applicable all over India. Technology experts lament that these systems that are already mandated in Europe and in vogue in the US, in all light-duty petrol models since 1996, should have been an integral part of the engine development in India.

Euro III upgrades are incremental. On the whole, the industry watchers feel that at the time of widespread transition from carburettor to fuel injection system, that began in 2000 to meet the Euro II norms, the industry could have taken a big leap directly from Euro I to Euro III and then quickly moved to Euro IV then. That would have saved time and reduced emissions.

GASEOUS FUEL (CNG & LPG): gaseous fuels – natural gas and Liquified petroleum gas (LPG) – have opened up opportunities in Asia to sidestep conventional polluting technologies of diesel and petrol. Both natural gas and LPG have the potential to cut particulate emissions from vehicles to negligible levels. The choice of natural gas in some countries in Asia, which have abundant gas reserves, is also propelled by energy security concerns.

While both natural gas vehicle (NGV) and LPG vehicle programmes are being driven by public health imperatives, their nature and scope of applications are very different. Natural gas is used in heavy duty and light-duty vehicles; use of LPG is predominant in small vehicles. Both have their unique challenges and prospects requiring independent assessment.

The application of natural gas, especially in buses, which is emerging as the new growth area in Asian cities, lends a unique character to NGV programmes and presents an opportunity to combat toxic diesel emissions. Delhi has implemented one of the largest natural gas bus programmes within a very short span of time. The credit for this goes, unanimously, to the environmentalist lawyer, Shri M.C.Mehta, The Supreme Court and the Environment Protection and Control Authority headed by the retired bureaucrat Shri Bhurelal, in that order. This has exercised a considerable impact on the city's air. Delhi's programme therefore, presents the most valuable learning curve in this region. The unique approach of linking the programme with the public transportation augmentation plan has helped attain an economy of scale. By continually working on emissions and safety regulations, Delhi could push conversion technology towards improvement.

Any new programme is expected to encounter operational difficulties that require immediate corrective action through constant monitoring. Without a clear roadmap, weak emission and safety regulations, inadequate enforcement, poor infrastructure and adhoc certification procedures can undermine the emerging programmes that otherwise promise enormous benefits.

Unlike the industrialised West – that is fast moving towards stringent fuel-neutral standards, dispensing with the need to take a fuel-based approach – Asian cities will continue to depend on a fuel substitution strategy to meet immediate air quality objectives. While there is a lot of excitement about the prospects of these programmes, progress is inexplicably very slow. The Indian government has failed to frame an integrated policy to develop gaseous fuels as a transport energy system with appropriate emissions, pricing and enforcement regulations to make the programmes sustainable.

The easy availability of natural gas has encouraged many countries to implement Natural gas vehicle (NGV) programmes. This has provided an immediate opportunity to reduce oil dependency as well as clean up vehicular emissions. The NGV market is growing continually compared to the more entrenched technologies of diesel and petrol.

Natural gas is essentially 80 to 95 percent methane and occurs naturally in underground reserves. Compression is the most common method for delivering natural gas for vehicle use. For automotive application, it must be either be compressed to 3,000 to 3,600 pounds per square inch or Liquified through super cooling to -161 degrees Centigrade (-327.2 degrees Fahrenheit) as Liquified natural gas (LNG).[141]

CNG engines are essentially spark ignition ones, the same as in petrol vehicles. CNG is more popular for short-range medium-duty applications (such as running city and school buses) and heavy-duty applications such as operating street sweepers and garbage trucks. Because of its lower fuel density, CNG is not considered a practical fuel for long distance heavy-duty truck applications. For long-range applications, LNG is the preferred fuel[142] though LNG application has begun in other parts of the world; it has not yet been initiated in India. Current Indian NGV programmes are based CNG.

There are, however, two broad approaches to use natural gas in internal combustion (IC) engines that have a bearing on emissions profile, fuel economy and power – stoichiometric and lean burn. Stoichiometric engines are similar to petrol engines: they operate with air/fuel mixture containing enough oxygen to completely burn the fuel. As a result, there is very little, if any, 'extra' oxygen left in the exhaust.[143] Worldwide, most light-duty NGV have stoichiometric engines. The overall efficiency of these engines is similar to petrol ones. But compared to most turbocharged diesel engines, these have low power. Hence, traditionally, their application has found only in light-duty vehicles such as cars.

Stoichiometric operation of engines allows the use of three-way exhaust catalyst (TWCs) like those in modern petrol engines, which can dramatically reduce CO, NOx and HC emissions. The combination of stoichiometric engines and TWCs has also been adapted to heavy-duty engines that show significant emissions reduction potential. Graduating to multi port injection (MPI) type stoichiometric engines improves engine efficiency comparatively,

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141 Anon, *New Engine Technologies*, Extension Energy Programme (2004), Washington state University, Washington DC, USA.

142 Anon, *New Engine Technologies*, Extension Energy Programme (2004), Washington state University, Washington DC, USA.

143 Anon, *Natural Gas used for Transportation: best practices for achieving optimal emissions reductions (2005)*, Northeast States Centre for Clean Air Future, International Council on Clean Transportation, M.J. Bradley and Associates, USA, p.4

and if fitted with TWC, emissions can be reduced further.[144] The non-turbocharged stoichiometric gas engines are relatively tolerant of natural gas impurities and can, therefore, operate with a wider range of fuel quality.[145]

Lean burn engines, on the other hand, operate by putting more air into the cylinder than is needed to burn the fuel. This excess air lowers the peak combustion temperature, thus reducing both NOx and PM emissions. This allows a much higher compression ratio, thereby increasing the efficiency compared to a typical throttled stoichiometric engine. Lean engines have more power than stoichiometric ones. They operate more like diesel engines. The carburettor-type lean burn engine has better fuel economy compared to the carburettor type stoichiometric CNG engine, though there is a little difference in the durability and the cost of the two.[146]

In the US, most natural gas engines used in heavy-duty vehicles like buses and trucks are turbocharged lean burn engines. The European fleet has stoichiometric and lean burn natural gas engines in comparable strength. Both natural gas engines (and lean burn) require precise control of the air-to-fuel ratio to ensure low emissions and peak fuel engine efficiency.

In India, bus manufacturers had to confront these choices while deciding the technology options. Both Tata Motors and Ashok Leyland have opted for stoichiometric CNG engines. Ashok Leyland opted for the stoichiometric technology with a TWC. Fuel quality was one of the major factors for this decision. In Delhi, the methane content in CNG was found to be less than 90 percent. Therefore, lean burn technology, which is sensitive to the low methane content, was ruled out according to R. Devarajan, special Director, Ashok Leyland. Indian engines use mechanical air-to-fuel

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[144] Masaki Okada, *Development of CNG direct injection diesel cycle engine (2004),* Paper presented at the Conference 'NGV 2004', International Association for Natural Gas Vehicles, Buenos Aires, Argentina, October 26-28, 2004.

[145] Anon, *Natural Gas used for Transportation: best practices for achieving optimal emissions reductions (2005),* Northeast States Centre for Clean Air Future, International Council on Clean Transportation, M.J. Bradley and Associates, USA, p.4

[146] Masaki Okada, *Development of CNG direct injection diesel cycle engine (2004),* Paper presented at the Conference 'NGV 2004', International Association for Natural Gas Vehicles, Buenos Aires, Argentina, October 26-28, 2004.

proportioning and mixing systems with electronic 'trim' of the air-to-fuel ratio, based on the feedback from exhaust oxygen sensors. They also use TWC, Which controls emissions of CO, NOx and HC.A study carried out for Centre for Science and Environment, Delhi[147]found that heavy-duty lean burn CNG engines used in Europe and the US generally exhibit greater power output and fuel efficiency than stoichiometric engines planned for Indian buses.[148] But they also concurred that that the immediate choice of a stoichiometric engine with a good TWC was appropriate for meeting the objective of emissions reduction as it could easily and readily make particulate matter (PM) emissions negligible. Vehicles fitted with these engines have proven to be far more cleaner compared to diesel buses in terms of PM and NOx emissions.[149]

Globally, NGVs, depending on the type of fuel systems (mechanical or electronic fuel metering), have successively evolved through four generations: the first generation with mechanical fuel metering and no feedback, the second with mechanical fuel metering and close-loop electronic lambda control (alternatively, fuel injection and no feedback), and the third with fuel injection and closed-loop control.[150]

The fourth generation technology with on-board diagnostic (OBD) capabilities has been made commercially available now. Researchers say that application of direct injection or multi- port fuel injection (MPFI) can improve engine efficiency. In fact, a CNG engine which has a direct injection along with a pilot fuel one is the most reliable and efficient. However, it is also more complex and expensive.[151]

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147 A *Study* was conducted by Christopher Weaver, President, fuel and Emissions Engineering Inc, Sacramento, USA; Lennart Erlandsson, manager, Air Quality at the Motor test Centre, Sweden and Frank Dursbeck, formerly with TUV, Germany, on CNG technology for CSE in 2001.

148 Frank Dursbeck *et al*, *Status of Implementation of CNG as a fuel for Urban Buses in Delhi (2001)*, CSE, New Delhi, p. 13.

149 *Ibid.*

150 Nils-Olof Nylunds & Alex Lawson, *Exhaust emissions from natural Gas engines, Issues related to Engine performance, Exhaust Emissions and Environmental Impacts (2000)*, A report for the IANGV technical committee, International Association for Natural Gas Vehicles, Auckland, New Zealand, p.36.

151 Masaki Okada, *Development of CNG direct injection diesel cycle engine* (2004), Paper presented at the Conference 'NGV 2004', International Association for Natural Gas Vehicles, Buenos Aires, Argentina, October 26-28, 2004.

Indian technology is closer to the global second generation technology. The Indian experience shows that even second generation technologies, the particulate emissions benefit of replacing conventional diesel is quite significant. It is, however, important to understand the emissions reduction potential and challenges of NGV programme, so that appropriate emissions regulations can be crafted to drive technology and maximise emissions benefits.

Alternative Fuels

BIOFUELS:[152] Biofuels are a wide range of fuels which are in some way derived from biomass. The term covers solid biomass, liquid fuels and various biogases. Biofuels are gaining increased public and scientific attention, driven by factors such as oil price spikes, the need for increased energy security, and concern over greenhouse gas emissions from fossil fuels.

Bioethanol is an alcohol made by fermenting the sugar components of plant materials and it is made mostly from sugar and starch crops. With advanced technology being developed, cellulosic biomass, such as trees and grasses, are also used as feedstocks for ethanol production. Ethanol can be used as a fuel for vehicles in its pure form, but it is usually used as a gasoline additive to increase octane and improve vehicle emissions. Bioethanol is widely used in the USA and in Brazil.

Biodiesel is made from vegetable oils, animal fats or recycled greases. Biodiesel can be used as a fuel for vehicles in its pure form, but it is usually used as a diesel additive to reduce levels of particulates, carbon monoxide, and hydrocarbons from diesel-powered vehicles. Biodiesel is produced from oils or fats using transesterification and is the most common biofuel in Europe.

Biofuels provided 1.8% of the world's transport fuel in 2008. Investment into biofuels production capacity exceeded $4 billion worldwide in 2007 and is growing.

Most transportation fuels are liquids, because vehicles usually require high energy density, as occurs in liquids and solids. High

[152] *http://en.wikipedia.org/w/index.php?title=Biofuel&action* accessed and viewed on July 14, 2010.

power density can be provided most inexpensively by an internal combustion engine; these engines require clean burning fuels, to keep the engine clean and minimize air pollution.

The fuels that are easiest to burn cleanly are typically liquids and gases. Thus liquids (and gases that can be stored in liquid form) meet the requirements of being both portable and clean burning. Also, liquids and gases can be pumped, which means handling is easily mechanized, and thus less laborious

First-generation biofuels - are biofuels made from sugar, starch, vegetable oil, or animal fats using conventional technology. The basic feedstocks for the production of first generation biofuels are often seeds or grains such as sunflower seeds, which are pressed to yield vegetable oil that can be used in biodiesel, or wheat, which yields starch that is fermented into bio-ethanol. These feedstocks could instead enter the animal or human food chain, and as the global population has raised their use in producing biofuels has been criticised for diverting food away from the human food chain, leading to food shortages and price rises.

Second generation biofuels - Cellulosic ethanol production uses non-food crops or inedible waste products and does not divert food away from the animal or human food chain. Lignocellulose is the "woody" structural material of plants. This feedstock is abundant and diverse, and in some cases (like citrus peels or sawdust) it is in itself a significant disposal problem.

Producing ethanol from cellulose is a difficult technical problem to solve. In nature, ruminant livestock (like cattle) eat grass and then use slow enzymatic digestive processes to break it into glucose (sugar). In cellulosic ethanol laboratories, various experimental processes are being developed to do the same thing, and then the sugars released can be fermented to make ethanol fuel. In 2009 scientists reported developing, using "synthetic biology", "15 new highly stable fungal enzyme catalysts that efficiently break down cellulose into sugars at high temperatures", adding to the 10 previously known.[28] In addition, research conducted at TU Delft by Jack Pronk has shown that elephant yeast, when slightly modified can also create ethanol from non-edible ground sources (e.g. straw).

Third generation biofuels - Algae fuel, also called oilgae or third generation biofuel, is a biofuel from algae. Algae are low-input, high-yield feedstocks to produce biofuels. Based on laboratory experiments, it is claimed that algae can produces up to 30 times more energy per acre than land crops such as soybeans,[153] but these yields have yet to be produced commercially. With the higher prices of fossil fuels (petroleum), there is much interest in algaculture (farming algae). One advantage of many biofuels over most other fuel types is that they are biodegradable, and so relatively harmless to the environment if spilled. Algae fuel still has its difficulties though, for instance to produce algae fuels it must be mixed uniformly, which, if done by agitation, could affect biomass growth.

Second and third generation biofuels are also called advanced biofuels.

SOME OF THE MOST COMMON FORMS OF BIOFUELS:[154]

Bioalcohols - Biologically produced alcohols, most commonly ethanol, and less commonly propanol and butanol, are produced by the action of microorganisms and enzymes through the fermentation of sugars or starches (easiest), or cellulose (which is more difficult). Biobutanol (also called biogasoline) is often claimed to provide a direct replacement for gasoline, because it can be used directly in a gasoline engine (in a similar way to biodiesel in diesel engines).

Ethanol fuel is the most common biofuel worldwide, particularly in Brazil. Ethanol can be used in petrol engines as a replacement for gasoline; it can be mixed with gasoline to any percentage. Most existing car petrol engines can run on blends of up to 15% bioethanol with petroleum/gasoline. Ethanol has a smaller energy density than gasoline, which means it takes more fuel (volume and mass) to produce the same amount of work. An

153 Eviana Hartman, *A Promising Oil Alternative: Algae Energy* in *The Washington Post*, January 6, 2008.

154 *http://en.wikipedia.org/w/index.php?title=Biofuel&action* accessed and viewed on July 14, 2010.

advantage of ethanol (CH_3CH_2OH) is that it has a higher octane rating than ethanol-free gasoline available at roadside gas stations which allows an increase of an engine's compression ratio for increased thermal efficiency. In high altitude (thin air) locations, some states mandate a mix of gasoline and ethanol as a winter oxidizer to reduce atmospheric pollution emissions.

Many car manufacturers are now producing flexible-fuel vehicles (FFV's), which can safely run on any combination of bioethanol and petrol, up to 100% bioethanol. They dynamically sense exhaust oxygen content, and adjust the engine's computer systems, spark, and fuel injection accordingly. This adds initial cost and ongoing increased vehicle maintenance. As with all vehicles, efficiency falls and pollution emissions increase when FFV system maintenance is needed (regardless of the fuel mix being used), but is not performed. FFV internal combustion engines are becoming increasingly complex, as are multiple-propulsion-system FFV hybrid vehicles, which impacts cost, maintenance, reliability, and useful lifetime longevity.

Even dry ethanol has roughly one-third lower energy content per unit of volume compared to gasoline, so larger/heavier fuel tanks are required to travel the same distance, or more fuel stops are required.

Methanol is currently produced from natural gas, a non-renewable fossil fuel. It can also be produced from biomass as biomethanol. The methanol economy is an interesting alternative to the hydrogen economy, compared to today's hydrogen produced from natural gas, but not hydrogen production directly from water and state-of-the-art clean solar thermal energy processes.

Butanol is formed by ABE fermentation (acetone, butanol, ethanol) and experimental modifications of the process show potentially high net energy gains with butanol as the only liquid product. Butanol will produce more energy and allegedly can be burned "straight" in existing gasoline engines (without modification to the engine or car), and is less corrosive and less water soluble than ethanol, and could be distributed via existing infrastructures.

Green diesel[155] - Green diesel, also known as renewable diesel, is a form of diesel fuel which is derived from renewable feedstock rather than the fossil feedstock used in most diesel fuels. Green diesel is not to be confused with biodiesel which is chemically quite different and processed using transesterification rather than the traditional fractional distillation used to process green diesel.

Green diesel feedstock can be sourced from a variety oils including canola, algae, jatropha and salicornia in addition to tallow.

Biodiesel[156] - In some countries biodiesel is less expensive than conventional diesel. Biodiesel is the most common biofuel in Europe. It is produced from oils or fats using transesterification and is a liquid similar in composition to fossil/mineral diesel. Chemically it consists mostly of fatty acid methyl (or ethyl) esters (FAMEs). Oils are mixed with sodium hydroxide and methanol (or ethanol) and the chemical reaction produces biodiesel (FAME) and glycerol. One part glycerol is produced for every 10 parts biodiesel. Feedstocks for biodiesel include animal fats, vegetable oils, soy, rapeseed, jatropha, mahua, mustard, flax, sunflower, palm oil, hemp, field pennycress, pongamia pinnata and algae.

Pure biodiesel (B100) is by far the lowest emission diesel fuel. Although liquefied petroleum gas and hydrogen have cleaner combustion, they are used to fuel much less efficient petrol engines and are not as widely available.

Biodiesel can be used in any diesel engine when mixed with mineral diesel. The majority of vehicle manufacturers limit their recommendations to 15% biodiesel blended with mineral diesel.

In some countries manufacturers cover their diesel engines under warranty for B100 use. Although Volkswagen of Germany, for example, asks drivers to check by telephone with the VW environmental services department before switching to B100. B100 may become more viscous at lower temperatures, depending on the feedstock used, requiring vehicles to have fuel line heaters. In most cases, biodiesel is compatible with diesel engines from 1994

[155] *http://en.wikipedia.org/w/index.php?title=Biofuel&action* accessed and viewed on July 14, 2010.
[156] *http://en.wikipedia.org/w/index.php?title=Biofuel&action* accessed and viewed on July 14, 2010.

onwards, which use 'Viton' (by DuPont) synthetic rubber in their mechanical injection systems.

Electronically controlled 'common rail' and 'pump duse' type systems from the late 1990s onwards may only use biodiesel blended with conventional diesel fuel. These engines have finely metered and atomized multi-stage injection systems that are very sensitive to the viscosity of the fuel. Many current generation diesel engines are made so that they can run on B100 without altering the engine itself, although this depends on the fuel rail design.

Since biodiesel is an effective solvent and cleans residues deposited by mineral diesel, engine filters may need to be replaced more often, as the biofuel dissolves old deposits in the fuel tank and pipes. It also effectively cleans the engine combustion chamber of carbon deposits, helping to maintain efficiency. In many European countries, a 5% biodiesel blend is widely used and is available at thousands of gas stations. Biodiesel is also an *oxygenated fuel*, meaning that it contains a reduced amount of carbon and higher hydrogen and oxygen content than fossil diesel. This improves the combustion of fossil diesel and reduces the particulate emissions from un-burnt carbon.

Biodiesel is safe to handle and transport because it is as biodegradable as sugar, 10 times less toxic than table salt, and has a high flashpoint of about 300 F (148 C) compared to petroleum diesel fuel, which has a flash point of 125 F (52 C).

In the USA, more than 80% of commercial trucks and city buses run on diesel. The emerging US biodiesel market is estimated to have grown 200% from 2004 to 2005. "By the end of 2006 biodiesel production was estimated to increase fourfold [from 2004] to more than 1 billion gallons"

In India biodiesel is being used in part of the bus fleet of the various State Transport Corporations. Madhya Pradesh State Transport Corporation was the pioneer among the State transport corporations in this endeavour.

ALTERNATE FUELS IS THE FUTURE: In the future the number of automobiles is going to increase to such an extent that despite the maximum technological possible reduction in emissions from conventional internal combustion engines, air pollution from vehicles will remain a highly potent threat to the public health. This is because there is a limit to the emission efficiency as far as conventional internal combustion engines running on conventional fuels are concerned. Even if technological advancement reaches its pinnacle, emissions will always take place. The only option left, in such a scenario, is the alternate fuelled vehicle. With alternate fuelled vehicles, the dream of producing zero emission vehicles becomes real. Alternative fuelled vehicles hold the key to the future of the automobile industry.

While technological improvement in engine design and pollution control equipment will without a doubt, have an impact on pollution and emissions, its success, to a large extent, depends on the quality and nature of fuel used by the vehicle.

Fuels are the source not only for providing the energy for moving the vehicle but also for chemicals whose combustion emit many toxic gases and particulates. These emissions have taken a heavy toll on human health and environment. To make matters worse, fuel as indispensible it is to give life to a vehicle, is also a resource whose supply is dependent on nature.

As is the common practice, India has woken up to harsh reality after much damage has been done and is trying to cope with bringing the changes simultaneously in technology and fuel quality.

Basically, automotive fuels can be classified into conventional fuels as well as what has come to be known as alternate fuels.

1. Conventional fuels are predominantly fossil fuels. Petrol and diesel are the main fuels in this category.
2. Alternated fuels can be both fossil fuel origin like compressed natural gas (CNG) and liquified petroleum gas (LPG) and non-fossil fuel origin like:

- Methanol and denatured ethanol as alcohol fuels (alcohol mixtures that contain no less than 70 percent of the alcohol fuel.
- Hydrogen fuels[157]
- Electricity
- Solar energy
- Biodiesel

The chemical properties of various alternative and conventional fuels are given below:[158]

(Table 6.16)

PROPERTIES OF FUEL

Property	Petrol	Methanol	Ethanol	CNG	Hydrogen
Chemical Formula	C_4-C_{12}	CH_3OH	C_2H_5OH	CH_4	H_2
Molecular Weight	100-105a	32.4	46.07	16.04	2.02_x
Composition (weight) - Carbon - Hydrogen	85-88 12-15	37.5 12.6	52.2 13.1	75 25	0 100
Octane No.	86-94	100	100	120+	130+ RON
Stoichiometric Air/fuel weight	14.7	6.45	9.0	17.2	34.3

Conventional fuels, the most common fuel used all over the world, have the following advantages over alternate fuels:

- Higher energy density content than other fuels.
- Economical as their mere scale of operations makes them less expensive.
- Supported by vast infrastructure including refineries, gas stations, etc. However most of the advantages of conventional fuels are superficial and thus their

[157] Hydrogen can be used as motor vehicle fuel through *Fuel Cells.* A fuel cell combines hydrogen and oxygen to produce electric current that may be used to run vehicles. Some of the fuel cells proponents believe thew technology has matured enough for use in larger scale whereas others argue that costs, raw materials and infrastructure to sustain the use of such cells still needs to be addressed through more research.

[158] *Alternate Fuels and Alternate fuelled Vehicles (Chapter 8)*, "Green Rating Project: Environmental Rating of Indian Automobile Sector (2001)", A Centre for Science and Environment (CSE) Study Report, p. 211

disadvantages of conventional fuels over alternate fuels overwrite all its advantages.

The major disadvantage of conventional fuel is that emissions, which contribute to air pollution, ozone depletion and global warming.

The advantages of alternate fuels are:

- Potential to reduce by 50 to 90 percent or more the number of cancers currently caused due to vehicle air toxic emissions[159]
- Potential to reduce emissions from the vehicles, for example, the emissions from CNG vehicles are estimated to be 20 percent compared to 100 percent emissions from vehicles using reformulated gasoline. CNG vehicles demonstrate very high reduction in ozone-forming emissions.

Disadvantage of alternate fuels is their vehicle range is less and their cost is high, especially during their initial use when modifications would be needed in the transportation infrastructure.

(Table 6.17).

ALTERNATE FUEL PROS AND CONS[160]

FUEL	ADVANTAGES	DISADVANTAGES
Electricity	• Potential for zero emissions from vehicles • Power plant emissions easier to control • Can recharge at night when power demand is low	• Current technology is limited • Higher cost; lower vehicle range, performance • Less convenient refuelling
Ethanol	• Excellent automotive fuel • Very low emissions of HC and toxics • Made from renewable resource • Can be domestically	• High fuel costs at low scale operation • Somewhat lower vehicle range, but only marginal • Extremely limited

[159] *Source:* United States Environment Protection Agency (1993).
[160] *Green Rating Project*, A CSE Study Report (2003).

	prepared in India	refuelling infrastructure currently
Methanol	• Excellent automotive fuel • Very low emissions of ozone forming HC and toxics • Made from renewable resources • Can be made from a variety of feedstock's, including renewables	• Fuel could initially be imported • Somewhat lower vehicle range • Extremely limited refuelling infrastructure currently
Natural gas(Methane)	• Very low emissions of HC, toxics and CO • Made from a variety of feedstock's, including renewables • Excellent fuel, especially for fleet vehicles	• Higher vehicle cost • Lower vehicle range • Less convenient refuelling • Extremely limited refuelling infrastructure
Hydrogen	• Obtained from water thus having tremendous potential to become cleanest source of energy • Almost zero pollution • Provides high-energy conversion processes and is compatible with essentially all energy uses.	• Technology has not reached commercial stage • Current storage and distribution system not suitable, needs to be developed • Major investments in research and development

There has been considerable effort to produce cleaner conventional fuels by modifying them (such as oxygenated gasoline, reformulated gasoline, etc.), but the result was not effective to reduce pollution in a significant manner. The only option left for reducing emissions from vehicles is by replacing the conventional fuels with alternative fuels.

The consumption of conventional fuels like petrol and diesel by motor vehicles in India is almost 100 percent with minimal use of alternate fuels. In recent times, though due to judicial pressure,[161] there is a slow shift towards the use of CNG in metropolitan cities.

While conventional fuels are chemical based and are processed from fossil of plants and animal life created over centuries, alternate fuels are substantially non-petroleum based and yield energy security and environmental benefits.

Fuel Adulteration

When the whole community concerned with the running of vehicles and its consequences in the form of pollution, etc, talking about fuel adulteration cannot be irrelevant. Fuel adulteration has been a problems for decades and one of its main causes is the fluctuating price of petrol and diesel in the conventional fuel mode. In mid-2008 fuel prices soared to $US 140 per barrel in the international markets when the economic trajectory of most countries, which obviously is dependent on oil, went haywire. Most of the revenue receipts of these countries went in putting the balance of payments right. India's plight was more amplified because of the subsidy already given by the government in oil, that is, petrol, diesel, kerosene, liquified petroleum gas (cooking gas) cylinders. The situation obviously, though not completely, raised the fuel prices in the country. This further emboldened the fuel adulterators to maximise their stock. These people in the form of petrol dealers, petrol carriers, small scale vendors (in the small villages and hamlets where there were no regular petrol pumps), etc. took advantage of the economic stalemate. The irony was that popular vehicular fuel like petrol and diesel were mixed with kerosene that was being purchased by them (the adulterators) in the rate subsidised by the government. The scenario was very dim for the purpose of controlling and preventing pollution from vehicles, more so from those vehicles using the adulterated fuels. This was a big blow to the country's agenda of promoting and strengthening sustainable automobile use.

[161] *MC Mehta v Union of India,* arising out of WP (C) No. 13029 of 1985 and the constitution of the Environment Pollution (Prevention and Control) Authority on January 28, 1998 vide one of its several orders.

There are laws[162] to prohibit this practice already in place and it is for the enforcement agencies to implement them to its logical end. This practice of fuel adulteration has not only attempted to defeat the measures of curbing vehicular pollution but it also has a large and distinctive economic implication for the country.

There is laws made earlier in respect to fuel, especially petroleum. The Petroleum Act, 1934[163] and other allied laws[164] with their relevant Rules[165] were laws relating to petroleum and natural gas, but they were more concerned with the economic or trade aspects, such as exploration, refinery, transportation, distribution, storage and other like matters. These laws have been looked into considerably but some important matter relevant to the present study was found in Chapter two of the Petroleum Act, 1934, which deals with testing of petroleum. The provisions of the said chapter is included within eight sections, namely section 14 to 22, and proper application of these sections will have far reaching effects in checking of adulteration of petroleum products, petrol and diesel, at the fuel stations.

Chapter two of the abovementioned Act lays down the procedure for testing of petroleum. Section 14 deals with Inspection and sampling of petroleum wherein the Central Government may, by notification in the Official Gazette, authorize any officer by name or by virtue of office to enter any place where petroleum is being imported, transported, stored, produced, refined or blended and to inspect and take samples for testing of any petroleum found therein. The Central Government may make rules- (a) regulating the taking of samples of petroleum for testing; (b) determining the cases in which payment shall be made for the value of samples taken, and the mode of payment, and (c)

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162 One of the most relevant legislation for the control of fuel adulteration or supply of impure oils is dealt with by the *Essential Commodities Act, 1955 (E.C.Act).*There are various Petroleum Control orders of both the Central and the State governments under the Essential Commodities Act, 1955. Petroleum products can be brought under the definition of 'Goods' and as such action can be brought under the Consumer (Protection) Act, 2002 against the dealer selling spurious petrol and diesel.

163 Act No.30 of 1934

164 *The Oilfields (Regulation & Development) Act,1948; The Oil Industry (Development) Act, 1974; The Petroleum and Minerals Pipelines Act, 1962.*

165 *The Petroleum Rules of 1976*

generally, regulating the procedure of officers exercising powers under this section.

A Standard Test Apparatus is to be used for testing of samples of petroleum, which is government issue. This apparatus is to be verified of its correctness from time to time and should be open for inspection regarding its correctness for which prescribed fees are to be paid.[166] According to section 17 of the Act the Central Government may authorize any officer by name or by virtue of office to test petroleum of which samples have been taken under this Act, or which may have been submitted to him for test by any person, and to grant certificates of the results of such tests. The testing officer after testing samples of petroleum shall make out a certificate in the prescribed form, stating whether the petroleum is petroleum Class A or petroleum Class B or petroleum Class C, and if the petroleum is petroleum Class B or petroleum Class A, the flash-point of the petroleum.[167] The testing officer shall furnish the person concerned, at his request, with a certified copy of the certificate, on payment of the prescribed fee, and such certified copy may be produced in any Court in proof of the contents of the original certificate.[168] A certificate given dl this section shall be admitted as evidence in any Proceedings which may be taken under this Act in respect of the petroleum from which the samples were taken, and shall, until the contrary is proved be conclusive Proof, that the petroleum is petroleum Class A or petroleum class B or petroleum Class C, and, if the petroleum Class B or petroleum Class C, of its flash-point.[169]

The owner of any petroleum, or his agent, who is dissatisfied with the result of the test of the petroleum may, within seven days from the date on which he received intimation of the result of the test, apply to the officer empowered under Sec. 14 to have fresh samples of the petroleum taken and tested.[170] On Such application and on payment of the prescribed fee, fresh samples of the petroleum shall be taken in the presence of such owner or agent or

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[166] Section 15, *The Petroleum Act 1934*.
[167] Section 19 (1) of *the Petroleum Act 1934*
[168] Section 19 (2) of *the Petroleum Act 1934*
[169] Section 19 (3) of *the Petroleum Act 1934*
[170] Section 20 (1) of *the Petroleum Act 1934*

person deputed by him, and shall be tested in the presence of such owner or agent or person deputed by him.[171] If, on such re-test, it appears that the original test was erroneous the testing officer shall cancel the original certificate granted under Sec. 19, shall make out a fresh certificate, and shall furnish the owner of the petroleum, or his agent, with a certified copy thereof, free of charge.[172]

The Central Government has been empowered to make rules in the matters regarding testing of petroleum under the Act to facilitate proper implementation of the enactment[173]

The abovementioned provisions of the Petroleum Act, 1934 would be useful instruments for the cure of impure petroleum products like petrol, diesel and other lubricating oils used in vehicles. Implementation of these provisions would make a positive and drastic change in the present vehicular pollution scenario.

Checking adulteration of fuel under any law or legislation, whatsoever, is an important step towards achieving certain amount of success in sustainable use of automobile.

At this particular juncture, when the whole world in its quest to achieve minimum pollution of the atmosphere to contain global warming and climate change are, in the context of transportation, especially road transport, suggesting the maintenance of fuel quality, transition to alternate fuels and alternate fuelled vehicles together with the corresponding technological amendments, it would be very apt to mention the advantages of the 'Hybrid' vehicles. They are vehicles considered to be an important part of the future vehicle industry, since they decrease fuel consumption without decreasing the performance compared to a conventional vehicle.

Hybrids

Hybrid electric vehicles (HEV) combine the internal combustion (IC) engine with the battery and electric motor of an

[171] Section 20 (2) of *the Petroleum Act 1934*
[172] Section 20 (3) of *the Petroleum Act 1934*
[173] Section 21 of *the Petroleum Act 1934*

electric vehicle. The combination offers significantly improved fuel economy and lower emissions compared to conventional vehicles.[174] The IC engine in a normally configured automobile is abysmally inefficient, delivering 15-20 percent of the energy in gasoline to the wheels. On the other hand, the hybrid, which draws energy from gasoline motors, employ much smaller battery back-ups, generators, electric motors and controllers that help to double the efficiency of the automobile.

Not all HEVs are similar; the term commonly encompasses a wide range of technology configurations offering a similarly wide range of environmental benefits. They come in three varieties: Series, Parallel and dual-mode.

Series Hybrid: These have no direct connection between the engine and the drive wheels. Instead the engine generates electricity, which is used by an electric motor, buffered by batteries. The batteries also allow for high demand operation, allowing the electric motor power to exceed the engines output for short times, and for all electric driving at low-power levels. These are ideal for vehicles that have lots of stop –and-go driving but generally operates at low speeds, for example urban buses.

Parallel Hybrid: These use the petrol engine and the electric motor in concert. It is a combination of motor/generator placed in between the engine and the driveline. It allows for higher power operation and greater fuel efficiency. But they do not decouple the IC engine from the drive line, and therefore, cannot achieve fuel economies as high as the series or the dual-mode. E.g. the Honda Civic.

Dual-mode Hybrid: This can operate in all electric modes, as a straight IC engine, or despatching both power sources. Dual-mode hybrids offer the maximum efficiency, as they can be configured for optimum output under any condition. Dual-mode hybrids are ideal for steady-state highway driving but they are more expensive and complex than series and parallel hybrids. E.g. The Toyota Prius.

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[174] Emma Stromberg, *Optimal Control of Hybrid Electric Vehicles*, Master's Thesis performed in "Vehicular Systems" (Regd. No. LiTH-ISY-EX-3394-2003), 22nd August 2003

The Toyota Prius does not require a key to start. The petrol engine is Toyota's 1.8-litre VVT-I, which makes 98 bhp while the electric motor makes 80 bhp. Both power sources are linked to an epicyclical power splitter that allows each power unit to work separately or together. Power is then transmitted to the front wheels via a variable transmission. The electric motor also acts as a generator and when decelerating and braking, helps in charging the 202-volt nickel hybrid battery. If the battery is fully charged, it can run in electric only mode up to 50 km per hour. As the speed increases the petrol engine turns on almost silently (there is no conventional starter motor) and from then on the car simply where to draw power from, based on the use of the throttle.[175] Among these the best is the dual-mode followed by the parallel and series hybrids, in that order.[176]

The first hybrid car has hit Indian roads – and it's a Honda Civic which will run on both petrol and battery power. Priced at a steep Rs.21.5 lakh (ex-showroom Delhi), the car is powered by a 1.3 ltr petrol engine and an electric motor. India is the 33rd country where the Honda has launched its Civic hybrid. With crude oil projected to surge to $200 a barrel sometime next year from the current $137 and with no commercial viable alternative fuel anywhere in sight, auto aficionados are increasingly drawn by the allure of hybrids. The Honda Civic hybrid's biggest selling point is its fuel efficiency of 19 to 23 km a litre - on par, if not better, than a Maruti Zen or a Hyundai Santro.[177]

The Company said that the hybrid car was 47 percent more fuel efficient than the petrol version. This is because the car draws on petrol or battery power, depending on the speed of the car. The battery charges on its own when the car runs on petrol.[178]

The biggest turn off for the customer is the price – which is more expensive than the executive saloons like Honda Accord or the Toyota Camry. Honda blames it on the high customs duty of

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175 Ouseph Chacko, *Green and Lean*, The Telegraph (Calcutta), July 31, 2010.

176 Michael Walsh & Charlotte J. Pera, *Progress towards Clean Cars, Trucks and Buses (2003)*, "International Council on Clean Transportation", San Francisco, "The Hewlett Foundation" and "The Energy Foundation", San Francisco, USA

177 *Hybrid: high mileage and high price,* The Telegraph, *Calcutta,* June 19, 2008, p.1&4

178 *Ibid*

104 percent that has to be paid on imports of completely built units (CBUs).[179] Recent indications given by the Government on this matter has been positive.[180]

The Central Government may reduce import duty on hybrid vehicles to promote use of eco-friendly cars and help carmakers introduce more such vehicles in India, Union Heavy Industries and Public Enterprises Minister Vilasrao Deshmukh said in New Delhi. "My department will recommend this to the Finance Ministry. We need to discuss modalities in detail to make this happen. Suggestions can come from various stakeholders that we can consider," Mr. Deshmukh told journalists after opening the two-day 'Fourth environmentally friendly vehicles (EFV) conference'.[181]

Mr. Deshmukh said that if India wanted to have green vehicles, it would have to offer concessions to manufacturers of such cars, otherwise nobody would come forward. "We have to give more importance to vehicles which have lesser emissions. We are still to have norms and guidelines that differentiate between hybrid vehicle and normal vehicle; and for that we will wait for the outcome of the conference," he added.

At present, in India, import of all vehicles, including hybrid, attract an import duty of over 100 per cent, making it highly expensive for Indian customers. Earlier some auto majors tried to introduce their hybrid cars in India, but failed due to its high cost because of hefty import duty.[182]

Refineries

Refineries are another aspect, though technological, which has a large bearing on the fuel quality. Indian refineries were reticent about making commitments to supply the matching fuel for Euro IV emissions standards. The government had, therefore, diluted the 2010 deadline for implementation of Euro IV standards proposed by the Dr.Mashelkar headed Auto Fuel Policy

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[179] *Ibid*

[180] *Centre may cut duty on hybrid vehicles,* The Times of India, New Delhi, 20th October, 2009.

[181] *Ibid.*

[182] *Ibid.*

Committee[183]with a rider in the form of a review in 2006, based on the emissions inventory study that was undertaken then. The critics lamented that it was done to build an escape route. This added upto the fact that it was the refinery capacities and not the regulators who will decide the fate of India's technology roadmap.[184]

Given the fact that investments in refineries in the recent years have occurred on a precedented scale while economic reforms have gathered speed, linking up this process with a stringent fuel quality roadmap can maximise environmental benefits. The assessment of the refinery capacities to produce cleaner fuels, therefore, becomes necessary to find ways to tighten the road map.

The implementation of the Euro IV norms in 12 cities including the four metros and Euro III emission standards all over the country[185]from 1st April 2010 together with the deregularisation of the petrol prices from 25th June 2010 and the deregularisation of diesel price in the anvil, an opportunity has been made available to both the Private and government refineries to make quality fuel products and conduct proper pricing on the same.

The credit of bringing a paradigm shift in the peoples' perspective of the effects of air pollution in general and vehicular pollution in particular goes first and foremost to Shri M.C.Mehta, an environmental activist-lawyer and a Magsaysay Award winner. The loose threads of this problem was brought into focus and glare of the Supreme Court by his epoch making petition, namely, Writ Petition (Civil) No. 13029 of 1985, which gave rise to the now popularly known in the Enviro-legal circles as the *M.C.Mehta Cases* and commonly known as the *Delhi Pollution Case*. Further, the Shri Bhurelal headed Environment Pollution (prevention and Control) Authority [EPPCA] for the National Capital Region of Delhi was constituted on January 29, 1998 under Environment

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[183] Please refer *Mashelkar Committee on Auto Fuel Policy* below.

[184] Anumita Roychowdhury, Vivek Chattopadhyaya, Chirag Shah & Priyanka Chandola, *A Technology roadmap* in Ajit Chak & Souparno Banerjee (ed.), *The Leapfrog Factor: Clearing the Air in Asian Cities*, Centre for Science and Environment (CSE), 2006, at p. 188.

[185] Please refer *Tables 8 to 15* above.

(Protection) Act, 1986, by the Central government, unfortunately, on the goading of the Supreme Court.[186] That too arose from the same petition. The mandate of the Apex court to the Authority was to find the root cause of the problem and menace of vehicular pollution in Delhi and the neighbouring areas; and suggest ways and means to curb the same.

Its 'agenda' and 'brief' was to suggest ideas to promote sustainable use of automobile among other things. Thus the findings of the said committee in its report on causes and solutions of vehicular pollution put the fuel quality and technology under scrutiny. They have suggested various measures to improve fuel quality and to shift from the use of conventional fuels, petrol and diesel, to alternate fuels and simultaneous transition to engines compatible with such fuels.

It is pertinent to mention here that among several reports prepared by the abovementioned authority in the matter of curbing the menace of vehicular pollution and paving a way for sustainable automobile use, the Report on Clean Fuels[187] is noteworthy. Some recommendations made in the report are path-breaking in the area of preventing and controlling vehicular pollution through improvement in fuel quality together with the options of alternative fuels and the corresponding technology compatible to use such fuels. The genuininty of the report is manifested by the fact that representations of all stakeholders, in the form of consumers, Auto manufacturers, Fuel dealers, Oil companies, various Transport Corporations (both public and private), NGOs, private individuals interested in the issue, etc. have been taken into consideration while preparing the said report.[188]

Above all this, the backroom inputs and active participation of the Centre for Science and Environment, New Delhi cannot be forgotten. Their goading the government to follow the mandate of

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[186] *M.C.Mehta v Union of India,* AIR 1998 SC 617 & 773.

[187] *Report on Clean Fuels,* a Report prepared and submitted by the "Environment pollution (Prevention and Control) Authority [EPCA]" in response to the Supreme Court Order dated *March 26, 2001 & April 27, 2001* [arising out of W.P.(C) No.13029 of 1985; *M.C.Mehta v Union of India and others*].

[188] The representation made by various bodies and organizations are laid out in *Annexures I & II* of the report.

the Apex Court, their investigative and informative reporting and their scandalous exposures of the Central government's dilly dallying on the issue of fuel quality standards and emission norms have provided fodder for both the Environment Pollution (Prevention and Control) Authority and the Supreme Court in providing pure air to breathe in the people of Delhi, in particular and the citizens of India in general.

Mashelkar Committee on National Auto Fuel Policy

The contribution of the Mashelkar Committee, even though having received heavy criticisms from various quarters, too, cannot be ignored when the subject of fuel quality and corresponding technology is being discussed. The said committee to be headed by Dr. R.A. Mashelkar, then Director General, Council of Scientific and Industrial Research (CSIR) was constituted by the Union government after a meeting held under the Chairmanship of the then Prime Minister, Shri Atal Behari Vajpayee on 30th August 2001 with the objective to frame the "National Auto Fuel Policy".

The Committee was actually constituted on 13th September 2001 to recommend an 'Auto Fuel Policy" for major cities and the rest of the country, to devise a roadmap for its implementation, and recommend auto fuels, automobile technologies and fiscal measures for minimization of the social cost of meeting environmental quality and institutional mechanisms for certifications of vehicles, fuels as also monitoring and enforcement measures.[189] But when last heard, no notification has been issued yet for the implementation of the same. This, among other things, shows the desperation of the government that such drastic reforms in the vehicular fuel and technological arena can spoil its agenda to boost the low-priced automobile market as has been exposed by the Automotive Mission plan 2006-2016 unveiled by the ministry of heavy industries and public Enterprise recently.

RECOMMENDATIONS OF THE COMMITTEE:

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[189] R.S.Bedi & A.S.Bedi, *Encyclopedia of Environment and Pollution Laws: Acts, Rules, Notifications, Policies and Procedures,* Orient Law House, 2002 p. 924.

1. (A) Roadmap for emissions norms for new vehicles and fuel quality (except 2&3 wheelers):

Entire country -

- Bharat stage II norms from April 1, 2005.
- Euro III equivalent norms from April 1, 2010

For cities: Delhi, Mumbai, Kolkata, Chennai, Bangalore, Hyderabad, Ahmedabad, Pune, Surat, Kanpur and Agra -

Bharat stage II norms

- Delhi, Mumbai, Kolkata and Chennai: Already introduced 2000-01
- Bangalore, Hyderabad, Ahmedabad, Pune, Surat, Kanpur, and Agra from April 1, 2003.

Euro III equivalent norms for all vehicles from April 1, 2005.

Euro IV equivalent emissions norms for all vehicles from April 1, 2010.

(B)Roadmap for Two/three-wheelers:

Entire country -

- Bharat stage II norms from April 1, 2005
- Bharat stage III norms preferably from 2008 but not later than April 1 2010

2. Air quality data and research development: Provide funding support for strengthening of the network and the supervision/monitoring of data collection. Surveys and studies on sources of pollution and source apportionment be initiated in polluted cities.

3. Health effects of air pollution: A database linking air pollution/vehicular emissions related diseases and air pollution levels be created for planning. Medical community and other concerned agencies to play an active role in prevention and control of air pollution and adverse health effects. Organise well-designed multicentric epidemiological studies. Set up a core group of experts from ICMR, CPCB, CSIR and MOEF to steer such studies.

4. Vehicle technology: Expeditious implementation of the proposed auto fuel policy in the report. Declaration of fuel economy standards by automobile manufacturers should be made mandatory.

5. Supply of auto fuels: Liquid fuels of specified quality throughout the country. Alternative auto fuels along with liquid fuels in cities with high vehicular pollution. At present stage of development of the infrastructure the committee considers it inadvisable to recommend that city public transport use only gaseous or other non-conventional fuels.

6. Alternative auto fuels: CNG and LPG: Use of these fuels should be encouraged in cities with high levels of vehicular emissions. For safety reasons only fixed fuel tanks be allowed.

7. Other alternative fuels: A comprehensive programme of policy support, R&D support and other measures for zero emissions vehicles should be drawn up. Encourage bio-fuels with policy support for R&D and fiscal incentives. Strengthen certification system for alternative fuels for safety, reliability and durability.

8. Pollution Under Control Testing Centres: New PUC checking system for all categories of vehicles by April 1, 2005. Inspection and maintenance system for categories of vehicles by April 1, 2010. Performance checking system of catalytic converters and conversion kits by April 1, 2007. Augmentation of city public transport by April 1, 2005.

For National capital territory of Delhi: New PUC checking system for all categories of vehicles by October 1, 2003. Inspection and maintenance system for categories of vehicles by April 1, 2005. Performance checking system of catalytic converters and conversion kits by October 1, 2004

In other selected cities (Mumbai, Kolkata, Chennai, Bangalore, Hyderabad, Ahmedabad, Pune, Surat, Kanpur & Agra): New PUC checking system for all categories of vehicles by April 1, 2004. Inspection and maintenance system for categories of vehicles by April 1, 2006. Performance checking system of catalytic converters and conversion kits by April 1, 2005. Finalise plans for augmentation of city public transport by April 1, 2004.

FISCAL REGIME: A onetime budgetary support to the refineries in the north-east for upgradation of fuel quality. Lower custom duty on imported capital goods etc needed for fuel quality improvements and automobile technology, including alternative fuels. Lower excise duty on indigenously manufactured goods for fuel quality improvement. 100 percent depreciation on plant and machinery put up for upgradation of product quality and automobile technology including alternative fuels. Lower customs duty on the imports of CNG and LPG kits, dispensing equipments. Lower duties and taxes on gaseous fuels vis-a-vis liquid fuels. Provide fiscal incentives to both manufacturers and use of electric vehicles Reduction of pollution from in-use vehicles Roadmap for in-use vehicles

INSTITUTIONAL MECHANISM: The existing authorities responsible for enforcing automobile emissions norms and fuel quality standards should be brought under a single new authority – National Automobile pollution and Fuel Authority.

The Cabinet which includes three Ministries, Finance, Petroleum and Surface Transport, cleared the first "National Auto Fuel Policy" laying the roadmap for the next decade on the quality of fuels and the standards for vehicles. According to their policy, the 11 most polluted cities, including the three metros (plus Ahmedabad, Hyderabad, Surat, Pune, Kanpur, Agra and Bangalore), will only catch up with Delhi by 2005, the rest of the country will have to wait for a "review" in 2006 to see if they will get clean fuel and vehicles by 2010. The Cabinet rejected the proposal to set up an independent regulator—as prescribed by the Mashelkar panel—to monitor the implementation of the roadmap. Instead, the state road transport authorities will monitor vehicles; the Petroleum Ministry will ensure fuel quality while the Ministry for Road Transport and Highways will keep a tab on engine specifications. Also, the usage of CNG/LPG would be encouraged in cities affected by high vehicular pollution.

The Government's policy clearly defied the original draft approved by the committee headed by CSIR chief R. A. Mashelkar and endorsed both by the Supreme Court and the Cabinet.

In 2006 Auto Policy, a vision document was prepared by the Government. Its Policy objectives were as follows:

This policy aims to promote integrated, phased, enduring and self-sustained growth of the Indian automotive industry. The objectives are to:-

(i) Exalt the sector as a lever of industrial growth and employment and to achieve a high degree of value addition in the country;

(ii) Promote a globally competitive automotive industry and emerge as a global source for auto components;

(iii) Establish an international hub for manufacturing small, affordable passenger cars and a key centre for manufacturing Tractors and Two-wheelers in the world;

(iv) Ensure a balanced transition to open trade at a minimal risk to the Indian economy and local industry;

(v) Conduct incessant modernization of the industry and facilitate indigenous design, research and development;

(vi Steer India's software industry into automotive technology;

(vii) Assist development of vehicles propelled by alternate energy sources;

(viii) Development of domestic safety and environmental standards at par with international standards.

The outcome of the aforementioned document was the Automotive Mission Plan 2006-2016.[190] According to the foreword by the Departmental secretary, the Plan was actually a laying down of the roadmap for the future development of the industry and to further improve the automobiles in the Indian domestic

[190] *Automotive Mission Plan 2006-2010: A Mission for Development of Indian Automotive Industry*, A Roadmap document Prepared by the "Ministry of Heavy industries and Public Enterprise", December 2006.

market, to provide world class facilities of automotive testing and certification and to ensure a healthy competition among the manufacturers at a level playing field.

The document further elucidates the main aim of the Mission Plan, that is to promote sale of automobiles to generate employment in particular and boost economic growth in general when it states:

"The growth of the middle class with increasing purchasing power along with strong growth of economy over a past few years have attracted the major auto manufacturers to Indian market. The increasing pull of Indian market on one hand and the near stagnant auto sectors in markets of USA, EU and Japan on the other have worked as a push factor for shifting of new capacities and flow of capital to the auto industry of india. The increasing competition in auto companies has not only resulted in multiple choices for the Indian consumers at competitive costs, it has also ensured an improvement in productivity by almost 20 percent per year in auto industry, which is the highest in Indian manufacturing sector."[191]

To maintain this high rate of growth and to retain the attractiveness of Indian market and for furthering the competitiveness of Indian companies, the government through the development Council on Automobile and Allied industries constituted a Task Force to draw up a ten year Mission Plan of the Indian Automotive industry. The challenge was to give a futuristic plan of action with full participation of the stakeholders and to implement it in a mission mode to remove the impediments coming in the way of growth of industry. Besides making concerted efforts for removal of obstacles for accelerated growth, the prime need was to put in place the required infrastructure well in time to facilitate growth."[192]

Recently in the capital Mr. Vilasrao Deshmukh, Minister of Heavy industries and Public Enterprise, addressing the two-day 'Fourth Environmentally Friendly Vehicles (EFV) Conference', said

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[191] *Ibid*, (Preface)
[192] *Ibid*.

that sustainable mobility was one of the key challenges before the automobile industry. This includes not only reducing the impact of vehicular emissions on the environment, but also attaining greater fuel efficiencies with the ultimate aim of shifting to alternative sources of cleaner and renewable energy. Underlining the need for more fuel-efficient vehicles to reduce emissions and save environment. Mr. Deshmukh said the conference would help promote use of environmentally-friendly vehicles to ensure sustainable road transport.[193]

Mr. Deshmukh also said the targets of Automotive Mission Plan (AMP) would be achieved as per schedule. According to the AMP, the auto industry is estimated to be worth $145 billion by 2016, which would require an investment of $35-40 billion.[194]

One of the outcomes of the 'Plan' was the coming into the scene of the 'Nano' from the stables of Tata Motors and now even well known two-wheeler company (the second largest manufacturer of two-wheelers), Bajaj Auto, is planning to join the gravy train of producing cheap four wheelers. What and how does this bear on the vehicular pollution scene of the country? At best, we can only hope against hope that Bajaj Auto follows its new found tradition of producing fuel efficient engines[195] which it has been recently doing with its two-wheelers and eco-friendly[196] vehicles like its latest three-wheelers.

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[193] *Centre may cut duty on hybrid vehicles* in *The Times of India,* New Delhi, 20th October, 2009.
[194] *Ibid.*
[195] *Bajaj unveils world's 'most fuel efficient' engine,* The Business Standard, New Delhi, June 24, 2009
[196] *Bajaj Auto launches eco-friendly auto rickshaw,* The Business Standard, Mangalore, June 20, 2009.