Is clean diesel a myth or a solution?

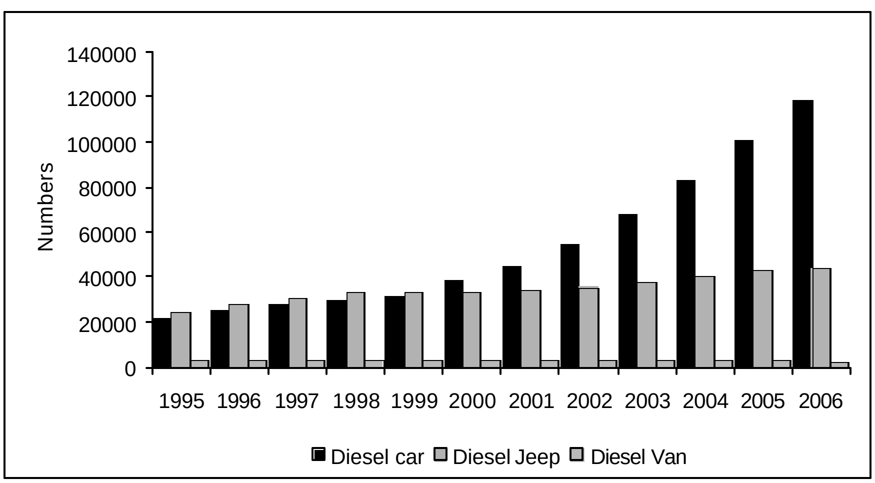
The Centre for Science and Environment (CSE) organized a roundtable discussion on 'Is clean diesel a myth or a solution?' in New Delhi on December 10, 2007. This discussion forum brought together national and international experts, policy makers, civil society groups and industry representatives to discuss the pollution challenge of rapid dieselization of car fleet.

Controlling urban air pollution is turning out to be an enormous challenge not only because of the rising numbers of total vehicles but also due to the increased toxic risk from the growing numbers of diesel cars. There is considerable public and policy concern regarding rapidly rising diesel car numbers in Indian cities. In 1999 CSE had said diesel cars, the *"Engines of the Devil,"* should go. We need cleaner alternatives as India had not even implemented Euro I emissions standards. Then diesel cars were only 2 to 4 per cent of the new car sales. At such a low penetration no one was prepared to believe CSE's forecast that their numbers would explode very soon and negate all gains of pollution control in the city. But within a few years they have and proven the doubters wrong. Diesel cars today form nearly 30 per cent of the new car sales and are poised to touch 50 per cent by 2010. Nearly all SUVs are on diesel.

International regulators and scientific agencies have raised serious concerns regarding the carcinogenicity of diesel particulates. Globally, there is considerable thrust on cleaning up of diesel emissions significantly to be able to take advantage of the higher fuel efficiency of diesel vehicles. Emissions standards are becoming uniformly stringent for all vehicles irrespective of the fuel they use. But to what extent it has been possible to resolve the efficiency vs pollution trade off? Should we allow uncontrolled dieselization without clean diesel fuel and technology? Is clean diesel a myth or part of the solution?

Very few people in India understand why even after meeting Euro III emissions standards (Bharat Stage III) in the major cities, serious concerns continue to persist regarding the toxic and extremely harmful diesel emissions. Why diesel vehicles still do not pass the muster of global benchmark for clean diesel. The *Right To Clean Air campaign* of the Centre for Science and Environment therefore, presents this fact sheet to explode the myths to help chart the way forward.

Graph 1: Growth of diesel car, jeep and vans in Delhi



Source: Based on data provided by transport department, Government of National Capital Territory of Delhi, mimeo

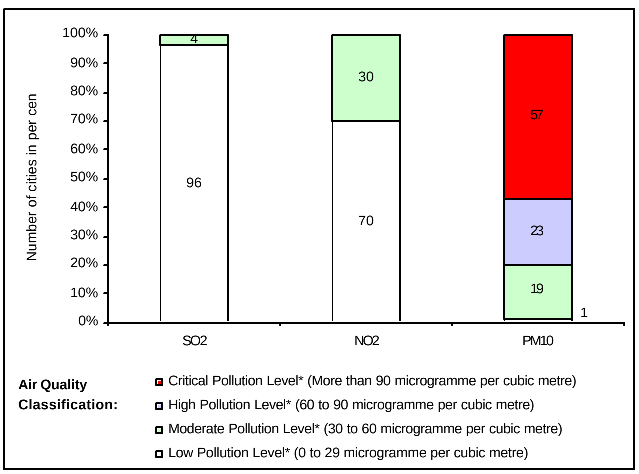
1. Can diesel cars be held responsible for worsening air quality?

Diesel-related pollutants are either already very high or rapidly increasing in Delhi's air and in other Indian cities.

Both particulates and nitrogen dioxides have emerged as pollutants of concern in Indian cities. The contribution of diesel emissions to fine particulate matter, oxides of nitrogen and other carcinogens like polycyclic hydrocarbons should not be underestimated. The sulphur dioxide (SO2) and nitrogen oxides from diesel vehicles also contribute significantly towards the build-up of secondary particulates and ozone. The particulate emissions from uncontrolled diesel engines are 6-10 times greater than those from petrol engines.[i] Extremely tiny diesel particles go deep into the lungs and are also very toxic. Diesel vehicles, however, emit lower carbon monoxide (CO) and hydrocarbons (HCs) compared to petrol vehicles.

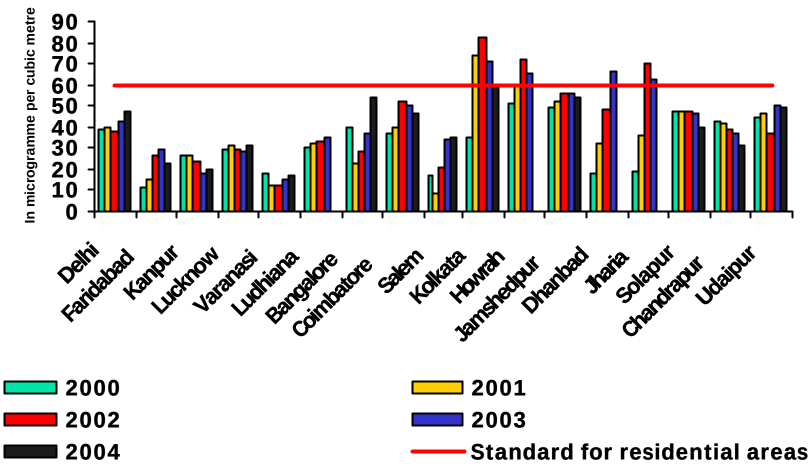
The air quality data from the Central Pollution Control Board shows that more than half of cities monitored in India have recorded critical levels of PM10 levels. This year in Delhi, the daily levels of even smaller particulates less than 2.5-micron size (PM2.5), have reached 240 microgram per cubic metre in end-October. Levels of nitrogen dioxides (NO2) have been increasing in the city to dangerous levels, (reaching upto 300 micrgramme per cum), which is a clear sign of pollution from vehicles. The ground level ozone, known to be extremely hazardous for human health is very poorly assessed in India. But limited data indicates higher number of days violating the WHO guidelines in summer of this year in Delhi. On a nation-wide scale high and rising trend in NOx levels have been noted in other cities including Kolkata, Pune, Bangalore, Delhi, Jharia, Howrah among others.

Graph 2: More than half of Indian cities have critical level of particulate pollution



Source: Based on ambient air quality data, CPCB, New Delhi

Graph 3: Nitrogen dioxide level is an emerging problem



Source: Based on ambient air quality data, CPCB, New Delhi

According to the WHO, particulate matter does not have a safe threshold. It states that the lower range of concentrations at which adverse health effects has been demonstrated is not greatly above the background concentration which has been estimated at 3-5 µg/m3 in the United States and Western Europe for particles smaller than 2.5 micrometer, PM2.5. The epidemiological evidence shows adverse effects of particles after both short-term and long-term exposures.[ii]

This is especially alarming in view of the PM air quality levels in the major, highly populated cities across India that goes several times the standards. The strongest evidence for ambient PM exposure health risks have come from epidemiological studies that have shown statistically significant associations of ambient PM levels with a variety of health effects in sensitive populations, including premature mortality, hospital admissions, respiratory illness and symptoms, and physiologic changes in mechanical pulmonary function.

Thus, Indian cities cannot continue to add the high emitters of PM, especially vehicles. The level of roadside exposure to particles from traffic has a significant effect on health and the severity of the public health impact. In a six city assessment in the developing countries the World Bank has found that vehicles contribute an average of 6 per cent of direct PM emissions but 32 per cent of the PM exposure. In three of these cities vehicles contribute an average of 50 per cent of the direct exposure and 70 per cent of PM exposure.

The vehicular emissions can be half of the total PM in some polluted locations. In a recent source apportionment study of PM10 in Greater Mumbai region carried out by Nagpur based-National Environmental Engineering Research Institute shows that automobile exhaust contributes as high as 33 per cent and 54 per cent of the PM at Vile Parle and Metro Junction locations respectively.[iii]

In India, rigorous emissions inventories have not been carried out to understand the impact of dieselisation on ambient air. A collage of small evidences, however, bears out the impact on air quality. A World Bank supported study on source apportionment of PM2.5 (particulate matter less than 2.5 micron in size) in selected Indian cities released in 2004 shows that, depending on the season, the contribution of diesel fuel to the total PM2.5 ambient concentration can be as high as 61 per cent in Kolkata, 23 per cent in Delhi and 25 per cent in Mumbaiiv. The fine particulates have serious health consequences as per the health studies conducted in other countries.

Dire impact of dieselization on air quality is evident from studies conducted in other cities as well. A 2004 study carried out by Mario Camarsa, fuel and technology expert formerly with the UK-based Enstrat International Limited, has assessed the impact of low-sulphur diesel (LSD) fuel on diesel emissions in three Asian cities — Bangkok, Bangalore and Manila. [v] This bears out the varying but growing trends in diesel emissions in these cities. In Bangalore, the Camarsa study found diesel engines to be a significant contributor of the total NOx emissions from vehicles — as much as 40 per cent — and comparatively less significant contributor of PM10. [vi]

2. Why are we concerned about diesel emissions?

Many international regulatory and scientific agencies have determined that diesel exhaust is of sufficient concern to merit action. The rise in numbers of diesel vehicles is very disturbing because deadly facts about diesel toxicity and evidence of the acute cancer-causing potential of diesel pollutants are pouring in from around the world. The International Agency for Research of Cancer (IARC), World Health Organisation (WHO), United States Environmental Protection Agency (US EPA), Health Effects Institute, California Air Resources Board (CARB), National Institute for Occupational Safety and Health have all classified diesel emissions as carcinogen.

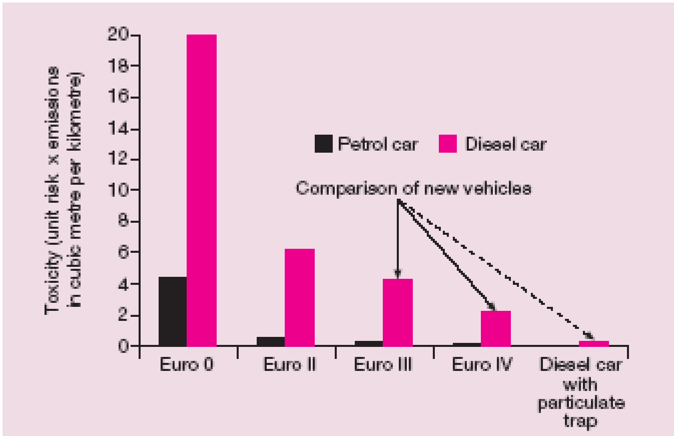
CARB identified diesel exhaust in 1990 as a chemical known to the state to cause cancer and after an extensive review in 1998, listed diesel exhaust as a toxic air contaminant.[vii] More recently, the US National Institute for Environmental Health Sciences added diesel particulates to its list of substances that are reasonably anticipated to be human carcinogens in its ninth national toxicology report on carcinogens. In fact, a multiple air toxics exposure study (MATES III) conducted by the South Coast Air Quality Management District in California found that diesel exhaust pose 84 per cent of the cancer risk in the basin or in southern California. The earlier estimate in the SCAQMD's during 1998-1999 under the MATES II found that 71 per cent of the cancer risk was due to diesel exhaust.

Several international and national health agencies have also reviewed relevant data on diesel exhaust and have classified either the exhaust mixture or the particulate component as probable human carcinogen. The deadly truth about diesel exhaust is that it includes a large number of toxic compounds that cause cancer, reproductive abnormalities and other toxic impacts. Even short term impacts are very high. A very recent study Respiratory Effects of Exposure to Diesel Traffic in Persons with Asthma in The New England Journal of Medicine (Volume 357:2348-2358 December 06, 2007, Number 23) states that diesel exhaust fumes on polluted streets have a measurable effect on people with asthma. It found that air pollution from diesel traffic worsened the lung function in people with asthma after walking for two hours on Oxford Street. It induced reductions in the lung capacity of the participants. These changes were accompanied by increases in biomarkers of neutrophilic inflammation and airway acidification. (see more health effects of diesel exhaust in Annexure 1).

The US based Health Effect Institute will now assess the new diesel engines with control systems meeting the new emission standards in the US for heavy-duty vehicles. Emissions from such engines will be characterized in detail in an Advanced Collaborative Emissions Study to assess chronic and acute health endpoints.

The data available from Europe for urban traffic shows that diesel and petrol cars meeting the same level of emission norms have different toxicity levels. The toxicity is several times higher for diesel emissions even as the emission standards are progressively tightened. (See graph 4: Toxic profile of diesel and petrol cars meeting Euro norms; also followed by India).

Graph 4: Toxic profile of diesel and petrol cars meeting Euro norms
A comparison of toxicity of emissions from diesel and petrol passenger cars meeting different norms in urban traffic



Source: Michael Walsh 2003, The global impacts of heavy-duty diesel vehicle emissions, USA, mimeo

3. Are modern diesel cars in India clean? All vehicles meet emissions standards. How can government discriminate one technology against the other?

i. Small steps do not help: Currently, in India, diesel vehicles meet Euro III (Bharat Stage II) emission standards in 11 cities and are five years behind Europe. In the rest of the country they meet Euro II standards that are ten years behind Europe. The implication of this time lag for diesel car emissions is particularly ominous as the European norms are lagging behind the world's best standards. And India is far behind Europe.

Estimates from the International Council on Clean transportation shows that the current US Tier-2 NOx and PM limit values for light-duty vehicles are approximately 80 per cent tighter than the current Euro IV car limits.[viii] Similarly, new US limits for heavy-duty vehicles are approximately 90 per cent tighter for NOx and 60 per cent tighter for PM than the future European heavy-duty Euro V limits.[ix] European norms are still not close to achieving the fuel neutral status of the US norms for light-duty vehicles. In the US the norms are uniformly stringent for all vehicles irrespective of the fuel they use. The US norms do not make any special allowance for diesel cars as opposed to the practice in Europe. Even in 2014 European NOx norms will remain more lax than the current US norms.

But the European standards have not been corrected to become fully fuel neutral to push both diesel and petrol technologies equally stringently.

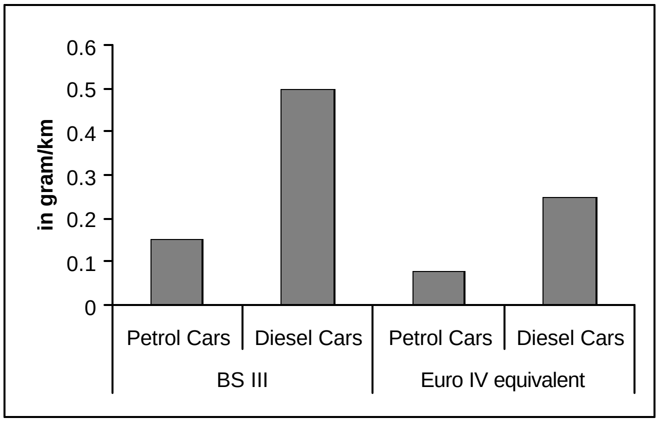
ii. Legal license to emit more PM and NOX: The current emission standards adapted from Europe and designed to allow diesel vehicles to emit higher pollutants than petrol vehicles. Even the Bharat Stage III standards allow higher limits for nitrogen oxides and particulate emissions compared to petrol cars. As a result, in India diesel cars meeting these standards are 'legally' allowed to emit nearly three times more NOx than the comparable petrol cars and also several times more particulates. Petrol vehicles have negligible emissions of particulates, while every diesel car is allowed to emit 0.05 gm/km in the Bharat Stage III norms.

Petrol vehicles on the other hand are given higher standards for CO, as compared to diesel however, due to improvement in petrol vehicle technology and widespread use of three-way the ambient CO levels have reduced substantially. The problem is that health concerns over diesel particulates are far greater and in Indian cities, in particular, particulate pollution is on the rise with devastating implications. Comparatively diesel technology has been slower to improve and this is a global phenomenon. There are complex trade-offs in diesel technology. The simultaneous lowering of NOx and PM in diesel vehicles still presents a serious engineering challenge as emissions control in diesel vehicles are beset with trade-offs. Ways to control PM emissions increases NOx and affects fuel economy. Ways to improve NOx emissions also affects fuel economy. This is also the reason why diesel norms are taking time to get significantly stringent in Europe.

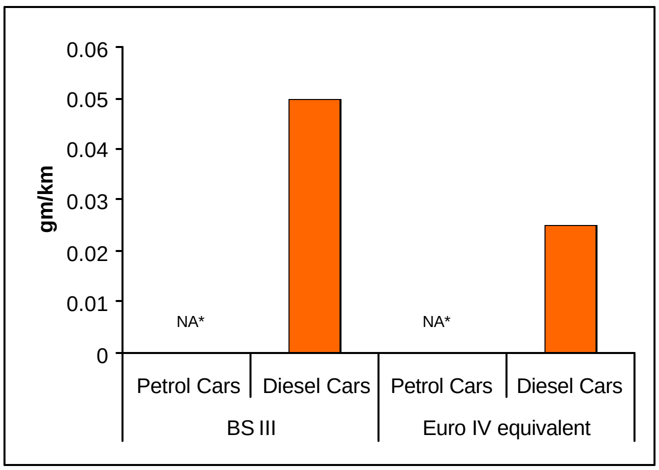
Graph 5: Diesels have unfair emission advantage in Indian norms

Diesels are legally allowed to emit nearly three times more NOx in Bharat Stage III (Euro III equivalent)

(A) NOx norms for cars



(B) PM norms for cars



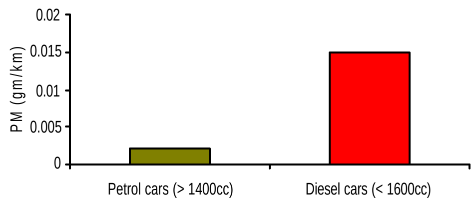
Note: * Mass PM emissions from petrol cars is considered negligible hence it is not regulated.
Bharat Stage III emission norm are equivalent to Euro III emissions norms
Source:
Bharat Stage III emission norm: Anon 2004, Notification No G.S.R. 686 (E), dated 20th October 2004 – Bharat Stage III emission norms, Ministry of Shipping, Road Transport and Highways, Government of India
Euro IV equivalent emission norm: Anon 2002, Report of the expert committee on Auto Fuel Policy, Government of India, New Delhi, August

Investigations carried out by CSE, based on actual emissions data available from the Pune-based Automotive Research Association of India, expose enormous differences in the actual emission levels of Euro III (Bharat Stage III) diesel and petrol cars that are currently sold in Delhi and other major Indian cities.

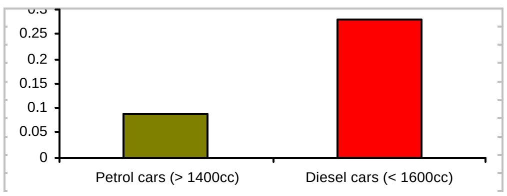
Euro III diesel cars emit 7.5 times more toxic particulate matter (PM) than comparable petrol cars. This means, one diesel car is equal to adding 7.5 petrol cars to the car fleet in terms of PM emissions and 3 petrol cars in terms of NOx emissions. This clearly reflects the flawed emission standards that allow diesel cars to emit more NOx and PM compared to petrol cars. Total air toxics from a diesel car that are very harmful and carcinogenic are 7 times higher than petrol cars.

Graph 6: Emissions data for Euro III diesel and petrol cars

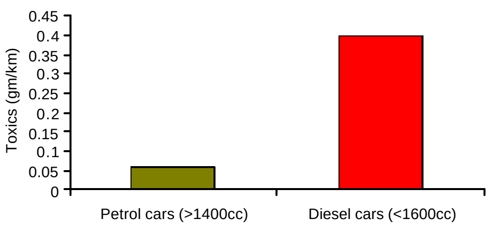
A. PM emissions: Euro III diesel car emits 7.5 times more PM than petrol cars



B. NOx emissions: Euro III diesel car emits 3 times more NOx than petrol cars



C. Total toxics emissions: Euro III diesel car emits nearly 7 times more air toxics



Source: Automotive Research Association of India, Pune

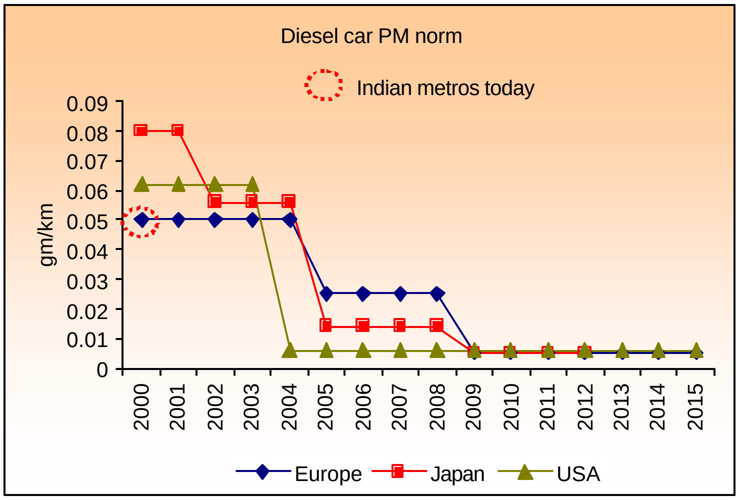
iv. Other countries are adopting fuel neutral standards: The US has already adopted fuel neutral and very stringent emissions standards that do not differentiate between petrol and diesel vehicles any more. All light duty vehicles irrespective of the fuels they use have to meet same and equally stringent emissions standards. This helps to create level playing field for all types of technologies and fuels to compete fairly on emissions ground. This is one of the reasons why diesel penetration in the US car market has been less than 1-2 per cent.

The US, California and Japan, have leapfrogged their emissions standards to phase in the clean diesel fuels and technologies. This includes diesel fuel with sulphur content less than 10 to 15 ppm along with advanced exhaust after-treatment devices.

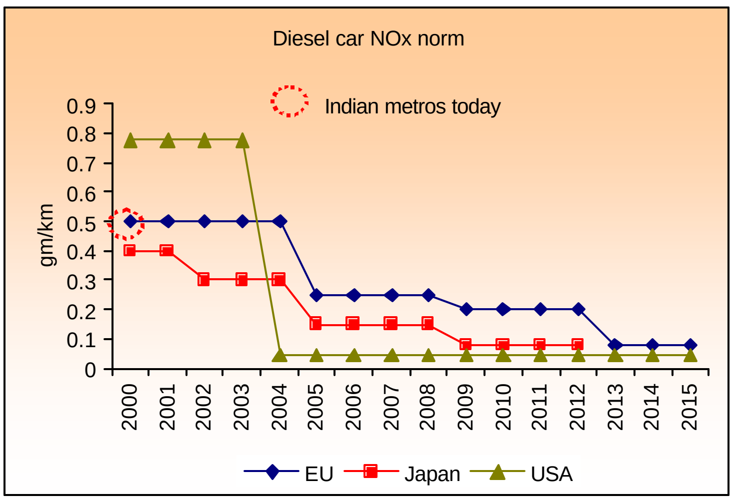
The particulate norms for diesel cars in Europe will close gaps with the US and Japan only in 2009 when Euro V will be enforced. European NOx norms will catch up with Japan only in 2014 when Euro VI norms are expected to be enforced. But even then it will trail behind the current US norms by at least 43 per cent. By any measure India is far behind the industrialized nations which are tightening their standards. (See graph: Emission norm roadmap for cars in EU, US and Japan). Given this situation, there is no way that we can call diesel vehicles in India, meeting our current emission norms, as 'clean'.

Graph 7: Emission norm roadmap for cars in EU, US and Japan

A. Diesel car PM norm



B. Diesel car NOx norm



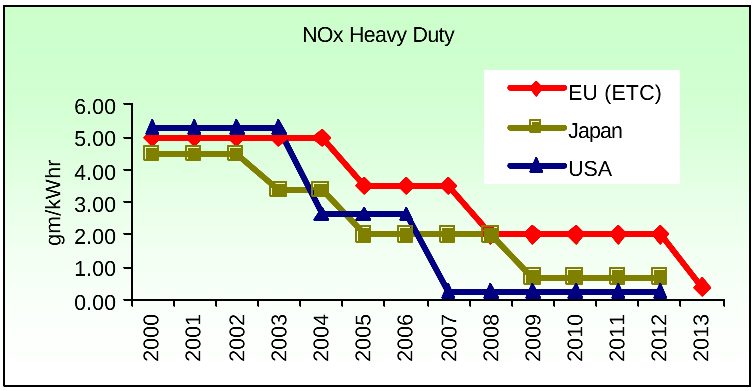
Note: Indian metros are currently following the Euro III emission norms that were enforced in EU in 2000. In 2005 Europe has moved ahead to enforce Euro IV emission norms.
Sources: Proposed Euro V limit values for diesel passenger cars, European Commission, Brussels; Future Diesel: Exhaust gas legislation for passenger cars, light-duty commercial vehicles and heavy -duty vehicles, Federal Environmental Agency, Germany; International Council on Clean Transportation.

Box: Reduction in heavy-duty vehicle emissions remains inadequate

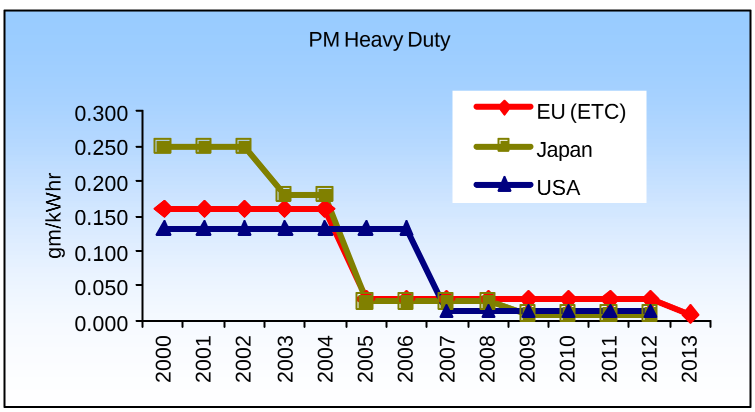
The heavy-duty segment has been the slowest to improve in India. While buses get an opportunity to meet the one-step-up standards in a few metro cities, trucks lag behind deplorably as they continue to meet the minimum national standards. Till 2005 truck technology has remained predominantly Euro I and has thereafter graduated to the Euro II level. There is no hope of trucks moving soon to Euro III in India country-wide as they are exempt from the standards even in cities that have enforced Euro III as the matching fuel is not available on the highways. However, in these cities public transport buses are mandated to move to Euro III. This has dampened initiative for fast upgrades in truck technology.

As large part of India, except the 11 cities are meeting the Euro II equivalent norms (came in Europe in 1994-95) the heavy-duty industry in India is way behind the globally best emissions standards. In Europe the Euro IV emission standard is currently in force and the next tightening of norms will be in 2008 when the Euro V norms will come into force, however new norms remain lax on PM and NOx compared to the globally best standards. The new US heavy-duty emissions limits are nearly 90 per cent tighter for NOx and 60 per cent tighter for PM than the Euro V limits. The European Commission has recently come up with a proposal on Euro VI emission norms for heavy-duty engines, which are expected to be 66 per cent tighter in case of PM limits and 80 per cent in NOx limits compared to Euro V level. Therefore, as the trend suggests, only after 2013 the Europe with its Euro VI will be close to the stringency level of US and Japan.

Graph: Heavy duty vehicle emission roadmap
A. Trends in heavy-duty vehicle NOx norms



A. Trends in heavy-duty vehicle PM norms



Source: Compiled data from USEPA, European Commission and Diesel Net

Europe has been too slow in tightening the NOx limits and in fact the Euro V limit values were merely 20 per cent tighter than the current Euro IV norms. Under the new regulations, for NOx control, the Euro VI emission norm requires a reduction of 80 per cent from the Euro V level. Commission says, “to comply with this emission limit, internal engine measures (e.g. exhaust gas recirculation - EGR) and aftertreatment devices (e.g. Selective Catalytic Reduction – SCR) will be needed at the current state of the art.” As the new proposal would need fitment of aftertreatment devices the EC is also introducing requirements for the type-approval of exhaust after-treatment components such as catalysts and diesel particulate filters (DPFs). While there is a clarity and worldwide experience in using diesel particulate filter (DPFs), the NOx control strategies remain uncertain due to their tradeoffs with the PM emissions and fuel economy.

Currently the use of SCR to reduce NOx has drawn considerable attention as a viable option to control NOx effectively. This system injects a reducing agent – commonly urea – into the exhaust gas before the catalyst to achieve a higher rate of NOx conversion in oxygen-rich exhaust. There remains a technical challenge as its application demands precise estimation of NOx in the exhaust to adjust the dose of urea to be injected. Without it some excess reagent may slip through the catalysts and be emitted in the form of ammonia, which is harmful. To overcome this, efforts are on to provide NOx sensors to sense the exhaust NOx concentration and meter reagent injection. A downstream oxidation catalyst is used to mop up any unreacted urea.

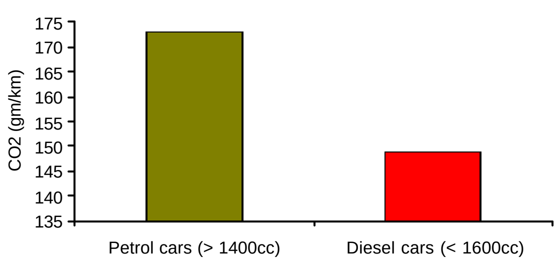
The SCR system is additionally dependent on separate refilling of the urea tank and requires a refilling infrastructure. The onus thus shifts to the vehicle user to refill the urea tank in the vehicles. Any lack of discipline can defeat the efforts to install such efficient conversion systems in the vehicles although compared to other NOX control systems SCR is less sulphur sensitive, sulphur reaction in urea-based SCR can form ammonium bisulphate that causes severe respiratory problems.

From India's perspective there are, however, misgivings over Europe's choice of SCR as this presents serious enforcement challenges. Effectiveness of the SCR system requires regular refilling of urea by vehicle operators. This, in turn, requires a urea-refilling infrastructure. There are strong apprehensions that vehicle users may avoid refilling to save costs, which may increase emissions to the level of pre-Euro norms. Europe is trying to resolve it by an electronic feedback system and a torque limiter that will get activated and slow down the vehicle if urea is not refilled. But any technology that depends on the user behaviour is at risk of failure, especially in Asia. SCR will, therefore, require detailed regulatory safeguards for proper enforcement. From the enforcement perspective in India, therefore, in-vehicle solutions like de-NOX adsorbers are more desirable.

4. Diesel vehicles are so much more energy efficient and emit lower CO2 emissions. Shouldn't we encourage them?

i. Avoid trade-off between efficiency and pollution: Diesel cars are 15 to 20 per cent more fuel efficient than a comparable petrol car and therefore emits lower greenhouse gas emissions.
ARAI data shows Euro III Indian diesel cars emit 1.2 times less carbon dioxide emissions compared to their petrol counterparts.

Graph 8: CO2 emissions: Euro III diesel car emits nearly 1.2 times less carbon dioxides



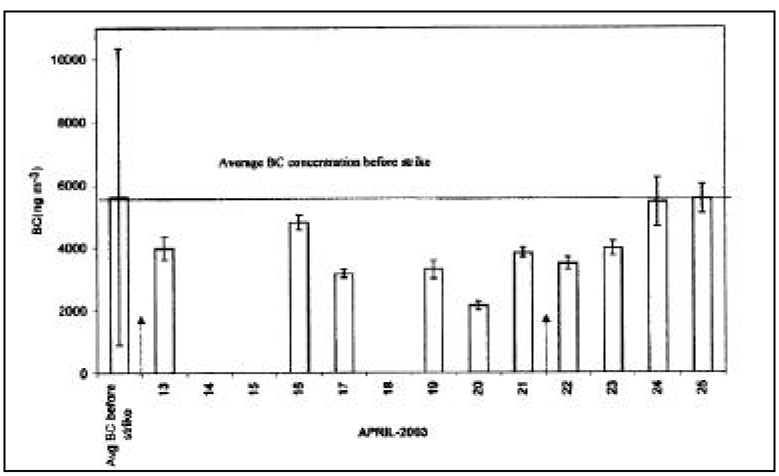
Source: ARAI, Pune

But any attempt to increase their numbers can increase local air pollutants. Europe illustrates the diesel dilemma best as it has continued to follow lax emissions standards while setting stringent CO2 emissions targets for the European car industry. In 1999 the car manufacturers in Europe had committed to a voluntary agreement to reduce new passenger vehicle CO2 emissions to 140 gm/km target by 2008 — an approximately 25 per cent reduction from 1995 levels. To achieve this target on a fleet wide basis the European carmakers have relied heavily on increasing the share of diesel vehicles to meet the fleet-wide target. As diesel cars are comparatively more fuel-efficient than petrol cars, increasing their share helped to lower the average fleet wide CO2 levels. This tendency in combination with cheaper diesel prices and weaker emissions regulations has caused a major shift towards diesel cars in Europe. Currently in Europe half of the new cars sold are diesel.

Scientists have now begun to implicate black carbon (BC) emissions for global warming. Atmospheric aerosol black carbon (BC) is known to be a significant absorber of solar and terrestrial radiation and is recognized as a potent greenhouse species of atmospheric aerosols. In 2001, Mark Z Jacobson of the US-based Stanford University found that diesel vehicles emit about 18 per cent more carbon per unit volume of fuel used than petrol vehicles. He predicted there would be greater global warming with diesel than with petrol over the next 100 to 150 years as soot is a far more efficient warming agent per unit of mass than CO_2.[x]

A study carried out in Hyderabad in India, assessed the impact of emissions associated with truck transport on ambient BC concentration. The study was carried out during a nationwide truck strike of April 2003. The results indicate a significant reduction in the BC loading associated with withdrawal of the trucks. The decrease was gradual, while the recovery was almost immediate. The sudden decrease in BC is attributed to the withdrawal of a potential source, while the gradual decrease subsequently is a result of the finite residence time of BC because of which the BC already in the ambient takes a finite amount of time to get removed from the atmosphere. [xi]

Graph 9: Levels of black carbon aerosols in air recede after truck strike



Note: This Figure shows the variations of daily average BC concentrations for the period 1 to 25 April 2003.

The points are the daily mean BC concentrations and the vertical bars through them are the standard error. In the Figure, the first bar represents the average BC concentration before the strike days (1–12 April). From the second bar onwards, the average day BC concentration on each day has been plotted (13–25 April). The days lying between the two vertical arrows indicate the total duration for which the truck strike was on normally, while the dashed arrow indicates partial resumption of truck traffic within Andhra Pradesh.
The Figure shows the signature of impact of the truck strike, with a sudden decrease in the BC concentration on the day the strike started. On the subsequent days after 13 April 2003, BC concentration continued to decrease, though more gradually to reach the lowest BC concentration (17 nanogram per cubic meter) on 21 April eight days after the trucks were withdrawn.
Source: K. Madhavi Latha et al 2004, *Impact of diesel vehicular emissions on ambient black carbon concentration at an urban location in India*, Current Science, Vol. 86, No. 3, 10 February 2004

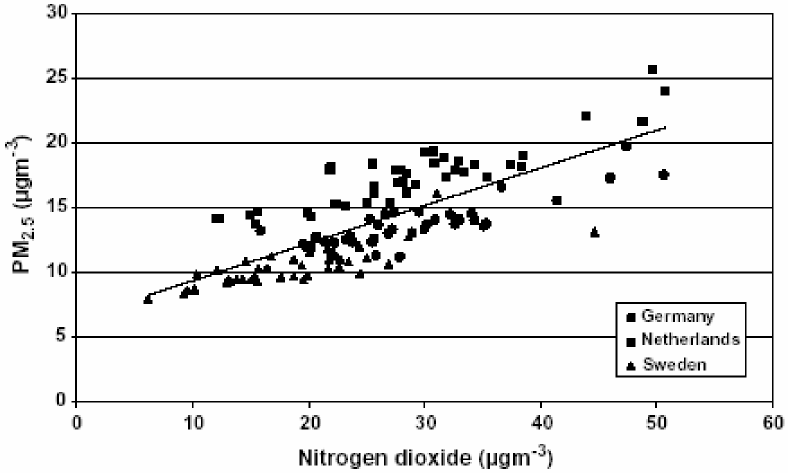
ii. Diesel has complicated air pollution control in Europe: As a result of such high numbers of diesel cars meeting lax emission standards some European cities are at risk or are already violating air quality targets for NOx and PM10. In fact, Europe has recently revised their ambient air quality guidelines. Accordingly, the PM10 standard (24 hourly average standard of 50 microgrammes per cubic metre) must not exceed on more than 35 days in a calendar year. Many European cities like Munich, Stuttgart, Dusseldorf, Berlin, exceed the air quality standards and the civil society has begun to drag the city authorities to Court. According to European Environmental Bureau lower tax rates on diesel fuel and dieselization of the fleet; growing traffic volumes and investment in road-infrastructure over other modes of transport [xii] are contradicting the clean air measures in the member states.

Concern over diesel emissions has led countries like Germany to launch clean diesel campaign and mandate fitment of particulate traps along with diesel fuel with sulphur content as low as 10 ppm. But Europe has not yet been able to solve the problem of NOx emissions. Due to the primacy attached to fuel economy and the attendant problem of CO2 emissions diesel cars are now getting caught in the trade-off between NOx and fuel efficiency. While the future PM emissions norms under Euro V and Euro VI will close gap with the US standards, the NOx norms continues to remain comparatively lax.

This is because meeting equally stringent NOx and PM levels and tight fuel efficiency target present a difficult engineering challenge in diesel engines. For instance, additional NOx control technologies that are needed to reduce NOx further are still in the making and large scale commercial application has not been possible yet.

Therefore it is important that India recognises the inherent flaws of the European approaches and not repeat the mistake. We cannot afford to allow the problem to grow and then deal with the pollution aftermath. It is important to be precautionary and stem the tide at the early stages of dieselisation.

Graph 10: European cities are violating air quality standards: NO2 levels strongly correlate with PM2.5in European cities

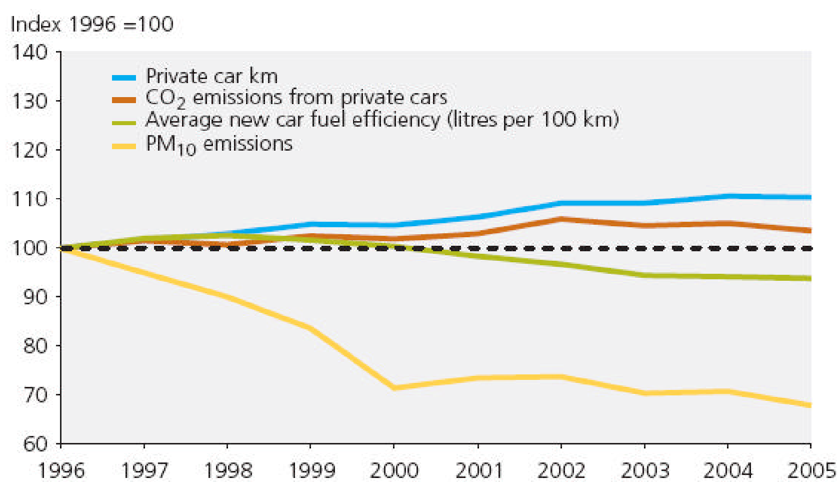


Source: M P Walsh, US

iii. Rebound effect: Scientists also warn against the rebound effect of diesel. The efficiency gains through technological improvement are lost because in most countries lower diesel prices encourage higher usage of diesel vehicles and that nullifies the gains. Diesel fuel has higher carbon content than petrol. This means more CO2 emissions per unit of diesel fuel burnt. Studies have found that the UK is failing in maintaining the PM10 reduction trend due to rise in diesel vehicles. A study carried out by DEFRA in the UK shows that between 1996 and 2005 the amount of fuel used for each 100 km driven by new cars in the UK decreased by 6 per cent as a result of improvements in efficiency. Emissions of CO2 from private cars rose by 4 percent in the same period, mainly because of increasing distances travelled by car, which rose by 10 percent. PM10 emissions declined by 29 percent between 1996 and 2000 but subsequently have decreased by only a further 3 percent as the improvements have been offset by an increase in the use of, and emissions from, diesel cars.

The scientists have also implicated the black soot from diesel vehicles for global warming that can undermine the lower CO2 emissions benefit of the diesel vehicles.

Graph 11: Negation of gains



Source: DEFRA, UK

Diesels presents a complex challenge of balance. Recently the European Commission has presented an estimate of total lifetime costs of cars running on petrol and diesel. The estimates shows that there is hardly any real benefit of plying a diesel car, once pollution caused by them over lifetime is taken into consideration.

Table: lifetime costs and vehicle prices
(indicative example for illustrative purposes only)

	Vehicle price	Life-time cost for					Vehicle price + lifetime costs
		Fuel	CO_2	NOx	NMHC	PM	
Diesel car (200.000 km)	17,000 €	5,500 €	530 €	220 €	10 €	435 €	23,695 €
Petrol car (200.000 km)	15,000 €	7,700 €	669 €	70 €	20 €	87 €	23,547 €

Source: Anon 2007, Sustainable economics with clean and energy efficient vehicles, MEMO/07/594, European Commission, Brussels

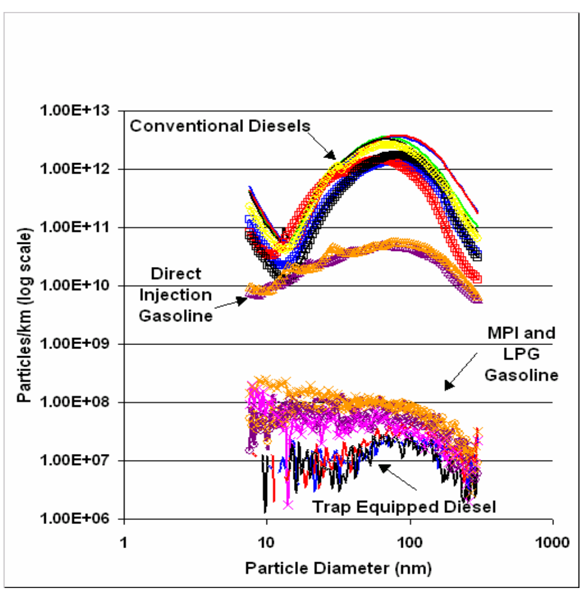
7. Do petrol/CNG engines emit more ultrafines than diesel engines?

First diesel engines will have to be cleaned up to bring down its emissions to the level of petrol vehicles. Then extra controls will be needed to near eliminate the ultrafine emissions. Solutions exist. Enable them.

A study done by Ricardo for the UK government below that clearly shows that the particle count of conventional diesel engines is the highest. PM numbers of direct injection petrol engines can also be significantly high. But petrol engines with multi point fuel injection system and gaseous fuel like LPG have particulate count several times lower than the conventional diesel engines. Only when diesel engines improve and are fitted with advanced particulate traps, the particle count can come down significantly to be within the comparable range of other technologies.

Emissions control technologies have begun to emerge that can effectively control both mass and number of ultrafine particles. An important benefit of count based particle standards will force industry to use the appropriate closed filters, which can reduce the ultra fine particles effectively. This will prevent the use of open filters that have been developed to control only the particulate mass and allow a high number of ultra fine particles to pass. As we know the UN/ECE's Particulate Measurement Programme (PMP) has been already been initiated to address this issue.

Graph 12: Comparable particle count of different type of engines



Source: Axel Friedrich 2004, Diesel toxicity and risk reduction strategy in Germany: Why Germany even after meeting Euro IV standards has a campaign on diesel? Presentation of Umweltbundesamt (UBA), Germany in the Centre for Science and Environment, New Delhi, Conference: THE LEAPFROG FACTOR: TOWARDS CLEAN AIR IN ASIAN CITIES, March 30 — April 1, 2004, New Delhi, India

The message is clear: We must not remain locked up in the conventional diesel technologies as represented by Euro II, and III that are known to emit more toxic particles and more harmful sulphate particles (especially if high sulphur fuel is used). But move quickly to the more advanced technologies that need 10 ppm diesel and advanced CDPF that can be used effectively to lower both mass and numbers of particles. In fact the upcoming Euro V norms in Europe have already proposed PM number count based standards. PM standards are being enforced for gasoline direct injection technologies. Europe and the US are already looking for new methodology for particle count that are expected to be significantly more accurate and precise at very low emission levels than the mass based method.

8. Refineries claim spending so much to produce ultra low sulphur diesel cannot be justified from the air quality stand point as vehicles are small contributors. Is it true?

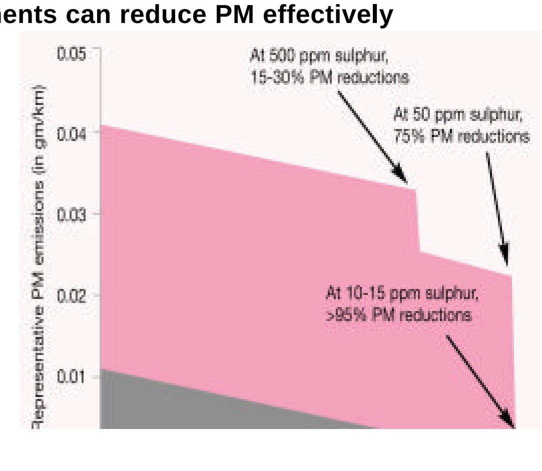
Fuel sulphur is the biggest block to technology improvement today. The sulphur in fuel threatens to become the next major obstacle to clean air, since it impedes the introduction of a new generation of engine and emission control technologies globally. The International Council on Clean transportation (ICCT) has therefore issued a statement calling sulphur the "lead of the new century". The new emissions control technologies that are emerging to clean up diesel emissions are very sulphur sensitive. High sulphur in fuels can poison and damage them. To enable their application near zero sulphur fuel will have to be introduced.

Why do we need ultra low sulphur diesel?

i. The ultra low sulphur diesel fuel helps to lower fleet-wide emissions on road. Studies show that emissions decline as fuel sulphur is lowered. In a recent experiment carried out in Bangkok, different sulphur content fuels (800ppm, 500ppm, 150ppm sulphur containing petrol grades and 500ppm, 350ppm and 50ppm diesel grades) were tested in Euro II and Euro III, petrol and diesel engines. The results indicate that when Euro II diesel engine which normally runs on 500 ppm sulphur fuel, is fuelled with cleaner diesel with 50 ppm sulphur, the PM emissions reduce by 27.9 per cent and CO and HC emissions by 51.9 per cent and 38.3 per cent, respectively. The emission reduction is much higher when Euro III diesel engines are fuelled with 50ppm sulphur diesel[xiii].

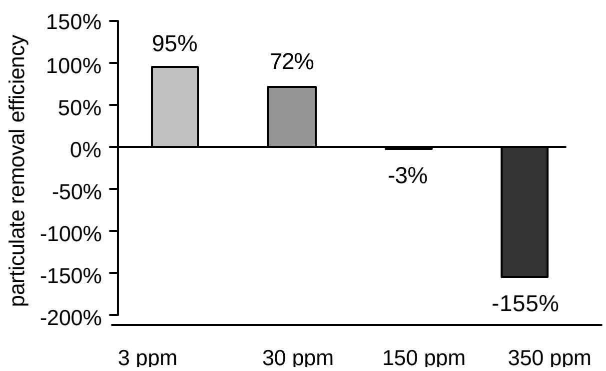
ii. Enable application of the advanced emissions control technologies. Fuel sulphur can destroy these components or greatly reduce the effectiveness of these traps. Studies are available to show that the continuously regenerating diesel particulate trap and the catalysed diesel particulate trap can achieve 95 per cent efficiency in particulate emissions control if used with 3 ppm sulphur fuel. But this efficiency will drop to zero if 150 ppm sulphur fuel is used, and particulate emissions may double over the baseline with 350 ppm sulphur fuels. (See Graph: Effectiveness of trap in near-zero sulphur diesel)

Graph 13: Only a combination of ultralow sulphur fuel and advanced emissions control components can reduce PM effectively



Source: International Council on clean transportation

Graph 14: Effectiveness of trap in near-zero sulphur diesel
PM conversion efficiency drops to nearly zero with High sulphur diesel



Note: OICA mode test cycle, particulate filter type is continuous regenerating particulate trap
Source: Anon 2000, Diesel particulate filter – final report, phase 1 interim data report no.4, Diesel emission sulphur effects program, the US Department of Energy, Engine Manufacturers Association, Manufacturers of Emission Controls Association.

In fact, the big change associated with the clean diesel rule in the US is the drastic cut in sulphur levels in fuels. The new emissions control technologies that are needed for diesel vehicles to comply with Tier II emissions standards for light duty vehicles and the new standards for heavy duty vehicles are very sulphur sensitive. Potential of these technologies can be fully realised only if used in conjunction with near zero sulphur diesel. Therefore, the US regulators have mandated extremely low-sulphur diesel fuel level of 15 ppm. Both CARB and USEPA foresee the use of NOx catalyst and PM filters for further reduction in emissions, but only with use of very low – 15ppm sulphur content diesel fuel.

The message that comes through strongly is that very low sulphur fuels are necessary for the implementation of the new aftetreatment devices including catalysed diesel particulate filters and a self-regenerating particulate filter and also de NOx catalyst. Without the ultra low sulphur fuels transition to stringent emissions standards that require the use of the new generation aftertreatment devices will be held back even in other countries including India.

New investments in refinery upgrades are underway in India now. These investments should be linked with a stringent roadmap to speed up change. Otherwise introduction of clean fuels and technologies will be delayed considerably. Currently, India has opted for stepped approach to emissions and fuel standards -- the emissions standards in major cities are one notch better than the rest of the country. Lack of uniform norms impedes introduction of advanced technologies as market gets segregated. This is largely the reason why the heavy-duty technology that move on highways and do not have access to uniform quality of fuels, has stagnated. Restricting cars to tighter standards within a few cities will also obstruct rapid improvement in car technology.

10. Why the current practice of pollution under control certificate is adequate to address the challenge of in-use emissions from diesel vehicles?

i. Solutions for in-sue diesel vehicles is very limited and also ineffective.

Not only is the diesel vehicle allowed to emit more but even its regulation on the road is difficult. The most common test, the smoke density tests for diesel vehicles as conducted under the pollution under control (PUC) programme, the I/M programme in India, are inefficient in checking emissions on the road. The dominant testing method available for diesel is the smoke opacity test (free-acceleration smoke test). The current and uniform smoke opacity norm is 65 Hartridge smoke units (HSUs). This was not revised when the new norms were notified by the Ministry of shipping, road transport, and highways in its notification of February 2004. It added engine speed and oil temperature measurements at the time of the smoke opacity tests to ensure that the smoke measurement is done on a sufficiently warmed up engine at the right engine speed. Smoke opacity standards for diesel cars should have been made tighter. The smoke density of the modern diesel engines cannot have such high HSU levels. This is evident from the of PUC data. Rarely any vehicle fails the PUC tests.

Moreover, experts say that while smoke tests can at best check for major engine malfunction in old vehicles, these are not very effective in new engines that normally have low smoke levels. Modern diesel vehicles, which may not emit black smoke, have high fine particulate emissions. However, it is difficult to measure these particulate emissions on road and in pollution-under-control tests. Direct measurement of PM from the in-use diesel fleet has not matured for wide commercial application across the world.

Also diesel NOx emissions measurement in in-use vehicles programme is not common globally. These tests are very expensive and also very complicated for in-use application. California is still looking at the possibility of introducing NOx measurement for in-use application to ensure that repair to correct high smoke emissions does not cause higher NOx emissions as a trade off. Australia that has introduced more advanced smoke tests and also particulate measurements in in-use diesel vehicles has a small programme of NOx measurement, and Oregon in the US also has a programme for diesel light duty vehicles. This essentially means, globally there is barely any system to track in-use NOx emissions. It is also not clear what impact maintenance has on diesel NOx emissions that are inherently high and normally remain stable during in-use operations.

ii. Ultra low sulphur fuels opens up the option of retrofitment: As the near zero sulphur fuels make enforcement of stringent vehicle standards for the new vehicles possible, it also opens up the opportunity for the application of the same emissions control systems for reducing in-use diesel emissions as well. Entry of clean diesel fuel and advance emissions control technologies therefore, present a much bigger opportunity for a clean up in cities that do not have access to alternative fuels like CNG as in Delhi.

The availability of clean fuel also facilitates retroftment programmes -- fixing of exhaust treatment devices in in-use fleet. This combination can help to lower in-use emissions drastically. Many countries around the world have begun to implement such programmes to clean up some of their dirtiest local bus fleet and other vehicles.

The added attraction of this strategy is that the combined emissions from the in-use fleet as well as new vehicles can be improved simultaneously for a significant overall impact. For instance, the air quality benefit of moving to the Tier II and heavy duty diesel norms in the US is not likely to show up immediately as the on road fleet will continue to remain large and polluting for a much longer time. It may take nearly 15-20 years for a substantial fleet turnover for the full effect of the new technology. Retrofitment can leverage the emissions gains from the huge investments that are being made to bring down the diesel sulphur content to near zero levels that make retrofitting with advanced emissions control technology possible. All catalytic converters perform better and last longer with low sulphur fuels.

Sweden that had introduced 10ppm sulphur diesel quite early was one among the beginners to implement a retrofitment programme. Tokyo, New York City, and California have also taken the lead to develop retrofitment programmes. Germany has a retrofittment programme for years.
The advanced countries in Asia such as Japan, and Hong Kong have already begun to implement retrofitment programmes based on advanced aftertreatment devices. China has begun to look at this option actively.[xiv]

In India a pilot retrofitment programme for diesel buses has been initiated in Pune under a joint agreement between the Ministry of Environment and Forest and USEPA. Buses are being retrofitted with emissions control devices and run on different quality of fuels. Effect on emissions will be monitored with the help of onboard monitors and also through tests on ARAI.

But detailed regulations and skilled institutions for enforcement are essential for any retrofitment programme. The countries that have implemented retrofittment of vehicles have enacted elaborate laws to set emissions reduction targets and ensure that vehicles retrofitted with exhaust aftertreatment devices are of good quality and retain their efficiency.

Sign post

It is a myth that the diesel technology that is available in India currently is clean. The real technology jump needed to meet clean diesel emissions still lies in the future. But India cannot afford to delay and push back this target. Diesel vehicles – cars, buses and trucks, must not be allowed to spew toxic emissions and expose the large urban population to high health risks. This will have to be tracked immediately with clean technology pathways. Set immediate target for nation-wide introduction of Euro IV technology and leapfrog to Euro V/VI emissions standards.

India will have to get off the diesel route if the norms do not push application of clean diesel technologies and fuels. Eliminate economic incentives for owning and running diesel cars. Levy higher taxes on diesel to prevent use of cheap and poorer quality of diesel in cars, and persuade people to consider cleaner alternatives.

Annex: Health Studies

- Particulate air pollution and morbidity in the California Central Valley, 2002: A strong and consistent increase was observed in the rate of hospitalisations and/or emergency room visits for acute or chronic respiratory conditions associated with exposure to PM2.5 (particulate matter less than 2.5 micron in size). Every 10 per cent increase in the level of PM2.5 was associated with a 4.1 per cent increase in acute respiratory hospitalisations, a 7.5 per cent increase in chronic respiratory hospitalisations, a 5.2 per cent increase in acute respiratory emergency room visits and a 6.5 per cent increase in chronic respiratory emergency room visits.
- National Environmental Trust study in 2002: This calculates the cancer risk to children in the five most populated air basins in California. The report found that exposure to diesel particulate matter (DPM) will cause infants to reach the US Environmental Protection Agency's (USEPA's) one-in-one-million lifetime cancer limit in 17-32 days, depending on the air basin they live in. By the age of one, children will have exceeded this benchmark by 11 to 21 times, and by age 18, by 121 to 252 times. Adults reach the USEPA's one-in one million lifetime cancer limit in 35-71 days from exposure to DPM. The California Environment Protection Agency's (EPA) cancer unit risk estimates were used in this study.
- US Public Interest Group (US PIRG) report in 2002: This estimates the lifetime excess cancer risk to the US public from hazardous air pollutants. The report was based on population exposure levels from the EPA's National Scale Air Toxics Assessment (NATA) report, and DPM toxicity estimates from the California EPA. The report concluded that throughout the US the lifetime excess cancer risk from breathing hazardous air pollutants was one in 1,200, with DPM accounting for 89 per cent of this risk. Of the cancer risk from breathing DPM, 32 per cent was from emissions from on-road sources, and 68 per cent from off-road sources.
- World Health Organization (WHO) used four different studies: The studies were about the carcinogenic impact of diesel exhaust on rats. WHO used them to estimate unit risk values for cancer. Its conclusion was that the lifetime excess cancer risk ranged between 1.6 and 7.1 in 100,000 excess cancer cases per every microgramme per cubic metre of DPM.
- Puget Sound Clean Air Agency's draft report in 2002: This compared local air toxics monitoring data with data from the EPA's NATA modelling estimates for the Puget Sound region. The review confirmed the NATA modelling data and concluded that DPM accounted for 70 to 85 per cent of the total excess lifetime cancer risk from all air toxics, with mobile sources of DPM contributing 85-95 per cent.
- California's South Coast Air Quality Management District released the results from its Multiple Air Toxics Exposure study (MATES-II) in 1999: MATES-II was a comprehensive urban air toxics monitoring and evaluation study. Using the California EPA's lifetime excess cancer unit risk is three in 10,000 people per one microgramme of DPM per cubic metre. The study concluded that diesel was responsible for 70 per cent of the excess lifetime cancer risk, leading to an added average lifetime cancer risk of 980 in one million from exposure to DPM.
- As part of the Diesel Risk Reduction Plan to reduce PM emissions from diesel-fuelled engines and vehicles, California Air Resources Board (CARB) compared the lifetime excess cancer risk from diesel particles with the cancer risk from the top 10 air toxic risk contributors, using exposure information from its statewide air toxics monitoring network, and the California EPA's cancer unit risk estimate. CARB's conclusion was that exposure to air toxics in the state resulted in an average excess lifetime cancer risk of 758 in one million, and that diesel particles were responsible for more than 70 per cent of this added lifetime cancer risk.
- US-based Natural Resource Defense Council study in January 2001: It points out that schoolchildren suffer from sustained exposures to diesel exhaust while travelling in school buses for one-two hours every day during a school year of 180-200 days over a schooling period of 10 years. It concludes that a child riding a diesel school bus is being exposed to as much as 46 times the cancer risk considered significant by the USEPA.

Table: Diesel is Carcinogenic

2002	US Environmental Protection Agency	Likely human carcinogen
2001	American Council of Government Industrial Hygienists (proposal)	Suspected human carcinogen
2001	US Department of Health and Human Services	Reasonably anticipated to be a human carcinogen
1998	California Air Resources Board	Toxic air contaminant
1996	WHO International Programme on Chemical Safety	Probable human carcinogen
1995	Heath Effects Institute	Potential to cause cancer
1990	State of California	Known to cause cancer
1989	International Agency for Research on Cancer (IARC)	Probable human carcinogen
Source: January 2004, Patricia Monahan and David Friedman, The Diesel Dilemma, Diesel's role in the race for clean cars, Union of Concerned Scientists		

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