
Briefing Paper

Even before the Asian countries could deal with the health impact of particulate matter, the new science has implicated black carbon, a fraction of the particulate matter, for enhancing warming impact. This has blurred the boundaries between the local and global impact of pollution. In the transport sector particularly, the dominant use of high sulphur diesel and poor quality vehicle technology are aggravating both local toxic risks as well as climate risk because of high black carbon emissions. This multiple burden of risks demands active, cohesive and aggressive policy response across regions of the world to phase out dirty diesel and introduce clean diesel.

Cities of Asia now face this challenge of the balance – i.e. curb local air pollution to save lives, and at the same time, reduce climate impacts of growth and motorisation to save fuels and climate. It is disturbing to see the results of the global burden of disease that shows air pollution is still among the largest killer with disproportionately high impacts in Asia. Asian cities will have to be enabled to make quick transition to clean and efficient technology and mobility paradigm.

To achieve the objectives of climate and health co-benefits, it is important to deepen policy understanding of the challenges, policy action and opportunities in different regions of the world – Asia, Europe and the US. This will help to draw lessons and accelerate global technology roadmap and fiscal strategy for climate and health co-benefit that will also benefit Asia.

1. Black carbon challenge

Among the short term forcers, black carbon has come under spotlight for harming public health and aggravating climate impact. Black carbon is part of the tiny particles that come from all combustion processes, all dust generating activities, secondary particulates – nitrates and sulfate, and the condensation of gases into liquid droplets. These are emitted because of low temperature combustion of carbonaceous fuels, and incomplete combustion.

As very high concentration of long lived CO₂ has already committed the world to enormous warming, the elevated levels of short lived pollutants are said to be increasing the frequency and intensity of temperature spurts for as long as they are in the air. These have stronger warming potential in the short term than long lived CO₂. The most recent IPCC report (AR5) has taken on board global warming potential values for black carbon which is a doubling of the estimate of the warming caused by black carbon cited earlier. Black carbon when emitted has an immediate and large positive radiative forcing but its climate impact is gone as soon as it falls. CO₂ on the other hand, causes positive forcing on a mass-equivalent basis and lives so much longer and in a slow and steady manner can cause a very large and more widespread impact over a much longer period of time. Short-lived pollutants are an opportunity to make some impact in the short term on temperature spikes if done with aggressive action on CO₂.

2. Some warm. Some cool.

According to the climate science all particles do not warm. Some, especially organic carbon and sulphate have cooling effect as they are light-reflecting. If the ratio of their emissions is higher relative to black carbon they may have more cooling effect. But the exact threshold from negative to positive forcing for the major sources is still an area of uncertainty and is the focus of ongoing research. So scientists conclude that tropospheric ozone, black carbon, methane, F-Gases, are “Bad”. But sulfate aerosols, organic carbon, clouds, are “Good” from climate perspective. Share of cooling and warming particle determines the net positive or net negative impact of different sources.

There are still large uncertainties in the understanding of net warming or net cooling of some emissions sources. Sources like open burning and biomass burning, for residential biomass (cook stoves of the poor), that have a mix of both warming and cooling pollutants can behave differently. Scientists say they may even have net cooling potential.

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However, science is more certain about the fact that black carbon predominantly from fossil fuel combustion has warming effects. Emissions from both on-road and non-road transport that largely uses diesel has higher share of light absorbing black carbon and much lower organic carbon and has definite warming impact.

While the scientists are debating the uncertainties, especially related to biomass burning – which is done largely by the poor people of the world, there are stronger evidences to suggest that diesel emissions have much higher share of black carbon and therefore are warming. Diesel engines, part of luxury consumption, account for nearly all of the black carbon and diesel engines produce net warming when its other pollutants are taken into account.

3. Health co-benefits: All particles – warm or cool, must go to protect public health

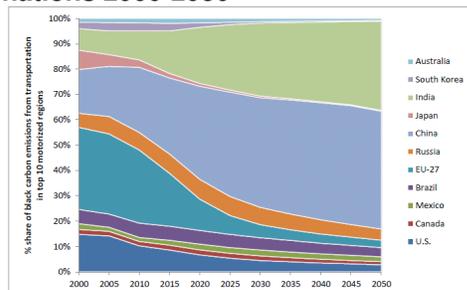
From health perspective all particles from all sources including transport and biomass burning are bad. Breathing fine particles (PM_{2.5}) causes adverse effects on the cardiovascular and respiratory systems. Both outdoor and indoor particulate exposures are linked to premature death, heart attacks, strokes, hospital and emergency room visits, acute and chronic bronchitis, and asthma-related effects. PM_{2.5} is also associated with infant mortality, low birth weight, and cancer. According to the Global Burden of Disease estimate outdoor air pollution is the ninth largest killer in the world and fifth largest killer in India. In 2010 air pollution caused 627,000 premature deaths and more than 18 million healthy life years lost in India. If the health impacts of both outdoor and indoor air pollution are combined then these are the top most killers in Asia. Even if there are uncertainties regarding climate impacts of particulate from different sources, health science demands urgent, quick and aggressive control of particles from all sources.

4. Black carbon and transport sector

Transport sector is one of the key sources of black carbon and is responsible for about 25 per cent of global black carbon emissions globally. There is a difference in regional trends. The UNEP Integrated Assessment Report 2012 states that in 2005 North East Asia, South East Asia and Pacific were the largest emitter of black carbon followed by the US and Europe. Though the overall black carbon emissions will decline by 2035, the relative position of the countries will shift depending on fuel consumption and level of technology.

Black carbon emissions from transportation among top 10 motorised nations during 2000-2050 show that the emissions were substantial during 2000-2010 in the US and Europe but would decline substantially thereafter as stronger air quality and public health policies will enable quicker uptake of emissions control technologies. However, the share of emissions in Asia and other developing regions will increase with motorization and dieselization. But these regions also have bigger opportunities to avoid substantial pollution if effective technology and fuel quality roadmap are adopted at the early stages of motorization.

Figure 1: Black carbon emissions by transportation by region among top 10 motorised nations 2000-2050



Source: World Bank 2014

5. Climate and health impacts of diesel black carbon

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Globally diesel black carbon is expected to be 20 per cent of the total black carbon emissions (Bounding the role of black carbon Report 2013). Total emissions from petrol vehicles are less than 10 per cent of diesel BC emissions, although petrol vehicles are more numerous. Diesel black carbon is several times higher than the petrol black carbon. Only in vehicles with gasoline direct injection can have high black carbon emissions. .

There are also serious concerns about diesel particles that have been recently branded by the WHO as a class 1 carcinogen, same as tobacco smoking, for strong link with lung cancer. Diesel vehicles contribute enormously to particulates and nitrogen oxides as well as to ozone formation that compound the disease burden. Therefore, mitigation of diesel emissions gives strong health and climate co-benefits. This is a win-win strategy for all regions.

6. Implication of dieselization

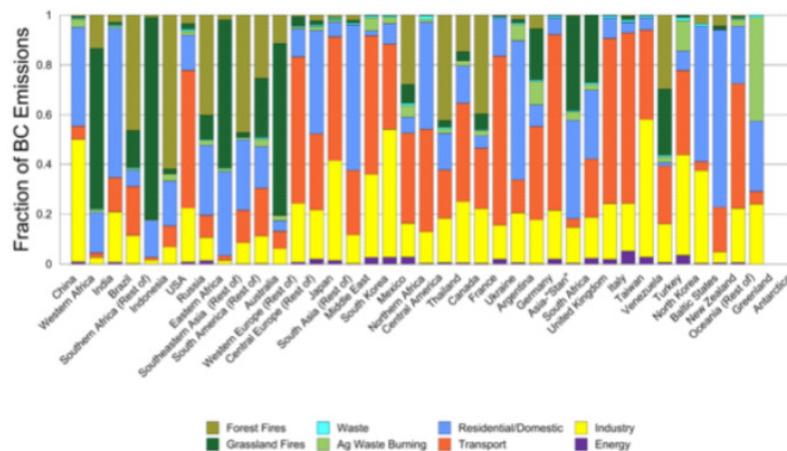
Climate impacts of diesel vehicles get very complicated when it is assessed from both CO₂ and black carbon perspective. Even though the automobile companies hard sell diesel cars for CO₂ benefits and fuel efficiency, most of this benefit gets negated because of black carbon emissions. Moreover, cheaper diesel fuel also encourages more driving that has a rebound effect on CO₂ emissions. Also diesel fuel has higher carbon content and if more of diesel is burnt more heat-trapping CO₂ escapes. Even under Euro IV particle standards, diesel vehicles may still warm the climate for well over the next 100 years (Jacobson's assessment). Additionally, CO₂ emissions from the upstream diesel refining process will increase. All these negate the marginal greenhouse gas reduction benefit of diesel car.

Increasingly, the industrialized countries that have already implemented tighter emissions standards are finding it difficult to control both particulate and nitrogen oxides together. Studies in Europe have shown how the current fleet of diesel vehicles is emitting much higher NO_x than what they were expected to. An assessment by International Council on Clean Transportation has found in-use diesel cars emitting seven times more NO_x than their emissions limit. NO_x contributes towards ozone formation which is also a climate forcer on a regional scale.

7. Regional approaches and imperatives of diesel emissions control

Diesel mitigation challenges and strategies vary across different regions of the world. In regions where agricultural burning, residential burning and cook stove emissions are controlled – like the US and Europe, the relative share of diesel black carbon in those countries dominates their pollution inventory. But in developing world the relative share of diesel black carbon is lower compared to other sources, though their levels are rising.

Figure 2: Relative position of black carbon sources in different regions



Source: Lamarque et al 2010

Europe: Europe has dieselised very rapidly because of price difference between petrol and diesel fuels, high taxation that puts an additional premium on fuel economy and the CO₂ mitigation efforts to encourage fuel efficient cars. Significant dieselization has taken place already – 50-70 per cent in different countries of Europe -- without the appropriate emissions control technologies. According to ICCT diesel black carbon accounted for 43 per cent of black carbon emissions in Europe in 2010 as opposed to global average of 20 percent.

As Asia follows European standards it is important to note that even with successive improvement in emissions standards (Euro I, II, III, IV, V, VI) very high ratio of black carbon to organic carbon persists in the emissions. According to the 2014 World Bank study fleet-wide averages taken in a global emissions inventory model shows that while the share of black carbon in the particulate emissions from Euro II model was 80 per cent it has reduced to 25 per cent in the Euro V fleet -- but still a problem. Black carbon reduction technologies become effective for cars at Euro V level and for heavy duty vehicles at Euro VI level that Europe is implementing now.

Particulate norms are lowered in cars and light-duty commercial vehicles from Euro IV to Euro V but not for buses or heavy-duty commercial trucks. Not until Euro VI more stringent limits are put into effect for these vehicles. Thus, Euro VI is the ultimate target not only for particulate control but also for black carbon control. In the case of cars and light- to medium heavy-duty commercial vehicles, a particle number limit at Euro V level forced the use of a diesel particulate filter. This explains the large reduction in diesel black carbon for these vehicles from Euro IV level. But the Euro V standard does not establish a particle number limit for heavy-duty commercial trucks and buses. So the black carbon share remains high for these vehicles. This has been done in Euro VI standard which finally forces the use of a diesel particulate filter in heavy duty vehicles.

The US: In the US the car segment has not dieselized as it has in Europe. The US does not maintain differential between petrol and diesel prices and consumer preference has remained in favour of petrol vehicles. The US also sets the same NO_x standard for diesel cars as for petrol cars. In Europe, diesel NO_x standards even if they were met in use have been 3 times higher up through Euro 5. Even with Euro 6, diesel NO_x is relaxed. Also relatively higher diesel penetration in the recent years has coincided with the introduction of tighter emissions standards of Tier II.

The large fleet of heavy duty truck and bus fleet as well as off-road vehicles continue to remain an important source of substantial black carbon emissions in the US. While overall black carbon emissions has reduced substantially from all sources over the years in the US, the relative position of diesel black carbon in the order of importance among all sources is the highest. The share of transport black carbon among all sources in the US is 52 per cent. As is evident from the California's heavy-duty truck program, the focus of the mitigation strategy is on new emissions standards, retrofitting or re-powering of old diesel engines, reducing emissions from off-road vehicles and other transport.

In the US the greater emphasis is on technology innovation for zero emissions, reduction of emissions from old fleet, marine pollution and re-engineering. Both the US and Europe will focus on rail based freight movement. Europe will also be more aggressive with mobility strategies.

7.2. Challenge of dieselization in Asia

There is a wide variation in the trend of motorization, dieselisation and emissions standards roadmap across different regions and countries of Asia. There are also distinct patterns in key vehicle producing regions of Asia - India and China and also non-vehicle producing country like Sri Lanka.

India: Dieselisation of car segment is a unique challenge of India. This is largely the result of wide difference in diesel and petrol prices. India has already experienced substantial dieselization

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of the car segment. Diesel cars are 50 per cent of new car sales. This is further compounded by the high emissions from the heavy duty fleet. Dieselisation has also increased the overall mass of the vehicle fleet and fuel consumption. India so far has implemented Euro III emissions standards nation-wide and Euro IV in about 30 cities and towns. This has led to some reduction in particulate load but this is at risk of being negated due to rapid motorisation. According to its proposed roadmap India will introduce Euro IV nation-wide in 2017-18; Euro V (with 10 ppm sulphur fuel) in 2020-21 and Euro VI in 2024-25. Significant improvement is possible from stringent and accelerated roadmap.

China: In China dieselisation of car fleet has not been such a problem largely because of the very small differential between diesel and petrol prices. Also as a policy matter government officials have discouraged light duty diesels. Moreover, stringent decisions like banning of diesel cars have been implemented in cities like Beijing. There has also been a proposal from China's Ministry of Environmental Protection (MEP) State Council to introduce 50 PPM Sulfur Nationwide by end of 2014 and 10 PPM by end of 2017. They have also proposed quicker steps in key regions. Key cities like Beijing have already introduced Euro V emissions standards.

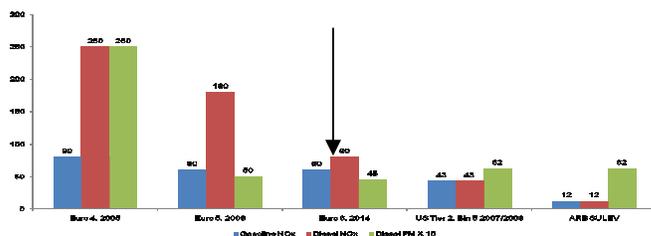
Sri Lanka: Sri Lanka is among the non vehicle producing regions of Asia and is a unique case that has adopted innovative fiscal strategy to contain dieselisation as well as introduce clean diesel. With innovative import duty strategy Sri Lanka has imposed double the import duty on diesel than the petrol cars and substantially lowered duties on hybrid cars. With this strategy Sri Lanka has turned the market around and succeeded in controlling and reducing dieselisation.

8. Way forward

Dieselisation is a serious health and climate concern that all regions of the world will have to address together. This requires deeper understanding of experience with diesel regulations and implementation in different regions to inform national action on diesel roadmap and air pollution control strategies.

Need effective and harmonized emissions standards roadmap: This demands upward harmonization of stringent emission standards across regions. Emissions control systems and fuel quality (10-15 ppm sulphur fuels) that are needed for effective control of diesel emissions become applicable only at Euro VI level. This will require legal adoption of emissions standards roadmap, adequate investments in refineries to produce clean fuels; and fiscal strategies to enable the transition. Developing regions will have to be enabled with good science, knowledge, nationally appropriate but accelerated emissions standards roadmap, and fiscal and investment strategies for clean fuels. This can also be complemented with accelerated fleet turn over. Particulate filters are very reliable but if the vehicles is not properly maintained it can create an unfavorable environment for these filters to operate.

Figure 3: Emission standards roadmap.



Need mobility management to complement technology roadmap: Future approaches in Europe for instance show that in the post Euro VI scenario Europe is expected to combine strong mobility and vehicle restraint measures to control pollution and cut emissions. Developing Asia has enormous opportunity in combining the two strategies effectively -- stringent technology

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roadmap with sustainable mobility practices – walk, cycle and public transport. Developing Asia will also require a stringent measure to increase the share of rail based passenger and freight transport to reduce emissions from heavy duty vehicles that dominate the black carbon inventory.

Need composite road map to include non-road transport: The experience of the industrialized countries show that as the share of on-road emissions decline the relative share of other modes of transport – off-road and marine transport increases. Developing Asia needs to develop more holistic strategies to include on-road, off-road, and non-road sources as is applicable.

Aggressive action on diesel can ensure health and climate co-benefits across regions.