India-California Air Pollution Mitigation Program (ICAMP)

Initiative for Mitigating Air Pollution from the Transportation Sector

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A joint initiative by the University of California at San Diego (UCSD), The Energy Resources Institute (TERI), India, and the California Air Resources Board (CARB)

Sponsor: The World Bank

Inception Note
Summary For Policy Makers
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FIRST DRAFT

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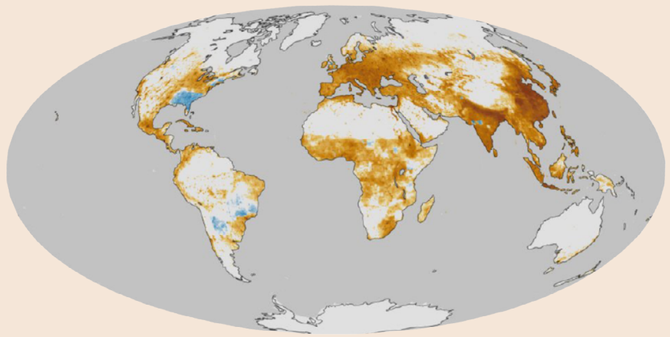
EXECUTIVE SUMMARY

California From The 1960s To Now

- The California Air Resources Board held its first meeting in 1968 when the black carbon (major component of PM2.5 from diesel combustion) concentration in urban locations exceeded 3500 nanograms per cubic meter. Its BC concentrations decreased by 90% by 2010 even as diesel fuel consumption increased by a factor of four!
- The main driver for CARB's policy actions is the concern for the health impacts of particulate pollution (PM2.5) and ground level ozone. Ambient air pollution leads to 3.2 million premature deaths worldwide every year



Premature mortality due to PM2.5. Dark brown regions experience more than 1000 deaths/1000 square kilometers. Source: NASA Earth Observatory, 2013.

- World Health Organization (WHO) has recently classified diesel engine exhaust as carcinogenic to humans based on sufficient evidence that exposure to these emissions is associated with an increased risk for lung cancer *(WHO, 2012)*
- The important lesson to be learned is that cleaning up the air does not necessarily deter development. In fact, it might have made the region more attractive for growth
- In addition to reducing air pollution related mortalities, the reduction of PM from the transportation sector had a surprisingly large impact on mitigation of anthropogenic climate change, because of the concomitant reductions in black carbon from diesel
- California-wide BC emission reductions since the 1980s, attributed in large part to diesel engine emissions mitigation, are equivalent to reducing CO_2 emissions by 21 million metric tons annually. This is approximately equal to 5% of the total direct CO_2 annual emissions of 393 million metric tons
- Global black carbon from transportation is expected to grow from seven to 77 percent between 2001 and 2020 *(Diesel Technology Forum, 2009)*.

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CARB's Air Pollution Reduction Programs:

Due to the health concerns from PM exposures, both ARB and local air pollution control and air quality management districts have developed programs to reduce emissions from these sources, which have also concurrently resulted in significant reductions of black carbon. The main programs are listed below. The most significant reductions have come from the upgrade of the on- and off-road legacy fleet to include diesel particulate filters. *a. Low Emission Vehicle Programs (LEV I, II, and III)* – which have significantly reduced emissions from new light-duty vehicles. *b. Heavy-Duty On-Road Engine PM Standards* – which have reduced emissions from new heavy-duty on-road engines and led to the use of diesel particle filters. *c. Off-Road Engine Standards* – similar to the engine standards for on-road engines, these standards will accelerate the reductions of PM and black carbon from new off-road engines (e.g., construction vehicles). *d. Diesel and Gasoline Fuel Specifications* – required changes to diesel and gasoline fuels which reduced the formation of particulate matter and enabled the use of catalytic after-treatment on both gasoline and diesel engines. *e. In-Use Fleet Rules* (Drayage and Truck and Bus Rules) – which require retrofitting or engine upgrades of the current on-road diesel engines so that almost every heavy-duty diesel engine will have a diesel particulate filter by 2014. *f. Fireplaces* – all major air districts have adopted rules limiting wood-burning in residential fireplaces and heaters as part of their efforts to meet State and federal air quality standards for PM2.5. In some districts, new wood-burning fireplaces are not allowed (new natural gas is allowed). *g. Diesel Clean-up Incentive Programs* – ARB incentive programs -- the Carl Moyer Memorial Air Quality Standards Attainment Program, the AB 118 Air Quality Improvement Program, and Proposition 1B funding -- have provided approximately $1.6 billion over the past 15 years to clean up diesel engines and simultaneously reduce black carbon.

California Environmental Protection Agency
Air Resources Board

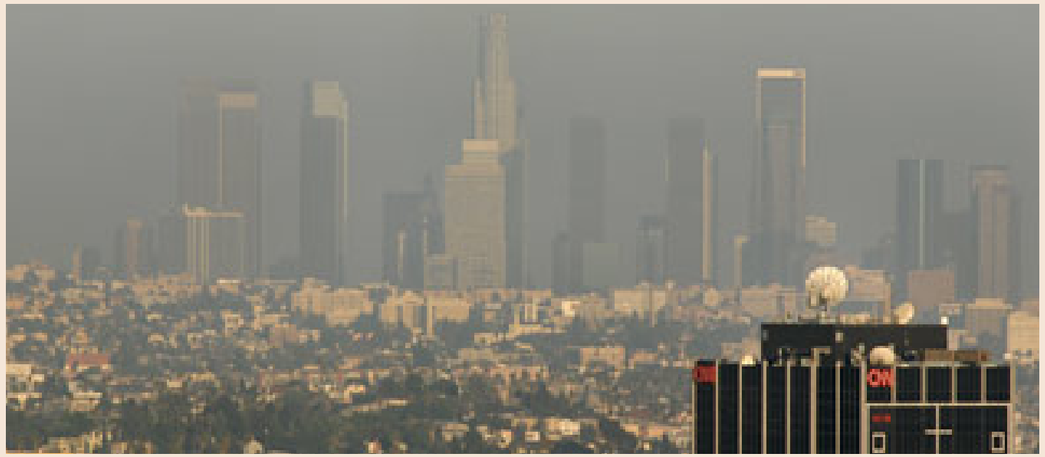
India: From Now To 2030

- India's transportation sector is experiencing impressive growth. The number of vehicles has grown from about 20 million in 1991 to about 140 million in 2011. Air pollution has become a major problem in cities with PM concentrations exceeding standards by factors of 5 to 10 in major cities. In cities like Bangalore, the transportation sector contributes more than 50% to PM2.5 (as of 2011), nearly the same as in California

- While emissions of air pollutants from human activity is the source of air pollution, the regional meteorology of persistent inversion that lasts over 4 months contributes to the large scale build up of heavy air pollution in South Asia

- The World Health Organization (WHO) estimates that over 700,000 people die each year in South Asia as a result of ambient particulate matter pollution, making PM2.5 emissions the sixth largest killer in the region. In addition, near surface ozone formed by NOx and VOCs from the transportation sector causes millions of tons of crop destruction annually in addition to impacting health

- Basically, Indian cities today face a situation similar to that of California in the 1940s to 1960s. Another relevant California experience is population growth. California's population grew from seven million in the 1940s to about 38 million today. The Los Angeles metropolitan area is the second-most populated urban area in the United States, after the New York metropolitan area. Los Angles historically experienced the most severe smog in the U.S., but air pollution levels have improved dramatically



Pollution and smog cloud the view of Hollywood, Calif. with downtown Los Angeles in the background. Source: Mary Knox Merrill/The Christian Science Monitor

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- What would it take to accomplish similar improvements in air quality of mega cities such as Mumbai, Bangalore, Delhi, Calcutta and Chennai within the next 30 years, without impeding the economic development of India? The fundamental goal of ICAMP is to examine how California achieved these impressive gains in air pollution without compromising development; and evaluate the nature and magnitude of scientific, technological and organizational infrastructure and policy initiatives that are required for India to make similar progress in the coming decades

- If India were to take a holistic approach and act in a coordinated manner on regulating fuel quality standards and emissions, there is a good possibility that vehicular emissions could be reduced by more than 80% from where present trends would place them in 2030

- Such dramatic changes will require shifts and improvements in public investment processes, scientific capacity building, monitoring capability, urban governance, distributional policy, and other related areas in addition to tightening and enforcing environmental regulation

Air pollution in India. (Photo: chilfriend news)

- There are three challenges involved in reducing vehicular emissions: first, motivating a consumer shift away from diesel to petrol vehicles by reducing the price difference between diesel and petroleum; second, tightening and enforcing vehicle emissions standards for all fuels; and third, mandating and enforcing fuel quality xstandards, particularly for diesel, that allow for some of the latest emissions control technologies to be used

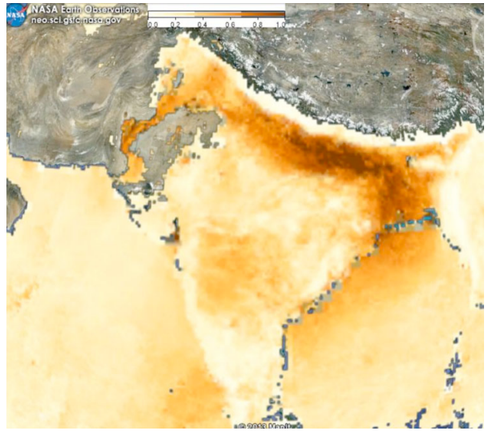
SUMMARY

View of part of the Los Angeles Civic Center masked by smog in 1948.
Source: Los Angeles Times photographic archive, UCLA Library

Background: The city of Los Angeles became notorious in the 1940s for its smog (see photo taken in 1948) and the oppressive smog events continued into the 1960s, when the California Air Resource Board (CARB) was formed. Mega cities like Delhi and Bangalore in India experience similar air pollution events now. The one major difference is, Californian cities experience severe smog events during days subject to Inversion; India (especially north India), on the other hand, is subject to a long, dry season of four months, when it is under quasi-permanent inversion. The poor ventilation of polluted air allows the cloud of air pollution to spread over the entire Indo-Gangetic plains with high concentrations of particles (PM2.5) and ozone, both of which lead to unprecedented mortality rates (*see cover image*) and crop damages.

While emissions of air pollutants from human activity is the source of air pollution, the regional meteorology of persistent inversion that lasts over four months contributes to the large scale build up of heavy air pollution in South Asia.

Setting the Stage: CARB's first meeting was held in 1968 when the black carbon (major component of PM2.5 from diesel combustion) concentration exceeded 3500 nanograms per cubic meter and by 2010 the BC concentrations decreased by 90% while consumption of diesel increased by a factor of four *(see figure 1)*.



Column-averaged particle concentration expressed in optical units

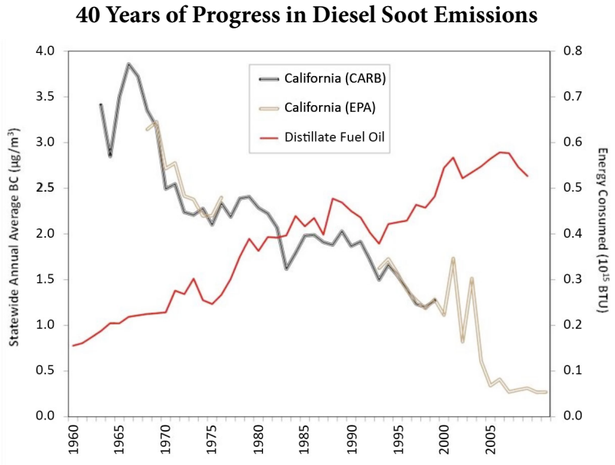


Figure 1. *Black line is ambient concentration of black carbon averaged over urban locations of California and red line is state averaged diesel consumption.*
Data: Kirchstetter et al, 2011.
Reproduced from Ramanathan et al. (CARB Report, 2013)

The important lesson to be learned is that cleaning up the air does not necessarily deter development. In fact, it might have made the region more attractive for growth.

Why did California take such aggressive steps? The main driver is the concern for the health impacts of particulate pollution (PM2.5) and ground level ozone. Ambient air pollution leads to 3.2 million premature deaths worldwide every year. In addition to reducing mortalities, the reduction of PM2.5 had a surprisingly large effect in mitigating climate change. The major contributor to PM2.5 reduction is from the diesel transportation (on-road and off-road) sector. For diesel combustion, black carbon contributes about 75% of the PM2.5. Coincidentally, black carbon is also the second largest contributor to global warming. In 2013 CARB published a multi-institutional report *(Ramanathan et al, 2013)* which concluded the following:

BC emission reductions since the 1980s, attributed in large part to diesel engine emissions mitigation, are equivalent to reducing CO_2 emissions by 21 million metric tons annually. This is approximately equal to 5 % of the total direct CO_2 annual emissions of 393 million metric tons.

The diesel sector is the most potent contributor to global warming compared with all other BC sources because of the following: On-road diesel is very low in sulfur in developed regions. In addition, diesel PM has more BC than OC compared with other sources of BC (e.g, biomass).

It follows that controlling diesel BC would mainly decrease atmospheric concentrations of BC and the decrease in other cooling aerosols such as sulfates or organics are minimal as revealed in California data *(Ramanathan et al, CARB report, 2013)*.

Why Target the Transportation Sector? India's transportation sector is experiencing impressive growth. The number of vehicles has grown from about 20 million in 1991 to about 140 million in 2011. Air pollution has become a major problem in cities with PM concentrations exceeding standards by factors of 5 to 10 in major cities. In cities like Bangalore, the transportation sector contributes more than 50% to PM2.5 (as of 2011), nearly the same as in California.

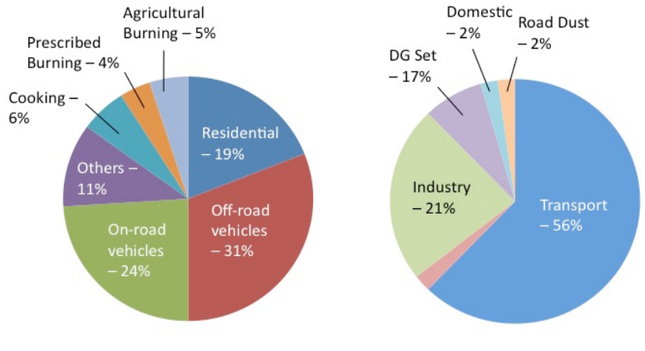


Figure 2. *California Black Carbon Sources, 2010 (left); Bangalore Elemental Carbon Sources (right).*

The World Health Organization (WHO) estimates that over 700,000 people die each year in South Asia as a result of ambient particulate matter pollution, making PM2.5 emissions the sixth largest killer in the region. In addition, near surface ozone formed by NOx and VOCs from the transportation sector causes millions of tons of crop destruction annually in addition to impacting health.

World Health Organization (WHO) has also recently classified diesel engine exhaust as carcinogenic to humans based on sufficient evidence that exposure to these emissions is associated with an increased risk for lung cancer (WHO, 2012).

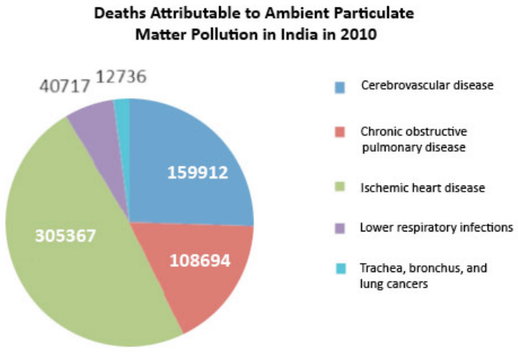


Figure 3. *Deaths attributable to ambient particulate matter pollution in India, 2010*

Some of the highest levels of outdoor air pollution in the world are found in Indian cities such as Delhi, Kolkata, Kanpur, and Ahmedabad. Though the Government of India has set the National Ambient Air Quality Standards (NAAQS), levels of pollutants often remain higher than these levels in the cities. Emissions from transport are a key component to ambient air pollution.

Why is the California Experience Relevant to India? Many Indian cities fail consistently to meet National Ambient Air Quality Standards (NAAQS). Basically, Indian cities today face a situation similar to that of California in the 1940s to 1960s. In addition, near surface ozone formed by NOx and VOCs from the transportation sector causes millions of tons of crop destruction annually in addition to impacting health. Another relevant California experience is population growth. California population grew from seven million in the 1940s to about 38 million today. The Los Angeles metropolitan area is the second-most populated urban area in the United States, after the New York metropolitan area. Los Angles historically experienced the most severe smog in the U.S., but air pollution levels have improved dramatically. The health-based standards for lead, CO, NO_2, SO_2, and sulfates have all been attained, and peak ozone levels have dropped 75 percent relative to levels in the mid-1960s. The southern California air basin recorded 167 days exceeding the National Ambient Air Quality Standard (NAAQS) of 0.12 ppm maximum hourly average in 1980, 158 days in 1985, 131 days in 1990, 98 days in 1995 and 33 days in 2000 *(CARB, 2002)*.

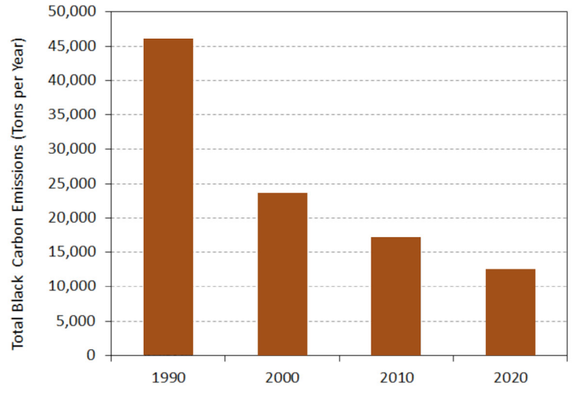


Figure 4. *Recent ARB estimates suggest that the annual black carbon emissions in California decreased about 70 percent between 1990 and 2010, in direct proportion to declining diesel particulate matter (DPM) emissions - a co-benefit of ARB's regulations on diesel engines.*

Annual black carbon emissions in California decreased about 70 percent between 1990 and 2010 in direct proportion to declining diesel particulate matter emissions – a co-benefit of ARB's regulations on diesel engines (CARB Data).

What would it take to accomplish similar improvements in air quality of mega cities such as Mumbai, Bangalore, Delhi, Calcutta and Chennai within the next 30 years, without impeding the economic development of India? It is such questions we wish to address within ICAMP.

The Scope of ICAMP:

> ***The fundamental goal of ICAMP is to examine how California achieved these impressive gains in air pollution without compromising development; and evaluate the nature and magnitude of scientific, technological and organizational infrastructure and policy initiatives that are required for India to make similar progress in the coming decades.***

Objective I: *To convene stakeholders and experts concerned with public health, environmental damage and climate change, environmental justice, economic development, and transport industry competitiveness to develop an action agenda of scientific research, technology development, and innovative pilot programs to reduce black carbon and ozone precursor emissions from the transportation sector in India.*

ICAMP envisages knowledge transfer among the participants to highlight potential approaches, understand key factors in adapting them to India. It will accelerate integration of air pollutant reduction measures with ongoing transport development initiatives in India. This could later lead to robust frameworks for similar knowledge-to-action dialogues in other issue areas and countries.

Objective II. *To develop concrete, practical pathways for reducing health, agriculture, and climate-damaging particulates and ozone precursor emissions from the transportation sector in India.*

We propose to organize a joint program of knowledge exchange and stakeholder dialogue between world-renowned scientists, policymakers, air quality regulators and stakeholders in India's air quality management.

ICAMP will be implementing its objectives through three steps to generate an action agenda for scientific research, technology development, and specific, feasible interventions to promote a low-emission development path for India's transport sector:

1. In-person interaction among scientists, policymakers, and transport stakeholders with deep knowledge about determinants emissions as well as control options, in a neutral setting to generate an initial set of ideas for intervention. The workshop jointly hosted by UCSD and CARB, is being organized in Oaklland, CA for October 2013. A delegation of 15 persons from India representing different stakeholder groups will visit California to attend two and half days of meetings with about 35 experts from the US.

2. Research to refine this agenda into more concrete, detailed proposals.

3. High-level policy enclave to disseminate the ideas and build partnerships for further research and policy pilots. The policy enclave is intended to be organized in February 2014 in New Delhi, India.

The exchange of in-depth knowledge on the socio-economic ecosystems underlying transport emissions, the lessons from regulatory and non-regulatory experience in both countries, and the perspectives of influential stakeholders in emission mitigation will contribute to four main results:

- Broad sensitization of policymakers/stakeholder groups on the issues of BC and other emissions from transport sector as well as the range of emissions reductions tactics
- Formation of new issue-based professional networks for continuing dialogue on emissions mitigation as the state of science, technologies, and monitoring evolves
- Social innovation: adaptation of existing experience and success into specific proposals for contextually appropriate, regulatory and non-regulatory instruments for rapid results in an important global economy
- Development and testing of a format for science-policy-development dialogue that could be implicated for other aspects of SLCP mitigation as well as in other policy areas where solutions rely on local, contextualized knowledge in addition to global science, innovation, and resources

Preliminary Findings of the Scoping Work

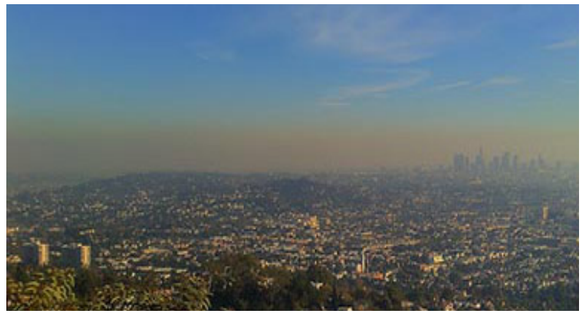
We are fully aware that the Oakland workshop likely will influence our understanding of opportunities to reduce emissions from transport sector. *Potential opportunities are listed (and elaborated further in the accompanying text) simply to promote targeted discussions during the workshop at Oakland.*

> ***If India were to take a holistic approach and act in a coordinated manner on regulating fuel quality standards and emissions, there is a good possibility that vehicular emissions could be reduced by more than 80% from where present trends would place them in 2030.***

I. California's air quality management:

CARB: California's legislature formed CARB in 1967. CARB works with public, business sector and local (city) governments to find solutions to California's air pollution problem. It draws on the world renowned scientific expertise in the state's academic institutions including, Stanford,

Caltech, University of California and many state colleges in the system by funding researchers to address mission-specific research questions. It also has state of the art monitoring systems for most, if not all, air pollutants. CARB has an annual budget of $150 million and oversees 35 local and regional air pollution control districts. In addition it receives $166 million per year from fees on vehicle registration and new tire sales. It has a staff of 1100 employees state-wide, most are engineers and scientists (PhDs and Masters).



Source: *ucdavis.edu*

Air Pollution Reduction Programs: Due to the health concerns from PM exposures, both ARB and local air pollution control and air quality management districts have developed programs to reduce emissions from these sources, which have also concurrently resulted in significant reductions of black carbon. The main programs are listed below. The most significant reductions have come from the upgrade of the on- and off-road legacy fleet to include diesel particulate filters. *a. Low Emission Vehicle Programs (LEV I, II, and III)* – which have significantly reduced emissions from new light-duty vehicles. *b. Heavy-Duty On-Road Engine PM Standards* – which have reduced emissions from new heavy-duty on-road engines and led to the use of diesel particle filters. *c. Off-Road Engine Standards* – similar to the engine standards for on-road engines, these standards will accelerate the reductions of PM and black carbon from new off-road engines (e.g., construction vehicles). *d. Diesel and Gasoline Fuel Specifications* – required changes to diesel and gasoline fuels which reduced the formation of particulate matter and enabled the use of catalytic after-treatment on both gasoline and diesel engines. *e. In-Use Fleet Rules* (Drayage and Truck and Bus Rules) – which require retrofitting or engine upgrades of the current on-road diesel engines so that almost every heavy-duty diesel engine will have a diesel particulate filter by 2014. *f. Fireplaces* – all major air districts have adopted rules limiting wood-burning in residential fireplaces and heaters as part of their efforts to meet State and federal air quality standards for PM2.5. In some districts, new wood-burning fireplaces are not allowed (new natural gas is allowed). *g. Prescribed and Agricultural Burning* – California's longstanding smoke management programs minimize the impacts of agricultural, forest and range land management burning operations. State law combined with programs to reduce health impacts have phased out the vast majority of burning. *h. Diesel Clean-up Incentive Programs* – ARB incentive programs -- the Carl Moyer Memorial Air Quality Standards Attainment Program, the AB 118 Air Quality Improvement Program, and Proposition 1B funding -- have provided approximately $1.6 billion over the past 15 years to clean up diesel engines and simultaneously reduce black carbon. *i. Cooking* – A number of districts have adopted rules to reduce PM2.5 emissions from commercial charbroiling operations. Emission reductions resulting from these regulations have reduced PM2.5 emissions by more than 80 percent.

Co-benefits of air pollution reduction: The control of black carbon from diesel is an effective means of mitigating near-term global climate change. However, we would like to caution that, without simultaneous reduction of CO_2 emissions, it will not be possible to limit future warming to below 2°C as required by the Copenhagen Accord.

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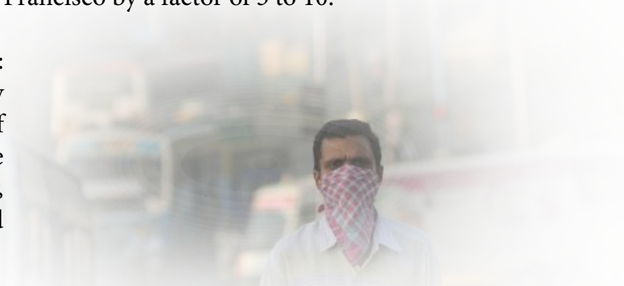
BC emission reductions since the 1980s, attributed in large part to diesel engine emissions mitigation, are equivalent to reducing CO_2 emissions by 21 million metric tons annually. This is approximately equal to 5% of California's CO_2 annual emissions of 393 million metric tons.

II. Indian transportation sector:

Growth: The number of motor vehicles grew from less than 10 million in the 1980s to about 140 million in 2011. This sector is expected to rise by three fold by 2030. Air pollution is a serious concern, especially in urban centers. About 80% of cities exceeded by a substantial margin the World Health Organization guidelines. Concentration of PM in cities like Mumbai and Kolkatta are larger than PM levels in Los Angeles and San Francisco by a factor of 5 to 10.

Health Effects: Air pollution impacts include: Bronchitis; Cardiovascular disease; respiratory disease; cancer; intellectual development of children; Asthma. More than 600,000 deaths are attributed to ambient air pollution. It is likely, more than 50,000 deaths per year could be avoided by advancing vehicular emission norms in India.



Policy Landscape for emission reduction: India's transport needs are currently growing faster than the economy and are likely to continue on this trajectory. Reducing emissions even as the kilometers traveled increase will require concerted effort to increase energy efficiency of transport and shift transport toward less polluting fuels and improving emissions controls.

These changes cannot simply be decreed, but will require shifts and improvements in public investment processes, scientific capacity building, monitoring capability, urban governance, distributional policy, and other related areas in addition to tightening and enforcing environmental regulation.

India's urban transport choices will set the tone for the energy-efficiency and livability of India's cities. All levels of government in India have officially recognized the challenge and committed to responding through increased investment in public transport as well as pedestrian and bicycle-friendly roads. The Urban Transport Working Group of the Prime Minister's National Transport Development Policy Committee argues that India's urban transport planning must move toward an overall approach of "Comprehensive Mobility Planning," to "Avoid" (reduce demand for trips through IT investment, land use planning, and other means); "Shift" (shift mobility from personal vehicles to more energy and space efficient public and non-motorized

transport); and "Improve" (increase fuel efficiency, reduce emissions) transport.

The policy framework to infuse environmental goals into urban governance is also nascent. Some cities have implemented emission reduction plans by court order (e.g. Delhi's switch to CNG), and all have a formal legal framework for setting air quality norms and enforcing vehicle emissions standards. However, the level of actual enforcement varies, and there institutional mechanisms for building environmental targets into broader plans for transport investment or land-use planning are nascent.

Emission Reductions Measures:

- There are three challenges involved in reducing vehicular emissions: first, motivating a consumer shift away from diesel to petrol vehicles by reducing the price difference between diesel and petroleum; second, tightening and enforcing vehicle emissions standards for all fuels; and third, mandating and enforcing fuel quality standards, particularly for diesel, that allow for some of the latest emissions control technologies to be used. Fuel quality and vehicle emission standards in India lag international leaders by more than a decade, and India is at risk of falling behind other developing countries as well

- Gaseous fuels like CNG and LPG have been introduced in an effort to reduce PM emissions in some of the hotspot cities like Delhi. CNG is now being supplied in 25 cities of the country. In Delhi, all the buses, auto-rickshaws, and taxis have been switched over to CNG. Some gasoline driven cars are also being retrofitted with CNG kits. In Bangalore, all the auto-rickshaws are retrofitted with LPG kits. Traffic management measures including construction of transport management infrastructure have been taken up in some cities for reducing congestion and hence corresponding idling emissions

- A rigorous quality assurance program, operating throughout the fuel supply chain to monitor and enforce fuel handlers' compliance with fuel-quality standards, is needed to ensure that vehicles equipped with high-performing emissions controls and fuel-efficient engines have adequately clean fuel to take full advantage of those technologies. There are some promising efforts in this direction, including research on mobile applications to remotely monitor their fleet and maintain locks on tankers as well as fuel testing kits and customer hotlines to report anomalies advertised at major brands' gas stations

- Reducing fuel efficiency and emissions per energy used are two avenues for reducing transport emissions in India. With respect to GHG emissions and vehicle fuel economy, no regulations have been passed to date, leaving India a nearly solitary outlier among the major vehicle markets in the world. Nor has progress been made on regulations for commercial vehicles and two- and three-wheelers. The lack of policy direction in this area contributes to India's deepening dependence on imported oil and diverts private and public resources that could otherwise be directed at more productive investments

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If India were to take a holistic approach and act in a coordinated manner on regulating fuel quality standards and emissions, there is a good possibility that vehicular emissions could be reduced by more than 80% from where present trends would place them in 2030.

The full text that elaborates on the summary in this Executive Summary outlines a nine-point program developed by ICCT towards this goal.