Centre for Science and Environment Workshop

Urban air quality challenges and strategies to reduce emissions from in-use and new vehicles

16-17 November, 2015
India Habitat Centre, New Delhi
Urban Air Quality Challenges and Vehicular Emission Reduction Strategies for Clean Air

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Orientation Workshop on ‘Urban air quality challenges and strategies to reduce emissions from in-use and new vehicles’

Venue: Amaltas Hall, India Habitat Centre, Lodhi Road
New Delhi

November 16-17, 2015
Air pollution makes headlines in Delhi

Delhi winter smog is not an act of God

During the first week of November, Delhi went under a thick layer of smog. The breeze nearly stopped, and the skies turned dark. The resultant outcry in the smog-hazed capital was nothing new and that it happened again.

The new twist came however, insisting that this was a deliberate act of God, possibly through the ongoing elevation of the Himalayas.

On the first day of the month, the city could have been the capital of the ancient empire of the city, where the smog was the norm. The Centre for Science and Environment (CSE), in its latest report, has delivered the bad news.

The smog is here to stay. It has also warned that Delhi is in the grip of a multi-pollutant complex, involving dust, smoke, and haze. The city is not alone in this, as other cities in the region are also facing similar problems.

The report highlights the need for urgent action to tackle the smog problem in Delhi and other cities. It calls for measures such as improving public transport, reducing traffic congestion, and promoting renewable energy sources.

The Centre for Science and Environment (CSE) is a well-respected environmental organization in India. It has been warning about the dangers of air pollution for many years and has been instrumental in bringing the issue to the forefront of public debate.

The report also notes that the smog problem is not just a local issue, as it is also affecting the quality of life for people living in the region. The Centre for Science and Environment (CSE) recommends measures such as improving air quality monitoring, promoting public awareness, and involving the public in the decision-making process.

The report concludes with the need for a coordinated effort from all levels of government, including the central and state governments, to tackle the smog problem. It calls for a long-term strategy to improve air quality in Delhi and other cities.
India: In grip of killer particles and multi pollutant crisis

• Close to half of urban population breath the air which exceeds the standard of PM10.

• NO2 is rising steadily

• Ozone levels are rising

• Unacceptable toxins and heavy metals

India: Between 1975 and 1995 when GDP doubled, vehicular pollution increased 8 times and industrial pollution 4 times. Need preventive action

Source: CSE computed based on data from Central Pollution Control Board, India
Smaller cities more polluted in India today

Source: MOEF, Lok Sabha 2015
Global Burden of Diseases 2010: Household air pollution second largest killer in India.

About 1.04 million direct premature deaths from indoor air pollution annually in 2010. 31.4 million disability adjusted life years—a measure of years lost due to ill-health, disability.

Source: http://cseindia.org/content/air-pollution-now-fifth-largest-killer-india-says-newly-released-findings-global-burden-dise
Road injury add to the public health impacts of motorisation

In India total number of road accident deaths is equivalent to wiping out at least 40% of Maldives population every year

Source: The World Bank Group and Global Road Safety Facility
Mounting global health evidences

Scale of global studies provide clinching evidences……..

Eg. the Arden Pope study (Journal of American Medical Association 2002) based on American Cancer Society data ......16 years, about 500,000 people in 116 metropolitan areas to arrive at irrefutable findings.

........... a mere increase of 10 microgramme per cum of PM2.5 can increase the risk of lung cancer by 8 per cent, cardiopulmonary deaths by 6 per cent, all deaths by 4 percent.

These findings are equally valid for India ...

Lungs are same everywhere.......
Studies in India looking at a more diverse health end points….

Predictably respiratory health symptoms dominate….
Broadens to other health end points – cardiovascular, eye disorders, cellular changes, cancer, premature deaths….

<table>
<thead>
<tr>
<th>Effects studied</th>
<th>No. of studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Respiratory</td>
<td>43</td>
</tr>
<tr>
<td>Cardio</td>
<td>7</td>
</tr>
<tr>
<td>Cancer Related</td>
<td>6</td>
</tr>
<tr>
<td>Eye related</td>
<td>4</td>
</tr>
<tr>
<td>Cytogenetic</td>
<td>6</td>
</tr>
<tr>
<td>Mortality</td>
<td>3</td>
</tr>
<tr>
<td>Others</td>
<td>8</td>
</tr>
</tbody>
</table>

Source: CSE
Global studies: Looking beyond lungs

**Diabetes:** First large-scale population-based study links diabetes with air pollution. Increase in insulin resistance in lab test …. and an increase in markers of inflammation (which may contribute to insulin resistance) after particulate exposure.

Strong and consistent association between diabetes prevalence and PM2.5 concentrations. For every 10 µg/m³ increase in PM2.5 exposure, there was a 1 per cent increase in diabetes prevalence. Counties with highest versus the lowest levels of PM2.5 pollution had a more than 20 per cent increase in diabetes, which remained after controlling for diabetes risk factors. (Diabetes Care 2011)

**Heart:** Acute effects of fine particulate air pollution on Cardiac Arrhythmia: PM2.5 exposure within approximately 60 min was associated with increased PVC counts in healthy individuals. (He F et al 2011 The APACR Study. Environ Health Perspect)

**Blood pressure:** Traffic-related Air Pollution and Blood Pressure in Elderly Subjects With Coronary Artery Disease: Found positive associations of systolic and diastolic BP with air pollutants. The strongest associations were with organic carbon, multiday average exposures, ect. (Delfino, Ralph J.a et al 2010,, Epidemiology, May 2010)

**Effect on foetus:** Studies have shown damaging impact of PAH on even fetus

Source: CSE
Health of children in Delhi seriously compromised …..

2012 epidemiological study on children in Delhi (CPCB and Chittaranjan National Cancer Institute of Kolkata):
-- Covered 11,628 school-going children from 36 schools.

-- Every third child has reduced lung function. Sputum of Delhi’s children contains four times more iron-laden macrophages than those from cleaner environs, indicating pulmonary hemorrhage.

-- The levels of these biomarkers in children have been found to be higher in areas with high PM10 levels.
Emerging evidences of health impacts in India……

Alveolar macrophage - biomarker of air pollution

Exposed group; Kolkata taxi driver
Increase in AM number

Control area: Sundarbans

Larger AM – particle laden
National Air Quality Index: For the first time India issuing health advisories (Example: Nov 13, 2015)

Source: Prepared Based on NAQI, CPCB
Be warned: Most health effects occur at much lower levels than reported in our cities.

Integrated Exposure-Response function for Ischemic Heart Disease

HEI Global Burden of disease, 2013
First generation reforms in Delhi.....

Delhi has fought hard to get breathing space

On vehicles
  - Introduced low sulphur fuels and petrol with 1 per cent benzene
  - Mandated pre-mix petrol to two- and three-wheelers
  - Moved from Euro I to Euro IV over the last decade
  - Implemented largest ever CNG based public transport programme
  - Capped the number of three-wheelers
  - Phased out 15 year old commercial vehicles
  - Strengthened vehicle inspection programme (PUC)
  - Efforts made to divert transit traffic
  - Set up independent fuel testing laboratories to check fuel adulteration

On industry
  - Relocated polluting units
  - Tighter controls on power plants. No new power plants.

Air quality monitoring
  - Adopted new ambient air quality standards
  - Expanded air quality monitoring and reporting

Other sources
  - Emissions standards for generator sets
  - Ban on open burning of biomass
Lesson from Delhi
Lost gains. After a short respite pollution curve turns upward

Particulate pollution decline and rise again due to rapid increase in vehicle numbers

NO2 levels rising steadily

<table>
<thead>
<tr>
<th>Year</th>
<th>PM10 levels in microgramme per cubic metre</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>-10%</td>
</tr>
<tr>
<td>2003</td>
<td>+75%</td>
</tr>
<tr>
<td>2004</td>
<td>+07%</td>
</tr>
<tr>
<td>2005</td>
<td>Massive increase in PM10 levels post 2007</td>
</tr>
</tbody>
</table>

Based on CPCB data

NO2

<table>
<thead>
<tr>
<th>Year</th>
<th>microgramme per cubic metre</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>50</td>
</tr>
<tr>
<td>2006</td>
<td>50</td>
</tr>
<tr>
<td>2007</td>
<td>40</td>
</tr>
<tr>
<td>2008</td>
<td>40</td>
</tr>
<tr>
<td>2009</td>
<td>40</td>
</tr>
<tr>
<td>2010</td>
<td>50</td>
</tr>
<tr>
<td>2011</td>
<td>70</td>
</tr>
</tbody>
</table>

Significant reduction in pollution initially; Saved more than 3600 premature deaths a year. But this gain is lost.
Vehicles are a special problem........
Where is the pollution coming from?
All sources need action

- PM2.5 emissions Delhi-NCR-Regions
- NOx emissions Delhi-NCR-Regions

Source: MOES, SAFAR
Total air quality approach focuses on the relative contribution of different pollution sources to the ambient pollution.

More important to understand the relative health risk of various sources in cities — Exposure -- emission-to-intake relationship for a specific source as the fraction of emissions inhaled by an exposed population.

Pollution concentration in our breathe is 3-4 times higher than the ambient air concentration.

Vehicular emissions contribute to significant human exposure. In densely-populated cities more than 50 – 60% of the population lives or works near roadside where levels are much higher.

**Chennai**

PM$_{2.5}$ emission apportionment

PM$_{2.5}$ exposure apportionment

Source: S Guttikunda – SIM Air
CSE assessment of exposure to pollution while traveling on roads

Average exposure to PM2.5 ranged between 192 to 642 microgramme per cum. Peaks as high as 457 to 1170. The average ambient level ranged between 191 to 277.

Source: Based on CSE exposure monitoring and DPCC data for ambient levels
How to reduce emissions from on-road vehicles in cities?
Vehicles need special attention
Motorisation in India .....”

Need stringent and preventive action and decision here to influence the future stock -- several times higher than the legacy stock.

Source: CSE
Cities beginning to see larger share of newer vehicles....Both old and new vehicles need action

-- Post 2010 vehicles are 58% of the total fleet in India
-- Post 2010 vehicles meeting BSIII & IV show larger share in emissions.
-- Their numbers are larger and average age of vehicles reducing. Old vehicles still remain a challenge as their emissions deteriorate with aging

Source: CSE estimates
India -- Weak emissions standards for new vehicles... 10-15 years behind Europe

Diesel car PM norms in g/km

- **EU**
- **USA**
- **India selected cities**
- **India rest of the country**

**Euro IV norms** 10 years behind Europe; Euro III 15 years behind Europe

Leapfrog to Euro VI standards in 2020

Source: India, Europe compiled from Diesel Net, USA data provided by Axel Friedrich, Germany

Note: Europe has additionally introduced particle number standards at Euro V level

Future norms of US and Europe are tightening NOx norms for diesel more
Strategies to reduce emissions from vehicles in cities
Globally city governments are working with several strategies to reduce emissions from on-road vehicles

-- Mandatory periodic emissions inspections and standards

-- Spotter programs and remote sensing to ensure good maintenance and remove grossly polluting vehicles

-- Use of cleaner fuels and alternative fuels

-- Fix or accelerate retirement age of vehicles and scrap

-- Retrofit high emitting vehicles with emission control systems

-- Introduce low emissions zones to ban high emitting and old vehicles

-- Taxation to discourage polluting and old vehicles

What can Indian cities do?
In-use emissions testing...

..... PUC: Can we make this work?
What ails India’s Pollution under control certificate (PUC) programme

-- Originally designed for carburettor technologies and old diesel vehicles; Not effective for advanced emissions control systems
-- Measures only under Idling conditions. Can not monitor real world emission performance
-- Difficult to ensure compliance, authenticity and correctness of tests.
-- Not effective in catching at least 15-20% of the vehicles that cause maximum emissions
-- Challenging to prevent false passes and cheating.
-- Standards do not match technology levels
-- Decentralized centres difficult to audit
-- Poor public acceptance of the programme

It is better to do nothing than do a poor programme
Some basic cosmetic changes......
PUC: Persistent Unresolved Charade

- CPCB audited Pollution Checking Centers, authorized by Department of Transport, Govt. of Delhi during 2012-2013.

- All the 75 centres checked Petrol; and 60 centre checked diesel vehicles as well

Source: CPCB website, Audit Report 2013
Very lenient norms. Cannot fail vehicles. Only norms for Bharat Stage IV compliant vehicles a little tighter

**Emission Control From In-Use Vehicles**

**Pollution Under Control (PUC) Tests:**
- Idle CO HC Emission Test for Gasoline vehicles
- Free Acceleration Smoke test for Diesel vehicles

**PUC Tests – Revised Norms from 1st October 2004**

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>CO (vol%)</th>
<th>HC (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 &amp; 3 wheeler (2/4 -stroke) (Vehicles manufactured on and before 31st March 2000)</td>
<td>4.5</td>
<td>9000</td>
</tr>
<tr>
<td>2 &amp; 3 wheeler (2 -stroke) (Vehicles manufactured after 31st March 2000)</td>
<td>3.5</td>
<td>6000</td>
</tr>
<tr>
<td>2 &amp; 3 wheeler (4 -stroke) (Vehicles manufactured after 31st March 2000)</td>
<td>3.5</td>
<td>4500</td>
</tr>
<tr>
<td>4 wheelers manufactured as per pre-Bharat Stage II norms</td>
<td>3</td>
<td>1500 *</td>
</tr>
<tr>
<td>4 wheelers manufactured as per Bharat Stage II, Bharat Stage III or subsequent norms</td>
<td>0.5</td>
<td>750 *</td>
</tr>
<tr>
<td>Diesel Vehicles</td>
<td>65 HSU (2.45 m⁻¹)</td>
<td></td>
</tr>
</tbody>
</table>

* For CNG Vehicles, NMHC = 0.3 x HC; For LPG Vehicles, RHC = 0.5 x HC

**PUC Tests – Proposed New Norms for BS-IV compliant 4 wheelers** (Notification under issue)

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>Idle</th>
<th>High Idle</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CO (vol%)</td>
<td>HC (ppm)</td>
</tr>
<tr>
<td>BS-IV compliant 4 Wheeler Petrol Vehicle</td>
<td>0.3</td>
<td>200</td>
</tr>
<tr>
<td>BS-IV compliant 4 Wheeler CNG/ LPG Vehicle</td>
<td>0.3</td>
<td>200</td>
</tr>
<tr>
<td>BS-IV compliant 4 Wheeler Diesel Vehicles</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* or as declared by vehicle manufacturer
In-use emissions testing...

Challenge of diesel vehicles.................
Special concern over diesel emissions

Diesel cars are legally allowed to emit more particulate and nitrogen oxide

One diesel car emits as much NOx as 3 to 5 petrol cars. PM is several times higher

• In June this year the International Agency for Research on Cancer of the World Health organisation (WHO) has reclassified diesel exhaust as Group 1 list of carcinogen that have definite links to cancer.

• Diesel exhaust is now in the same class of deadly carcinogens as asbestos, arsenic or tobacco among others. The IARC-WHO has urged worldwide efforts to reduce exposure to diesel fumes as much as possible.
Why diesel makes us climate insecure?

Black carbon emissions from diesel vehicles are several times more heat trapping than CO2.

CO2 emissions from the upstream diesel refining process will increase: European Commission has found lifetime pollution costs of Euro IV compliant diesel car is much higher than petrol cars.

Rebound Effect: Diesel fuel has higher carbon content than petrol. If more diesel is burnt encouraged by its cheaper prices and more driving, more heat-trapping CO2 will escape.

Nullifies marginal greenhouse gas reduction benefit of diesel car ……
Diesel vehicles
Based entirely on visible smoke that -- tested by “snap-idle” opacity test(SAE J1667). Very ineffective.
Smoke tests for diesel vehicles: A farce

Smoke readings differ depending on how well the vehicle is warmed up. It is very difficult to get consistent readings. Often authentic tests are not done.

- Results vary depending on the way the accelerator pedal is pressed.
- Doesn’t measure particulate.
- The smoke readings at different PUC
Poor failure rate in pre-2010 vehicles

Diesel vehicles: Smoke density norm of 65HSU -- Failure rate 6%
Move towards Clean diesel will bring more sophisticated emissions control systems that PUC cannot monitor.

Need clean diesel (10 ppm sulphur) along with advanced after treatment system.
Indian norms for on-road diesel vehicles: Lagging behind

Lenient smoke opacity tests in India

- **India**: 50 HSU for BS-IV vehicles and 65 HSU for pre-Euro IV diesels vehicles
- **Singapore**: 40 HSU
- **Pakistan**: 40-HSU
- **Indonesia, Thailand, Hong Kong, Malaysia**: 50-HSU for all vehicles

**China** is developing a nationwide I/M system for evaluating NOX emissions from in-use HDVs.

**Hong Kong**: Snap idle tests on chassis, smoky vehicle programme etc
Visual checks

**Hong Kong:** Spotter programs -- More than 5,000 trained citizen volunteer spotters. Resulted in thousands of vehicles being repaired each year.

**Other countries:** Authorities have hotlines consumers may call to report smoky vehicles.

*But these programs can only reduce visible smoke, and not health-damaging particles and NOX.*

**Remote sensing:** Checks vehicle’s exhaust with infrared light beams for CO2, CO, and HCs, and/or UV light to estimate concentrations of NOX. Useful tool to identify gross emitters; evaluate fleet-wide trends, and effectiveness of I/M programs. But expensive. California has implemented this.
Why smoke opacity tests are of no use in new diesel vehicles?

- No accurate correlation found between smoke readings and PM mass. Smoke is not a good surrogate for tiny particles.
- PM and NOX emissions cannot be tested.
- Hong Kong and China have introduced smoke tests on chassis dynanometer for diesel vehicles.
- Smoke readings get affected by other pollutants. There is need for improvement in resolution, stability, and noise to allow opacity measurements in advanced diesel engines.
- NO2 – smoke trade-off: Repairs to reduce visible smoke may actually increase both the number of ultrafine particles and NOX emissions -- OxiCats or particulate filters can increase NO2 in the total NOx from less than 10% to as much as 40% and more.
In-use emissions testing…

Petrol vehicles……

These vehicles are tested for carbon-monoxide, hydrocarbon, and lambda (indicates optimal conditions for proper functioning of catalytic converters)
Petrol norms for pre-Bharat Stage IV compliance vehicles cannot make a difference......

Carbon monoxide for post 2000 cars 0.5% (idle)
-- 4% fail. 96% pass

Hydrocarbons norms for post 2000 cars 750 ppm (idle)
-- 100% pass

Diesel vehicles: Smoke density norm of 65HSU
-- Failure rate 6%
The Lambda fiasco

**lambda value of \(1 \pm 0.03\)**

**Make-wise lambda result**

<table>
<thead>
<tr>
<th>Make [No. of cars in the sample]</th>
<th>Within 0.97-1.03</th>
<th>Outside</th>
</tr>
</thead>
<tbody>
<tr>
<td>All [1,144]</td>
<td>81%</td>
<td>19%</td>
</tr>
<tr>
<td>Maruti [771]</td>
<td>82%</td>
<td>18%</td>
</tr>
<tr>
<td>Hyundai [226]</td>
<td>81%</td>
<td>19%</td>
</tr>
<tr>
<td>Honda Siel [41]</td>
<td>93%</td>
<td>7%</td>
</tr>
<tr>
<td>Ford [27]</td>
<td>67%</td>
<td>33%</td>
</tr>
<tr>
<td>GM [20]</td>
<td>90%</td>
<td>10%</td>
</tr>
<tr>
<td>Fiat [16]</td>
<td>81%</td>
<td>19%</td>
</tr>
<tr>
<td>Toyota [14]</td>
<td>79%</td>
<td>21%</td>
</tr>
<tr>
<td>Tata Motors [8]</td>
<td>50%</td>
<td>50%</td>
</tr>
<tr>
<td>Daewoo [7]</td>
<td>71%</td>
<td>29%</td>
</tr>
<tr>
<td>Mitsubishi [6]</td>
<td>83%</td>
<td>17%</td>
</tr>
<tr>
<td>HM [4]</td>
<td>25%</td>
<td>75%</td>
</tr>
<tr>
<td>Skoda [3]</td>
<td>100%</td>
<td></td>
</tr>
</tbody>
</table>

Share of different makes in the sample

- Maruti 67.5%
- Hyundai 19.8%
- Honda Siel 3.6%
- Toyota 1.2%
- Fiat 1.4%
- GM 1.7%
- Ford 2.4%
- Mitsubishi 0.5%
- Daewoo 0.6%
- Tata 0.7%
- HM 0.3%
- Skoda 0.3%
## The Lambda fiasco

<table>
<thead>
<tr>
<th>Make</th>
<th>Lambda specification</th>
<th>RPM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;-- Rich</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(Probability for high CO and HC)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Desired limit</td>
<td>Lean→</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Probability for high NOx)</td>
</tr>
<tr>
<td>0.93</td>
<td>0.95</td>
<td>0.97</td>
</tr>
<tr>
<td>Min.</td>
<td>Max.</td>
<td>2,500</td>
</tr>
<tr>
<td>Others</td>
<td></td>
<td></td>
</tr>
<tr>
<td>General Motors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maruti</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fiat</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tata Motors</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: The data includes specifications for Lambda fiasco related to CO and HC emissions, with desired limits and min/max RPM values for various makes.
Problems with Idle CO Testing (2-wheelers)

- Large number of two-wheelers pose special challenge
- Idle CO check ineffective. Vulnerable to cheating:
  - Proper extension pipes are not used
  - Chances of leakages: leading to inappropriately low readings
- Carburetor adjusted to pass the test

Source: ARAI
A few extra steps in Delhi to make it work…..

Delhi ….

On PUC
- PUC system upgrades
- Lambda implemented
- PUC Audits
- PUC networking and centralised data base
- Considering compliance strategy (linking insurance with PUC etc)

On CNG – specialised safety checks; third party inspection, registration of CNG buses with authorised service stations; maintenance of inspection schedule etc

- Proposal for high volume centralised test centres

.........................But not enough......
Changing the fuel to reduce on-road emissions:

--- Cleaner fuel
-- Alternative fuels
Effect of sulphur in diesel fuel on emissions
Move to 50 ppm sulphur fuel nation-wide by end of 2015 and 10 ppm sulphur fuel by 2020

Source: ICCT
CNG helped Delhi to leapfrog: Euro II diesel bus emits nearly 46 times higher PM than Euro II CNG bus in India.

CNG Bus Emissions in 2004

Source: Teri
## Comparative emissions of Indian diesel and CNG buses (Euro II vintage)

<table>
<thead>
<tr>
<th>Type of bus</th>
<th>CO  g/km</th>
<th>HC  g/km</th>
<th>NOx g/km</th>
<th>PM  g/km</th>
</tr>
</thead>
<tbody>
<tr>
<td>Euro II diesel bus on 500 ppm sulphur fuel + DOC</td>
<td>1.45</td>
<td>0.29</td>
<td>6.24</td>
<td>0.35</td>
</tr>
<tr>
<td>Euro II diesel bus on 350 ppm sulphur fuel + DOC</td>
<td>0.65</td>
<td>0.15</td>
<td>5.85</td>
<td>0.11</td>
</tr>
<tr>
<td>Euro II diesel bus on 50 ppm sulphur fuel + CRT</td>
<td>1.42</td>
<td>0.04</td>
<td>13.58</td>
<td>0.009</td>
</tr>
<tr>
<td><strong>Euro II CNG bus + three way catalytic converter</strong></td>
<td><strong>3.18</strong></td>
<td><strong>1.455</strong></td>
<td><strong>5.35</strong></td>
<td><strong>0.0065</strong></td>
</tr>
</tbody>
</table>

Source: ARAI/Teri

Source: TERI
Second generation CNG
Significant gains

CSIR-IIP-University of Alberta study:

-- Ultrafine particles from Euro IV Indian diesel bus - 600 to 2000 times more than the Euro IV CNG bus.

-- CNG ultrafine emissions are less or close to Euro VI standards for particulate number.

-- Diesel bus emits 1000 times more ultrafine particle numbers than Euro VI limit on transient cycle.

-- CNG buses have performed much better on all parameters than the diesel bus – CO, NMHC, NOx, and are close to Euro VI norms

-- Diesel bus – CO is 19 times higher, NMHC 47 times higher, and NOx 17 times higher than Euro VI emissions standards.

-- Ultrafine from CNG bus is 12 to 40 times higher than advanced Canadian bus with traps. But Indian diesel bus emits 28,000 times higher ultrafines than the Canadian bus – much worse than Indian CNG bus.

<table>
<thead>
<tr>
<th></th>
<th>CO (gm/kwh)</th>
<th>NMHC (gm/kwh)</th>
<th>NOx (gm/kwh)</th>
<th>Total Particles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diesel bus</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acceleration</td>
<td>7.87</td>
<td>7.58</td>
<td>8.42</td>
<td>6.45x10^{14}</td>
</tr>
<tr>
<td>Cruise</td>
<td>2.68</td>
<td>-</td>
<td>7.14</td>
<td>4.46x10^{14}</td>
</tr>
<tr>
<td>CNG bus</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acceleration</td>
<td>0.43</td>
<td>0.15</td>
<td>0.87</td>
<td>2.78x10^{11}</td>
</tr>
<tr>
<td>Cruise</td>
<td>2.2</td>
<td>0.57</td>
<td>0.82</td>
<td>4.37x10^{11}</td>
</tr>
<tr>
<td>Euro VI (WHSC)</td>
<td>1.5</td>
<td>0.13</td>
<td>0.40</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.40</td>
<td>0.16</td>
<td>0.46</td>
<td></td>
</tr>
<tr>
<td>Euro VI (WHTC)</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
CNG buses: Need good maintenance
Bus Conversions

Some were very well done. Many were not...
Improve I/M for NGVs

Incidents such as vehicle fires, component failures, and borderline emissions performance will simply not be acceptable in the future......

Address concern over suspected catalyst failures in the current bus fleet. Retrofitted catalysts also need to be monitored for equivalent performance.

Improve durability requirements for good NGV programs and in-use benefits: In North America the emissions durability for these buses is 700,000 km, almost 10 times... Bus agencies can save cost of catalyst replacements in the field.

Prevent design failures -- use simple Design Failure Mode and Effects Analysis (DFMEA). Determine failure modes before the design is released; catch issues not covered under type approval. -- Getting it right the first time involves a much lower cost than dealing with warranty and damage costs in the field.....
Good I/M programmes can reduce pollution levels

- I&M in many countries have improved air quality and reduced transport emissions.
- Older programmes have reported improvement
  - **European Union**: CO reduced by 17 to 35%, HC 12.5% to 25%, negligible benefit in NOx at 2.5% to 5%
  - **USA** Petrol cars -- CO reduced by 13 to 74%, HC 14% to 68%, NOx at 6% to 40%.
  
  - India estimated that various I&M-related actions in India reduced 0.5 million ton HC+ NOx+CO emissions; and up to 15,000 ton reduction of PM emissions. (Shakti)
- If not done well it may lead to enormous investment without results
- **Several US cities**: Actual reductions from the I/M programs generally much lower than expected due to overly optimistic assumptions about consumer compliance, gross emitter identification rates, and the effectiveness of repair.
Next generation emissions control systems need advanced I/M Diesel and CNG pathways to meet Euro VI norms. Diesel emissions control route more complicated. Ensure on-road performance.
The way forward…

Draw lessons from the Volkswagen emissions fraud case…..
Volkswagen cars fitted with defeat devices to pass tests, but emit high NOx when on road.

Source: CSE
Unacceptable level of emissions

Source: CSE
Impact of this corporate fraud on emissions regulations in Europe

Real Driving Emissions Test Procedures and Standards by 2017 with a conformity factor of 1.6 for 2017 and 2018 dropping to 1.2 or possibly 1.3 for 2018/2019. Will adopt tighter test cycle.

In Use Testing of Random Vehicles: The proposed European Type Approval Authority to do testing of random in use vehicles samples and make the data publicly available. Protocols for testing will include vehicles, types of tests, etc. and I expect to hear from staff when they come up for air.

Voluntary label system: Labeling scheme linked to low emissions zones. If manufacturers could give tighter standards of Euro VI preferential treatment to accelerate the city’s efforts to achieve the air quality Directives. With label the consumers could choose the cleaner vehicles might be a strong incentive to accelerate the process.

Creation of a European Type Approval Authority
India’s tryst with corporate fraud

2005 --2012: General Motors sold 114,000 units of Tavera diesel SUV —BS-III and BS-IV variants—by tampering type approval tests.

For the certification, the company had sent pre-selected samples that were fitted with improved engines and were in a different weight category than what it sold afterwards.

The Ministry of Road Transport and Highways initiated a probe

GM admitted to the fraud and recalled 114,000 units of the Tavera in 2012-13.

But India does not have a system to penalise companies for such corporate fraud.
Eliminate bias in certification testing

Nitin Gokarn committee recommended –

-- Certification laboratories like ARAI should identify samples from factories and dealers. Companies can then transport the sample cars to ARAI with proper coding and identification number.

-- But there is no system in place that legally allows testing agencies to select any vehicle, anywhere, anytime

-- Need tightening of certification tests and minimising interference of manufacturers in pre-selection of sample cars sent for certification.
How to prevent inherent manufacturing defects?

**HC+NO\textsubscript{x}: Post 2000 vintage**

![Graph showing HC+NO\textsubscript{x} emissions before and after service for four stroke and two stroke models. The graph indicates a decrease in emissions after service.]

**CO: Post 2000 vintage**

![Graph showing CO emissions before and after service for four stroke and two stroke models. The graph indicates a decrease in emissions after service.]

Source: ARAI
USA: In-use compliance regulations for manufacturers responsibility

**Pre-production Testing:** EPA selects about 10% of vehicle models for confirmatory testing, randomly selected. If a vehicle fails the first test, the manufacturer fixes the problems. If the vehicle then fails the second test, the certificate of conformity is not issued. The entire process is repeated.

**Post production testing:** EPA can require manufacturers to test vehicles pulled off the assembly line, with no prior notice and at the manufacturer’s expense, at an EPA certified lab. If the vehicles do not pass SEA tests, the vehicles’ certificate of conformity can be revoked and its production must cease. In India it is called conformity of production testing.

**In-use testing and recall programme:** EPA conducts its own testing on a small sample of in-use vehicle testing. Vehicles are generally selected at random. If fail manufacturers have to recall the vehicles and fix at their own costs.

**The costs of fines and/or recalls due to noncompliance** have been a strong incentive for manufacturers to conduct proper testing and focus on designing durable products and putting in place internal self-audit systems to assure long-term compliance with standards.
What about India?

-- Regulations for pre-production and production are somewhat similar to the US and European systems

-- But unlike the US and Europe Indian certification agencies do not select test samples randomly from a manufacturer’s lot, they must give prior notice to manufacturers about the approximate time during which samples will be collected from a given lot. This can compromise testing

-- The type approval certificate will only be reissued when a vehicle passes COP testing. If, after repeated attempts, a vehicle still cannot pass COP procedures, the government has the legal authority to take further action against a manufacturer, such as issuing a recall.

-- This has not happened to date, though, and legal procedures for the MoRTH to issue mandatory recalls or levy fines have not been established
Modify Indian system

-- Allow testing agency to select any vehicle, anywhere, and at any time, without prior notice to the manufacturer. Ensure a truly random sample

-- The current system, even if executed perfectly, still leaves a chance that vehicles pass type approval and COP testing but emit much more in the real world. Eg General Motors’ Tavera SUV case

-- Current policy only authorizes the government to revoke certification for vehicles found to be out of COP compliance.

--- Need rules for government and manufacturer to remove noncompliant vehicles from the road are unclear. Mandatory recall policy for noncompliant vehicles will incentivize manufacturers to design and build vehicles that comply with emission standards for the duration of their useful life.

China has taken steps to move in this direction. China has recently revised its programs to allow the selection of vehicles at random without any prior notice. Furthermore, COP testing in China is now corroborated through inter-laboratory round-robin testing, which adds an additional level of scrutiny.
Manufacturers’ responsibility

**DISASTROUS RESULTS**

Swedish tests reveal that increase in emissions of in-use vehicles is higher than expected.

---

**POLLUTANTS**

- Carbon monoxide
- Hydrocarbons
- Oxides of nitrogen

- Emissions permitted at 0 km
- Emissions permitted at 80,000 km
- Actual emission at 46,000 km
- Projected emissions at 80,000 km

Need paradigm shift
New generation technologies need new generation approaches...

--- **On board diagnostic system**: Integrate this with I/M (Delhi discussing this under EPCA/Supreme Court). – OBD 1 in 2010 and OBD 2 in 2013.

--- **Increase durability requirement**: Consider one step forward before Euro VI standard

-- **Emissions warranty and recall programme**: Enforce immediately.

-- **Globally nations are preparing for a new regime**:

  -- **Not to exceed standards** -- to limit off-cycle emissions.

-- **On board monitoring**
Leverage OBD performance data for I/M in India

- In India OBD I is required from 1 April 2010 (except LPG or CNG-fuelled vehicles and those >3500 kg GVW).

- OBD II is required from 1 April 2013 for Bharat Stage IV light-duty vehicles of all categories.

- The OBD threshold limits are: NOX = 7.0 g/kWh and PM = 0.10 g/kWh.

- In India OBD data not made public yet.

- RTOs to evaluate integration of OBD with I/M programme.
Why OBD?

• If a problem or malfunction is detected, the OBD II system illuminates a warning light on the vehicle instrument panel to alert the driver.

• This warning light will typically display the phrase "Check Engine" or "Service Engine Soon," and will often include an engine symbol.

• The OBD system stores important information about any detected malfunction so that a repair technician can accurately find and fix the problem. No guess work.

• Smog Check inspections in USA for post 2000 model vehicles are now primarily based on an inspection of the OBD II system; Tailpipe testing is no longer required.
Benefits of OBD to Consumers

- Identifies emission-related components covered under warranty
  - Eliminates unnecessary repairs
  - Fault codes and other scan tool data give information about area of malfunction or a specific component

- Consumer protection
  - Durability incentivized by cost of warranty repairs / customer satisfaction

- Early Detection of Malfunctions
  - Prevent secondary malfunctions (e.g., detect misfire before catalyst damaged)
New generation emissions control technologies strong monitoring and compliance

India at risk --- Eg. Selective catalytic reduction (SCR) technology; particulate traps to come in the future

SCR already introduced in Bharat Stage IV buses (Bangalore)

Needs close watch and monitoring

How can this be addressed in I/M framework?

Experience in other regions -- Eg UK - DEFRA study –Transport for London (TfL) buses fitted with SCR systems, are not optimized for urban situations – such as low speed and low engine temperature. Use remote sensing detector equipment to help with the identification of the most effective emissions control technologies to reduce nitrogen dioxide, and the information needed for emission inventories…….’

-- Also found - Nitrogen dioxide from diesel cars increased overall from a 10-15% proportion of nitrogen oxide emissions for Euro 3 standard vehicles or older to an average of almost 30% for newer Euro 4 or 5 vehicles. How will compliance regime address this?
Other strategies to reduce emissions from on-road vehicles
India discussing fiscal incentive for scrappage of cars: Not acceptable

-- Proposal of fiscal incentive for scrappage of old cars – not acceptable in India.

-- Tax payers’ money cannot be used to subsidized car ownership

-- Such a programme can be considered only for trucks and buses that meet very poor emissions standards

-- Scrappage schemes should be linked only with stringent emissions standards for vehicles

-- Need regulations for recyclability and end of life requirements
Global approaches to scrappage for heavy duty vehicles

Mandatory scrappage regulations can be based upon age, mileage, or is used as a taxi

**China:** All classes of vehicles have mandatory age or mileage limits. Limits on cars under review. To retire 10 million “yellow-label” vehicles (diesel vehicles not meeting the Euro III standard and petrol vehicles not meeting the Euro I standard by the end of 2015.. National subsidies of $920 to $2,800 in 2010

**Beijing** Encouraged voluntary early retirement of yellow label vehicles. Offers $150 to $850 per vehicle for scrappage of the oldest yellow-label vehicles. This eliminated more than 150,000 vehicles. Reduced NOX emission by 32 tons per day. To retire 400,000 vehicles by the end of 2015.

**Egypt:** Bus, taxi, and other transit vehicles cannot renew licenses after 20 years of age. Scrappage programs voluntary; supported by fiscal incentive. Also retrofitment and repowering programs

**The United States:** “Cash for Clunkers” program required that the engines of scrapped passenger vehicles be destroyed.; **Carl Moyer programme**

**German scrappage program for light-duty vehicles** required owners to deliver cars to a scrap yard. Up to 50,000 vehicles received subsidies. But sold to other countries
Tax to discourage old and polluting vehicles

Direct taxation based on a vehicle’s emissions to promote low-emitting vehicles.

Germany and Switzerland:
-- Levy differentiated taxes on trucks based on their certified emission standard.
-- The fee is calculated based on the total weight of the vehicle, the number of kilometers driven, and the tailpipe emission standard.
-- Highest taxation rate per kilometer on Euro 0, I, and II vehicles; little less on Euro III vehicles; lowest tax rate on Euro IV or higher standards.
-- Enforcement through electronic identification cards

Emissions based taxes in other countries
Ban entry of old and polluting vehicles in targeted city areas: identified as low emissions zones

Low-emission zone (LEZ)

Certain vehicles are prohibited in LEZ to:
-- prevent local emissions,
-- encourage vehicle owners to purchase cleaner vehicles,
-- incentivize modal shift to lower-polluting transport modes,
-- reducing congestion and noise.

Local air pollution and congestion are typically the primary drivers of the creation of an LEZ
Need strategies to control emissions from transit trucks through cities...... Lessons for Delhi........
Need bouquet of action to control emissions from on-road vehicles
Soft options are over. Need hard decisions

Mandatory periodic emissions inspections and standards: Tighten norms and test procedure; need credible enforcement and compliance

Spotter programs for visibly polluting vehicles for community vigilance to ensure good maintenance; remove grossly polluting vehicles. High penalty

Use of cleaner fuels and alternative fuels

Use taxes to accelerate retirement age of vehicles. Cap age

Retrofit high emitting vehicles with emission control systems only of 10 ppm sulphur fuel is available

Consider low emissions zones to ban high emitting and old vehicles

Taxation to discourage polluting and old vehicles.

Leapfrog to Euro VI emissions standards for new vehicles by 2020

Cannot afford to delay action....
Thank You
15 year old pollution battle….

Series of orders from the Supreme Court

• December 6, 2001 order:
  • Banned entry of non-destined tucks from January 15, 2002.

• Orders of 11.2.2005, 11.3.2005 and 1.8.2005:
  • No corridor joining different highways should pass through Delhi.

• Directed construction of Western Peripheral Road or Kundli-Manesar-Palwal Expressway and Eastern Peripheral Expressway to bypass non-destined trucks
Delay has cost the city dear: High pollution and health impacts

The WPE to be completed not before July 2018.

Delay in commissioning work on the longer segment between Kundli-Mansesar (83 km out of 135 km).

The EPE will be completed by July 2018 at the earliest -- NHAI.

• The ban on non-destined vehicle entry to Delhi difficult to enforce.

• Lack of turn-around facilities and difficulties in identifying definition of vehicles.
Why this assessment?

To understand the real numbers and find short term measures

• CSE commissioned M/s V R Techniche Consultants Pvt Ltd to survey the commercial vehicles entering and leaving Delhi.

  • Traffic count survey conducted by using 24 X 7 video recording method at fixed spots near selected entry points between June 29 and July 18, 2015.

  • There are a total of 127 entry points, of which 9 are major. MCD collects toll at these entry points through private concessionaire.

Survey for 24 hours, from 8 am to 8 am and measured vehicles in both directions.

Survey conducted in 9 key entry points. According to MCD this account for close to 75% of total commercial vehicle entry into Delhi.
Survey points

• Selected Entry Points:
  1. Kundli border on NH1 (KGT Main)
  2. Tikri border on NH10
  3. Rajokari border on NH8
  4. Badarpur border on NH2
  5. KalindiKunj
  6. GhazipurMainon NH24
  7. Ghazipur Old
  8. ShahdaraIstborder on NH-19
  9. ShahdaraFlyover

• Types of vehicles surveyed:
  mini light goods vehicle
  light goods vehicle
  2-axle trucks
  3-axle trucks
  4-axle trucks
  5-axle trucks
  6-axle trucks
  more than 6-axles
Massive numbers entering and leaving Delhi

• Commercial vehicle entry
  
  • On a daily basis – 38,588 commercial vehicles (excluding taxis) enter Delhi from 9 locations
  
  • Extrapolated for 127 entry points – 52,146

• Entry and exit of commercial vehicles
  
  • Only from 9 points --- 85,799

  • Extrapolated for 127 entry points – 1,15,945
Gross under estimation of truck numbers by MCD

- From the same 9 locations
  - MCD – 22,628
  - CSE – 38,588
  - More than 70% difference!!!!!!
Gross underestimation across entry points

Comparison between CSE & MCD data in daily average trucks (Category-2 to Category -5) entering Delhi from selected 9 entry points
Source: CSE Traffic Count Survey & MCD Data for toll entry between 16.05.2015 to 31.07.2015

<table>
<thead>
<tr>
<th>Location</th>
<th>Entry Point(s)</th>
<th>Comparison between CSE &amp; MCD Data (Daily Average) from 16.05.2015-31.07.2015</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>CSE</td>
</tr>
<tr>
<td>Kundli Border/NH-1</td>
<td>KGT Main</td>
<td>8369</td>
</tr>
<tr>
<td>Tikri Border on NH-10</td>
<td>Tikri</td>
<td>3700</td>
</tr>
<tr>
<td>Rajokari Border on NH-8</td>
<td>Rajokari</td>
<td>9919</td>
</tr>
<tr>
<td>Badarpur</td>
<td>BFTL (Badarpur Toll)</td>
<td>4460</td>
</tr>
<tr>
<td>KalindiKunj</td>
<td>KalindiKunj</td>
<td>4271</td>
</tr>
<tr>
<td>Ghazipur</td>
<td>a) Ghazipur Main</td>
<td>3914</td>
</tr>
<tr>
<td></td>
<td>b) OldGhazipur</td>
<td></td>
</tr>
<tr>
<td>Shahdara</td>
<td>a) Shahdara alas</td>
<td>3955</td>
</tr>
<tr>
<td></td>
<td>b) Shahdara Flyover</td>
<td></td>
</tr>
<tr>
<td>Total from 9 entry points</td>
<td></td>
<td>38,588</td>
</tr>
<tr>
<td>Total from all 127 Entry Points</td>
<td></td>
<td>52,146</td>
</tr>
</tbody>
</table>
Massive loading of toxic pollution from trucks

Upto 30% of the problem can be curtailed with stringent action

PM Load
- Delhi Vehicles: 61%
- Non Delhi Trucks: 29%
- Non Delhi Others: 10%

NO2 Load
- Delhi Vehicles: 68%
- Non Delhi Trucks: 22%
- Non Delhi Others: 10%

Source: CSE
Trucks spike pollution in Delhi

PM Relation with number of Trucks Entering Delhi

- Summer trends: variable but overall correlates

NO2 Relation with number of Trucks Entering Delhi

Source: CSE
Winter shows sharper increase in night time pollution

Winter inversion worsens night time pollution from trucks
Big trucks are smaller in number but contributes more particulate load

<table>
<thead>
<tr>
<th>Share of different truck segments entering Delhi</th>
<th>Particulate load from LGV’s and HGV’s</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Entering Commercial Vehicles</strong></td>
<td><strong>PM Load</strong></td>
</tr>
<tr>
<td>- 5% LVG</td>
<td>- 39%</td>
</tr>
<tr>
<td>- 10% 2 Axle Truck</td>
<td>- 61%</td>
</tr>
<tr>
<td>- 16% 3 Axle Truck</td>
<td>- Light Goods Vehicles</td>
</tr>
<tr>
<td>- 1% 4 Axle Truck</td>
<td>- Heavy Goods Vehicles</td>
</tr>
<tr>
<td>- 1% 5 Axle Truck</td>
<td></td>
</tr>
<tr>
<td>- 1% 6 Axle Truck</td>
<td></td>
</tr>
<tr>
<td>- 1% MAV more than 6 Axle</td>
<td></td>
</tr>
</tbody>
</table>

- Light good vehicles – 65% of total commercial vehicles entering Delhi.

- They contribute 39% of the particulate matter load from the commercial vehicles entering Delhi.

Source: CSE
Big trucks are smaller in number but contributes more NOx load

<table>
<thead>
<tr>
<th>Share of different truck segments entering Delhi</th>
<th>Nitrogen oxide from LGV’s and HGV’s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entering Commercial Vehicles</td>
<td>NO2 Load</td>
</tr>
<tr>
<td>65% Light good vehicles</td>
<td>Light Goods Vehicles</td>
</tr>
<tr>
<td>16% 2 Axle Truck</td>
<td>42%</td>
</tr>
<tr>
<td>10% 3 Axle Truck</td>
<td></td>
</tr>
<tr>
<td>5% 4 Axle Truck</td>
<td></td>
</tr>
<tr>
<td>1% 5 Axle Truck</td>
<td></td>
</tr>
<tr>
<td>1% 6 Axle Truck</td>
<td></td>
</tr>
<tr>
<td>2% MAV more than 6 Axle</td>
<td></td>
</tr>
</tbody>
</table>

- Light good vehicles – 65% of total commercial vehicles entering Delhi.

- They contribute **42% of the nitrogen oxide** load from the commercial vehicles entering Delhi.

Source: CSE
How many trucks are non-destined?

• Data on non-destined commercial traffic is not reliable

• MCD data shows non-destined trucks – those to be turned back to comply with the Supreme Court order at a mere 0.3% of the total traffic.

• MCD found only 90 vehicles not destined for Delhi and the rest -- 29,000 had business to do in the city.

• Conducting a travel destination study has huge drawback, as drivers do not provide accurate or correct information.
CSE’s rapid and limited count found much more non-destined tucks

• A rapid diagnostic survey only on the roads approaching NH 1 and NH 10 entry to Delhi.

  • Truck drivers were randomly surveyed about their origin and destination, about trip and commodity carried.

  • This found that some 23% of all commercial vehicles travelling on NH 1 were not destined for Delhi.

  • Over 40-60% of heavy trucks (3-axle and above) were not destined for Delhi.

  • A challenge to distinguish between destined and non-destined vehicles.
• Harish Salve Amicus Cureai in the on going air pollution case in the Supeme Court files an application based on this study and EPCA report

• Seeks short term measures

• Delhi government struggling with the issue

• Delhi government budget proposal to levy a congestion fee on diesel commercial vehicles – A range from Rs 100 to Rs 1500 per vehicle.

• Not implemented
Equalise cost of moving through Delhi with alternative routes

• Pollution compensatory charge based pollute pay to equalise the toll cost to remove distortion

• Example:
  • NH 71 and NH 71A are toll roads connecting Rewari with Jhajjar and Rohtak to Panipat.

    • The toll rate for the 3-axle trucks to travel on this road is Rs 1420.

    • But MCD toll in Delhi for a 3-axle truck would be Rs 450.

    • Not much difference in trip length -- Travelling via NH71 and NH 71A is 172 km. But travelling through Delhi is marginally shorter at 163 km.
## Distorted cost

### Comparison of Toll Rates along various Alternatives

<table>
<thead>
<tr>
<th>Route (From Panipat to Rewari)</th>
<th>Length, in Km</th>
<th>Toll Rate for LGV</th>
<th>Toll Rate for 2-axle Trucks</th>
<th>Toll Rate for 3-axle Truck</th>
<th>Toll Rate for 4-axle and above</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Alternative 1</strong> NH71A-NH71 (Through Rohtak)</td>
<td>172</td>
<td>450</td>
<td>930</td>
<td>1420</td>
<td>1550</td>
</tr>
<tr>
<td><strong>Alternative 2</strong> Through Delhi</td>
<td>163</td>
<td>120</td>
<td>225</td>
<td>450</td>
<td>1120</td>
</tr>
</tbody>
</table>

### Distorted values of toll
Implement Radio-Frequency Identification (RFID) on trucks: Enable electronic payment and tracking as they pass through the tollbooths.

This can be easily implemented in Delhi.

The contract given by MCD to the private operator includes the provision to move towards RFID.

But no deadline has been given and there is clearly no incentive for the operator to move towards RFID, which would reduce the dealings in cash considerably.
Introduce Bharat Stage IV emissions standards nation-wide by April 2016

The current Bharat Stage III standards that apply to trucks across the country are 15 years behind Europe.

Trucks have at least 15-year life. Any delay in bringing in better technology or fuel, means more polluting on-road vehicles.

Introduce cleaner fuel nationwide as trucks travel long distances.

The current draft standards issued by the Ministry of Surface Transport and Highways requires inter-state (truck) traffic to move to Bharat Stage IV only in April 2017.

This delay is unacceptable.
Thank You