Purpose of this webinar series is to initiate a dialogue around Auto Fuel Policy in India

ICCT is conducting a study to evaluate the past successes and future prospects of India’s vehicle emissions control program

- New vehicle and engine emission standards
- Fuel quality standards
- Vehicle compliance and enforcement program
- Fuel inspection and compliance program
- Alternative fuels and new energy vehicle policies
- Fuel efficiency standards and labeling

For more information:
http://theicct.org/spotlight/vehicle-emissions-control-india
Today’s webinar focuses on costs & benefits of vehicular emissions and fuel quality control

- **Cost of clean vehicle technologies**
  - Going from Euro III to Euro VI

- **Cost of clean fuel**
  - Production of ultra low sulfur fuels (ULSF)

- **Health benefits**
  - Avoided premature mortality due to lower vehicular PM$_{2.5}$ emissions

- **Cost-benefit analysis**
Future Indian Emission Reductions—Bharat III to Bharat VI

- **LDV:**
  - 90% reduction in particulate matter (PM)
  - 60-85% reduction in NOx
  - 50-70% reduction in HC
  - 20-55% reduction in CO

- **HDV:**
  - 90% reduction in PM
  - 90% reduction in NOx
  - 80% reduction in HC
  - 30% reduction in CO

- **Two- and three-wheelers (potential BS III to BS V):**
  - 50% reduction in PM, NOx+HC, CO
ICCT emission reduction cost report

- Comprehensive assessment of emission reduction technologies

- Costs for US and Europe
  - Costs in India lower

- Full report [here](http://theicct.org/estimated-cost-emission-reduction-technologies-ldvs)
## Engine size of Indian vehicles

<table>
<thead>
<tr>
<th>Category</th>
<th>Diesel</th>
<th>Gasoline</th>
<th>CNG</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Average Fleet Engine Volume (L)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-Wheelers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2W75</td>
<td>-</td>
<td>0.07</td>
<td>-</td>
</tr>
<tr>
<td>2W125</td>
<td>-</td>
<td>0.11</td>
<td>-</td>
</tr>
<tr>
<td>2W250</td>
<td>-</td>
<td>0.175</td>
<td>-</td>
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<tr>
<td>2W999</td>
<td>0.5</td>
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<tr>
<td>3-Wheelers</td>
<td>0.416</td>
<td>0.173</td>
<td>0.173</td>
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<tr>
<td>3WP</td>
<td>0.416</td>
<td></td>
<td>0.2</td>
</tr>
<tr>
<td>3WC</td>
<td>0.416</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>Passenger Cars</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PC</td>
<td>1.4</td>
<td>1.1</td>
<td>1.1</td>
</tr>
<tr>
<td>U&amp;MPV</td>
<td>2.2</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Trucks &amp; Buses</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LDBus</td>
<td>3.1</td>
<td>3.1</td>
<td>3.1</td>
</tr>
<tr>
<td>LDTrk</td>
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<td>3.1</td>
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<tr>
<td>MDBus</td>
<td>3.6</td>
<td></td>
<td>3.6</td>
</tr>
<tr>
<td>MDTrk</td>
<td>3.6</td>
<td></td>
<td>3.6</td>
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<tr>
<td>HDBus</td>
<td>5.8</td>
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<td>5.8</td>
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<tr>
<td>HDSUT</td>
<td>5.7</td>
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<tr>
<td>HDCT</td>
<td>6.0</td>
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</tbody>
</table>
Clean vehicle costs

4-wheeler upgrade costs

- Bharat III
- Bharat IV
- Bharat V
- Bharat VI

Emission Stage

US$

Rs.

CNG Truck/Bus (6.0 L)

Diesel SUV (2.2 L)

Diesel Truck/Bus (6.0 L)

Gasoline Car (1.1 L)

Diesel Car (1.4 L)
2- and 3-wheeler upgrade costs

- Diesel autorickshaw (0.416 L)
- Large Motorcycle (0.175 L)
- Small Motorcycle (0.07 L)
- CNG autorickshaw (0.173 L)
### Per vehicle upgrade costs

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>Bharat III to Bharat VI</th>
</tr>
</thead>
<tbody>
<tr>
<td>CNG Autorikshaw</td>
<td>$50 (Rs. 2,500)</td>
</tr>
<tr>
<td>Small Motorcycle</td>
<td>$45 (Rs. 2,250)</td>
</tr>
<tr>
<td>Large Motorcycle</td>
<td>$60 (Rs. 3,000)</td>
</tr>
<tr>
<td>Diesel Autorikshaw</td>
<td>$240 (Rs. 12,000)</td>
</tr>
<tr>
<td>Gasoline Car</td>
<td>$80 (Rs. 4,000)</td>
</tr>
<tr>
<td>Diesel Car</td>
<td>$1,330 (Rs. 66,600)</td>
</tr>
<tr>
<td>Diesel SUV</td>
<td>$1,800 (Rs. 90,000)</td>
</tr>
<tr>
<td>CNG Truck/Bus</td>
<td>$3,275 (Rs. 1,63,750)</td>
</tr>
<tr>
<td>Diesel Truck/Bus</td>
<td>$4,810 (Rs. 2,40,500)</td>
</tr>
</tbody>
</table>
Refineries & BS IV cities in India

Clean fuel costs

Refineries and Fuel Standards in India

BS-IV standards implemented
Refineries
Capacity (MMTPA)
- 0.1
- 1
- 10

* indicates refineries still under construction

Major roadways

1 The National Capital Region (NCR) comprises four constituent sub-regions: the Haryana sub-region (Faridabad, Gurgaon, Mewat, Rohtak, Sonepat, Rewari, Jhajjar, Panipat and Palwal), the Uttar Pradesh sub-region (Meerut, Ghaziabad, Gautam Budha Nagar, Bulandshahr, and Baghpat), the Rajasthan sub-region (Alwar district), and the National Capital Territory (NCT) of Delhi.
ULSF production technologies

- **Hydrocracking**
  - Breaks down heavier crude fractions into lighter fractions suitable for transportation fuels
  - Removes sulfur
  - In lieu of fluid catalytic conversion (FCC)
  - More expensive than FCC

- **Hydrotreating**
  - Removes heterogeneous atoms such as sulfur
  - FCC feed hydrotreating (pre-FCC)
  - FCC naphtha hydrotreating (post-FCC for gasoline)
  - Distillate hydrotreating (post-FCC for diesel)

- **Fuel quality and yield restoration processes**
  - Maintaining gasoline octane number
  - Lubricity additives
  - Increase in crude input due to losses
Hart Consulting / MathPro study for ICCT to evaluate the cost of transition to ULSF

- India, China, Brazil, and Mexico studied
- Investments and increase in annual production costs
- Transition by 2015
Study assumptions

- ULSF for almost all gasoline and diesel applications
- Upgrades using only technologies already in commerce
- Same crude sourcing pattern in 2015 as in 2010
- New refineries not built expressly to produce ULSF
Additional costs for ULSF production

- **Operations**
  - Cost of additional hydrogen supply
  - Cost of replacing lost product yield
  - Cost of maintaining other aspects of fuel quality

- **Investments**
  - Annual capital charges (ACC) associated with investments
ULSF production investments

- Total Investment:
  - $4.1 billion (Rs. 21,000 crore)
    - LSF investment (current standards → 50 ppm sulfur):
      - $1.9 billion (Rs. 9,500 crore)
    - Extra USLF investment (50 ppm sulfur → 10 ppm sulfur):
      - $2.26 billion (Rs. 11,300 crore)

- 12th 5-year plan (2013-2017) public sector refinery investments:
  - $31 billion (Rs. 1,55,000 crore)
    - Much of LSF investment included in 12th five-year plan

- Some LSF and ULSF investment from private sector as well
ULSF production per liter costs

- **Current refineries (Groups A-D)**
  - Gasoline: 0.9-1.10¢ (Rs. 0.45-0.55)
  - Diesel: 0.8-1.10¢ (Rs. 0.40-0.55)

- **Transition year refineries (Group E)**
  - Gasoline: 0.20-0.30¢ (Rs. 0.10-0.15)
  - Diesel: 0.30-0.40¢ (Rs. 0.15-0.20)

- **Combining both (Groups A-E)**
  - Gasoline: 0.70-0.87¢ (Rs. 0.35-0.44)
  - Diesel: 0.64-0.88¢ (Rs. 0.30-0.44)
Effects of vehicular emissions

- Adverse health effects
  - Especially from PM$_{2.5}$
  - Exacerbation of asthma and other respiratory diseases
  - Premature mortality due to cardiopulmonary diseases and lung cancer

- Global warming
  - BC, CH$_4$, N$_2$O, CO$_2$, O$_3$

- Adverse effects on agricultural yields
  - NO$_x$, PM, O$_3$
## Comparison of what is possible

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Emission Standards</th>
<th>Fuel Standards</th>
<th>Enforcement &amp; Compliance&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Change in Fuel Type&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BAU</strong></td>
<td>Bharat IV in 20 cities, Bharat III in rest of India</td>
<td>Bharat IV in 20 cities (50 ppm sulfur), Bharat III in rest of India (350 ppm sulfur)</td>
<td>15% of vehicle fleet are gross emitters</td>
<td>50 (60)% of new LDV sales diesel by 2020(2030)</td>
</tr>
<tr>
<td><strong>Alternate</strong></td>
<td>Bharat V in 2014, Bharat VI in 2016, “SULEV” (LD) and “Bharat VII” (HD &amp; 2/3-Wheelers) in 2020</td>
<td>Bharat V (10 ppm sulfur in 20 cities) and Bharat IV elsewhere by 2014; 10 ppm sulfur countrywide by 2016</td>
<td>By 2020, only 3% of vehicle fleet are gross emitters</td>
<td>15% of LDV sales CNG and 10% LPG (2030); 75% bus sales CNG (2030); 50% of 3-wheeler sales CNG (2030)</td>
</tr>
</tbody>
</table>

<sup>a</sup> – Gross polluters are defined as vehicles where emission controls are non-functional  
<sup>b</sup> – LDV means PC only. Increases in CNG and LPG vehicle market share are assumed to happen at the expense of diesel market share.
Large reductions in PM emissions feasible

Annual PM Emissions (1000 metric tons)

- BAU
- Alternate

70% reduction by 2020

Health benefits
Assessment of health benefits

- Quantification based on World Health Organization (WHO) methods

- Based primarily on reductions in vehicular PM$_{2.5}$ emissions
  - PM$_{2.5}$/PM emission ratio: 0.76

- Only cities with population > 100,000 in 2000 studied

- Intake fraction method used to convert emissions into concentrations*
  - Intake fraction is fraction of pollutant inhaled/emitted

- Only addresses reduction in premature deaths due to lower incidence of
  - Adult cardiopulmonary diseases (due to PM$_{2.5}$)
  - Adult lung cancer (due to PM$_{2.5}$)
  - Child respiratory infections (due to all PM)

*Apte, JS et al. 2012. Global Intraurban Intake Fractions for Primary Air Pollutants from Vehicles and Other Distributed Sources.
Conservative estimation of health benefits

- Nationwide emissions apportioned to cities based on population share
  - Underestimates true number of cars in big cities

- No morbidity impacts evaluated

- No pollutants other than direct PM$_{2.5}$ emissions (PM$_{10}$ in the case of child respiratory diseases)

- No assessment of benefits in rural areas

- No co-benefits evaluated
535,000 cumulative avoided deaths by 2030
Value of statistical life (VSL) to monetize health benefits

- Based on willingness to pay (WTP) for a marginal change in likelihood of death
  - Amount paid to people for risks (e.g. jobs)

- $1.55 million (Rs. 7.75 crore) for India in 2006*
  - Annual VSL modified according to GNI-PPP
  - 2006 VSL in the US: $7.4 million (Rs. 37 crore)

- Mortality lag adjustments for monetization
  - 30% in Year 1
  - 50% in Years 2-5
  - 20% in Years 6-20

Benefits start outweighing costs around 2017
## Total costs and benefits

<table>
<thead>
<tr>
<th></th>
<th>Vehicle Costs</th>
<th>Fuel Costs</th>
<th>Benefits</th>
<th>Net Benefits</th>
<th>Benefits to Cost Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>In 2020</strong></td>
<td>$8.8 billion</td>
<td>$1.1 billion</td>
<td>$25.8 billion</td>
<td>$16 billion</td>
<td>1.6</td>
</tr>
<tr>
<td></td>
<td>Rs. 44,000 crore</td>
<td>Rs. 5,400 crore</td>
<td>Rs. 130,000 crore</td>
<td>Rs. 800,000 crore</td>
<td></td>
</tr>
<tr>
<td><strong>In 2030</strong></td>
<td>$10.3 billion</td>
<td>$1.2 billion</td>
<td>$88.6 billion</td>
<td>$77 billion</td>
<td>7.7</td>
</tr>
<tr>
<td></td>
<td>Rs. 52,000 crore</td>
<td>Rs. 6,100 crore</td>
<td>Rs. 443,000 crore</td>
<td>Rs. 385,000 crore</td>
<td></td>
</tr>
<tr>
<td><strong>Cumulative to 2030</strong></td>
<td>$170 billion</td>
<td>$18.7 billion</td>
<td>$903 billion</td>
<td>$714 billion</td>
<td>4.8</td>
</tr>
<tr>
<td></td>
<td>Rs. 8,52,000 crore</td>
<td>Rs. 93,500 crore</td>
<td>Rs. 45,14,000 crore</td>
<td>Rs. 3,570,000 crore</td>
<td></td>
</tr>
</tbody>
</table>
Preliminary conclusions

- Large long-term gain by implementing cleaner vehicle and fuel policies
  - Gains continue well beyond 2030
  - Costs decrease over time
    - Economies of scale & learning

- Co-benefits would be significant
Preliminary recommendations for discussion

- New Autofuel Policy should set stringent long-term (2013-2025) standards
  - Move to Euro VI equivalent standards as soon as possible to maximize health benefits
  - Catch up to international best practices

- Revamped national in-use compliance program for vehicles and fuels

- Key is to implement ULSF nationwide as soon as possible
  - Enable clean vehicle technologies
  - Govt. must allow oil companies to recover ULSF costs
For more information...

- ICCT India website: [http://theicct.org/india](http://theicct.org/india)
- Blog on vehicle and fuel taxes in India: [http://theicct.org/blogs/staff/india-2012-budget](http://theicct.org/blogs/staff/india-2012-budget)