Costs & Benefits of Cleaner Fuels & Vehicles in India

Gaurav Bansal / Anup Bandivadekar

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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





Engine size of Indian vehicles

Catagony		Diesel	Gasoline	CNG		
Calegory		Average Fleet Engine Volume (L)				
2-Wheelers	2W75	-	0.07	-		
	2W125	-	0.11	-		
	2W250	-	0.175	-		
	2W999		0.5			
3-Wheelers	3WP	0.416	0.173	0.173		
	3WC	0.416	0.2	0.2		
Passenger Cars	PC	1.4	1.1	1.1		
	U&MPV	2.2	2.0	2.0		
Trucks & Buses	LDBus	3.1	3.1	3.1		
	LDTrk	3.1	3.1	3.1		
	MDBus	3.6	-	3.6		
	MDTrk	3.6	-	3.6		
	HDBus	5.8	-	5.8		
	HDSUT	5.7	-	5.7		
	HDCT	6.0	-	6.0		

4-wheeler upgrade costs



2- and 3-wheeler upgrade costs



Per vehicle upgrade costs

Vehicle Type	Bharat III to Bharat VI
CNG Autorikshaw	\$50 (Rs. 2,500)
Small Motorcycle	\$45 (Rs. 2,250)
Large Motorcycle	\$60 (Rs. 3,000)
Diesel Autorikshaw	\$240 (Rs. 12,000)
Gasoline Car	\$80 (Rs. 4,000)
Diesel Car	\$1,330 (Rs. 66,600)
Diesel SUV	\$1,800 (Rs. 90,000)
CNG Truck/Bus	\$3,275 (Rs. 1,63,750)
Diesel Truck/Bus	\$4,810 (Rs. 2,40,500)



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Refineries & BS IV cities in India



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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



Clean fuel costs

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
- Full report <u>here</u>*





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, CH₄, N₂O, CO₂, O₃
- Adverse effects on agricultural yields
 NO_x, PM, O₃



Comparison of what is possible

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

 a – Gross polluters are defined as vehicles where emission controls are non-functional
 b – 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



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 (PM₁₀ in the case of child respiratory diseases)
- No assessment of benefits in rural areas
- No co-benefits evaluated

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535,000 cumulative avoided deaths by 2030

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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

*Madheswaran, S. 2006. *Measuring the Value of Statistical Life: Estimating Compensating Wage* Slide 23 *Differentials Among Workers in India.*

Cost-benefit analysis

Benefits start outweighing costs around 2017

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Total costs and benefits

	Vehicle Costs	Fuel Costs	Benefits	Net Benefits	Benefits to Cost Ratio
In 2020	\$8.8 billion Rs. 44,000 crore	\$1.1 billion Rs. 5,400 crore	\$25.8 billion Rs. 130,000 crore	\$16 billion Rs. 800,000 crore	1.6
In 2030	\$10.3 billion Rs. 52,000 crore	\$1.2 billion Rs. 6,100 crore	\$88.6 billion Rs. 443,000 crore	\$77 billion Rs. 385,000 crore	7.7
Cumulative to 2030	\$170 billion Rs. 8,52,000 crore	\$18.7 billion Rs. 93,500 crore	\$903 billion Rs. 45,14,000 crore	\$714 billion Rs. 3,570,000 crore	4.8

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: <u>http://theicct.org/india</u>
- First webinar on vehicular emissions in India: <u>http://theicct.org/blogs/staff/reducing-vehicular-emissions-india-webinar-notes</u>
- Second webinar on vehicular emissions in India: <u>http://theicct.org/blogs/staff/improving-fuel-quality-india-webinar-notes</u>
- Third webinar on ULSF costs in India and other countries: <u>http://theicct.org/webinar-transition-ultra-low-sulfur-fuels-india</u>
- Report on costs of transition to ULSF in India and other countries: <u>http://theicct.org/technical-and-economic-analysis-transition-ultra-low-sulfur-fuels-brazil-china-india-and-mexico</u>
- Report on costs of emission reduction technologies: <u>http://theicct.org/estimated-cost-emission-reduction-technologies-ldvs</u>
- Briefing on cost-benefit analysis of clean fuels and vehicles in India: <u>http://theicct.org/costs-and-benefits-cleaner-fuels-and-vehicles-india</u>
- Briefing on the benefits of low sulfur fuels in India: <u>http://theicct.org/benefits-low-sulphur-fuels-india</u>
- Briefing on the potential of lower vehicle emission standards in Indian cities: <u>http://theicct.org/potential-lower-vehicular-emissions-indian-cities</u>
- Blog on dieselization in India: <u>http://theicct.org/blogs/staff/harsh-calculus-dieselization-india</u>
- Blog on vehicle and fuel taxes in India: <u>http://theicct.org/blogs/staff/india-2012-budget</u>

Gaurav Bansal gaurav "at" theicct.org

Anup Bandivadekar anup "at" theicct.org

http://twitter.com/#!/ theicct