Real world emissions from diesel vehicles in US and European cities - The VW scandal and beyond

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Our right to clean air conclave
April 19 and 20th, 2016
New Delhi, India
The ICCT: mission and activities

The ICCT’s mission is to dramatically improve the environmental performance and efficiency of cars, trucks, buses, ships and aircraft in order to protect and improve public health, the environment, and quality of life.

- Non-profit research organization
- Air pollution, energy efficiency, and climate impacts
- Focus on regulations, government policies and fiscal incentives
- Activity across modes including aviation and marine
- Global outreach, with special focus on largest transportation markets

www.theicct.org
Topics

- Context for VW scandal
- Regulatory response in US and EU
- Implications for India
- Closing thoughts
Context for VW scandal:
Mounting evidence of the gap between real world and certification emissions
On-road NO$_x$ : Euro 6 Diesel cars are (on average) worse than they should have been 15 years ago
On-road emission behavior confirmed by 13 years of remote sensing data (Europe)

Chen & Borken-Kleefeld, Real-driving emissions from cars and light commercial vehicles - Results from 13 years remote sensing at Zurich/CH Atmospheric Environment, 88:157-164 (May 2014)
Vehicle emission standards in the US and EU
# Vehicle Testing Plan for WVU and CARB

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>WVU PEMS testing</th>
<th>CARB Chassis Test</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>VW Jetta 2013 Wagon</td>
<td>LA &amp; San Diego innercity loop</td>
<td>NEDC x2</td>
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<td></td>
<td>Rush-hour traffic</td>
<td>FPT x2</td>
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<td></td>
<td>Up/Down hill</td>
<td>US06 x2</td>
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<tr>
<td>VW Passat 2012</td>
<td>LA &amp; San Diego innercity loop</td>
<td>NEDC x2</td>
<td>PEMS cross check with CVS and Sensors PEMS</td>
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<tr>
<td></td>
<td>Rush-hour traffic</td>
<td>FPT x2</td>
<td></td>
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<tr>
<td></td>
<td>Up/Down hill</td>
<td>US06 x2</td>
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<tr>
<td></td>
<td>LA-Seattle (4000 km)</td>
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<tr>
<td>BMW X5 35D 2012</td>
<td>San Francisco &amp; LA Innercity loop</td>
<td>NA</td>
<td>Includes gravimetric PM measurement with Horiba TRPM</td>
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<tr>
<td></td>
<td>Rush-hour traffic</td>
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WVU / ICCT Study - In-use emissions testing of light-duty diesel vehicles in the U.S. (May, 2014)

- Real-world NOx emissions exceeded emission standard by 15 to 35X over five pre-defined routes categorized based on their predominant driving conditions, namely, i) highway, ii) urban/suburban, and iii) rural-up/downhill driving.
- All vehicles met emission standards on Federal Test Procedure

http://www.theicct.org/use-emissions-testing-light-duty-diesel-vehicles-us
The emission behavior varies significantly between manufacturers and even between vehicle models.

On-road Euro 6 conformity factors for selected cars (US factors would be 2x)

15 test vehicles in total (6 manufacturers), with different NOx control technologies:
- 10 selective catalytic reduction (SCR)
- 4 exhaust gas recirculation (EGR)
- 1 lean NOx trap (LNT)

Average Euro 6 NOx conformity factors (ratio of on-road emissions to legal limits):
- all cars: 7.1
- best performer (Vehicle C, SCR): 1.0
- bad performer (Vehicle H, LNT): 24.3
- worst performer (Vehicle L, SCR): 25.4

http://www.theicct.org/real-world-exhaust-emissions-modern-diesel-cars
Dieselgate and its aftermath shed light on gaps in US and Euro standard compliance and enforcement
Regulatory response in US and EU

- California Air Resources Board and US EPA updated in-use compliance procedures to include PEMS testing to identify defeat devices in diesel LDVs

- The EU is in the process of finalizing Real World Driving Emissions (RDE) provisions testing part of type-approval
  - Implementation starts in 2017

- The Commission proposing revisions to the Type Approval Directive
What is a defeat device? US vs. EU

- Software considered a defeat device in US is either not a defeat device or not prohibited as such under EU regulation.
- Regulatory language defining and prohibiting defeat devices in the U.S. and EU regulations is nearly identical.
- U.S. and EU regulations diverge is in their provisions concerning how manufacturers obtain the exemption provided for under those carefully specified, effectively identical conditions, and in their provisions for penalizing the failure to disclose auxiliary emission control devices or the illegal use of defeat devices.
Implications for India
Dieselgate implications for India

- VW has agreed to do a recall 325,000 vehicles in India, but the company is not admitting to the use of a defeat device in the legal sense of the word
  - In July 2013, General Motors’ Tavera model was found to have been cheating on emissions compliance certification for nearly 8 years
- Opportunity for India to upgrade its vehicle emissions compliance and enforcement program
  - Strengthen the Conformity of Production (COP) process
    - VW Vento 1.5L diesel was found to have high CO emissions during a March 2016 COP test by ARAI
  - Develop an in-use compliance program to randomly select in-use vehicles and test them against their original emission standards
  - Clarify definition of emission control devices, and how exemptions from the defeat device prohibition are administered
- Define a mandatory recall policy for emissions related defects
Compliance programs need to be strengthened across the board

- Develop a national program to randomly select properly maintained and used vehicles and test them against their original emission standards.
  - The program can build on the 10 pilot I/M centers being developed presently.
- Develop a national program to test fuel quality throughout the fuel supply chain, including retail stations.
  - Regional fuel testing labs should be developed.
- Mandate annual vehicle registration for all vehicle types across the country.
  - Annual registration can be linked with PUC testing and proof of insurance.
Closing thoughts
Real world diesel NOx reductions will require strong enforcement and the next generation of standards.
Background and additional reading

- http://www.theicct.org/future-of-vehicle-testing
- http://www.theicct.org/european-real-driving-emissions-regulation
- http://www.theicct.org/blogs/staff/miseducation-diesel-car
- http://www.theicct.org/nox-control-technologies-euro-6-diesel-passenger-cars
Thank you.

“We’ve found the problem. You’re looking at £18 billion plus parts and labour.”
US PEMS Route NOx emissions and CARB chassis results

Vehicle A (VW Jetta): 15-35 times higher than the FTP standard,

Vehicle B (VW Passat): 5-18 times higher than FTP standards,

Vehicle C (BMW X5): generally at or below the FTP standard.

NOx std. FTP-75: 0.044 g/km

http://www.theicct.org/use-emissions-testing-light-duty-diesel-vehicles-us
A broader perspective: comparing the US and EU Compliance Systems
ICCT recommendations to improve EU compliance system (many underway . . .)

<table>
<thead>
<tr>
<th>ICCT recommendation</th>
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<tbody>
<tr>
<td>Introduce <strong>Worldwide Harmonized Light Vehicles test procedure</strong></td>
<td>Scheduled for September 2017, with some industry representatives still lobbying for a delay</td>
</tr>
<tr>
<td>Introduce a <strong>testing and target scheme regarding the efficiency of vehicle air conditioning systems</strong></td>
<td>Test procedure has been developed, implementation is currently not scheduled</td>
</tr>
<tr>
<td><strong>Strengthen the road load determination procedure</strong> with measurement results publicly accessible and independent conformity testing</td>
<td>WLTP is expected to cover some aspects; publication of road load data not foreseen</td>
</tr>
<tr>
<td>Establish a <strong>European type-approval authority</strong></td>
<td>Currently not foreseen, but European Type Approval Directive proposes greater authority for Commission to oversee testing service centers, conduct vehicle testing under real world conditions, require software codes from car makers, and perform recalls as necessary.</td>
</tr>
<tr>
<td>Introduce a <strong>real-world adjustment factor</strong> for vehicle fuel consumption and CO2 emission figures</td>
<td>Currently not foreseen</td>
</tr>
<tr>
<td><strong>Put a stronger focus on in-use conformity testing</strong></td>
<td>European Commission Type Approval Directive proposal includes in-use testing by Joint Research Council</td>
</tr>
<tr>
<td><strong>Further developing consumer websites</strong>, by providing an EU-wide platform for vehicle owners to report fuel use.</td>
<td>Currently not foreseen</td>
</tr>
<tr>
<td>Require <strong>manufacturers to apply for and receive approval for any alternative emissions control calibrations</strong> before type approval, and clarify criteria for approval.</td>
<td>Currently not foreseen, but only recommended in March</td>
</tr>
</tbody>
</table>

In Europe, there are many ways to optimize vehicles for the laboratory testing.

- Disconnecting the alternator prevents the battery from charging, and reduces energy use.
- Carmakers can optimise the engine controls to reduce emissions.
- Careful lubrication and use of special lubricants help the car run more efficiently.
- Altering wheel alignment reduces rolling resistance.
- Fitting special tyres with a lower rolling resistance.
- Overinflating the tyres reduces rolling resistance.
- Taping over indentations or protrusions on the body reduces aerodynamic drag.
- Pushing the brake pads fully into the calipers reduces rolling resistance.
- The rolling road is programmed with the minimum weight or inertia class.
Major reform of China Clean Air Law strengthens authority for compliance and enforcement

- On Jan 1, 2016, China’s revised National Air Pollution Prevention and Control Law took effect (Clean Air Law).
- The new Clean Air Law substantially strengthens government authority to enforce emissions standards for motor vehicles.
- Section of Mobile Source Emissions Control expanded to eighteen articles from only four in the old version of the law, and ten of them are entirely new.
- Last month, Ministry of Environmental Protection (MEP) announced the establishment of an Air Pollution Control Department, which will also establish a new division of mobile source emission control.
It’s not just about NOx . . .
Real-world CO$_2$ in EU is 30+% higher than claimed

http://www.theicct.org/laboratory-road-2014-update
## Vehicle compliance issues

<table>
<thead>
<tr>
<th>Testing Protocol</th>
<th>India</th>
<th>US</th>
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<tbody>
<tr>
<td>Type approval (TA) and conformity of production (COP) through testing centers</td>
<td></td>
<td>TA, COP and in-use testing by manufacturers. EPA runs confirmatory tests, in-use surveillance tests, and oversees the selective enforcement audits (SEAs).</td>
</tr>
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<th>Compliance Testing</th>
<th>India</th>
<th>US</th>
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<tr>
<td>Manufacturers advised before COP, testing agency selects vehicles at random from plant</td>
<td>Vehilces from models identified for testing selected at random</td>
<td></td>
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<tr>
<td>Vehicles/engines must pass standard test cycle</td>
<td></td>
<td>Vehicles must pass supplementary test cycles (SFTP/ NTE) in addition to standard test cycles</td>
</tr>
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</table>

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<tr>
<th>Durability Requirements</th>
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<th>US</th>
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<tbody>
<tr>
<td>• 100k km (BS IV-LDVs) • Deterioration rates or 125k-167K km (HDVs)</td>
<td></td>
<td>• 180k km/ 10 years (LDV) • 700K km/ 10 years / 22K hours (HDV)</td>
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</table>
## Vehicle compliance issues

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<thead>
<tr>
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<tr>
<td><strong>In-use Vehicles</strong></td>
<td>I/M (PUC) inspections conducted by independent operators not linked to vehicle registration</td>
<td>I/M inspections conducted by state/local authorities linked to vehicle registration</td>
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<tr>
<td></td>
<td>Certificates issued to PUC compliant vehicles</td>
<td>Visible sticker issued to I/M compliant vehicles</td>
</tr>
<tr>
<td></td>
<td>PUC data not sent to centralized system</td>
<td>I/M data accessible to EPA to identify vehicles for in-use testing program</td>
</tr>
</tbody>
</table>
| **On-Board Diagnostics (OBD)** | OBD-II has been in effect on BS-IV LDVs only starting in April 2013 | • LDV OBD since 1996  
  • HDV OBD since 2005  
  • Increasing reliance on OBD for in-use monitoring |
| **Non-compliance**  | No mandatory recall policy                                              | Mandatory recall for vehicles not in compliance                                          |