Motor Vehicle Pollution Control
A Global Overview

September 6, 2018

Michael P. Walsh
International Consultant

Founding Chairman
Board of Directors,
International Council on Clean Transportation
Agenda

Serious Problems Remain
– Terrible Air Pollution with Resulting Adverse Health Impacts
– Non Compliance
– Climate Change

Technical Progress Remarkable
High Vehicle Population Growth Offsetting Gains
New Energy Vehicles Address All Three Problems

The Road Ahead
The Challenges We Face Remain Immense
GBD 2015
Premature Deaths: Air Pollution among top-ranked global risk factors

Outdoor PM contributed to 4.2 million premature deaths

Air pollution combined - ambient plus household - contributed to 10% of global mortality in 2015 – the 4th ranked global risk factor

GBD 2015 The Lancet
7 October 2016
Climate Change is Real and Already Occurring

Average Surface Air Temperature Increased 1.8°F Since 1901

Last Three Years Have Been The Warmest on Record

Human Activity is Dominant Cause of Observed Warming

Global Sea Level has Risen 7-8 inches Since 1900

Documented rise in Ocean Temperatures, melting glaciers, diminishing snow cover, shrinking sea ice, ocean acidification and increasing atmospheric water vapor.

Incidence of large forest fires in western US and Alaska

Source: Fourth National Climate Assessment, Volume 1, 2017
CO$_2$ Has Been Increasing Rapidly Since the Start of the Industrial Revolution.
Fortunately We Have Been Taking Steps to Address these Serious Problems
### Incredibly Cleaner Cars Are Now on the Road

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>1968</th>
<th>Tier 3</th>
<th>% Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exhaust HC + NOx</td>
<td>12.4 g/mi</td>
<td>0.03 g/mi</td>
<td>99+%</td>
</tr>
<tr>
<td>CO</td>
<td>87 g/mi</td>
<td>1 g/mi</td>
<td>99%</td>
</tr>
<tr>
<td>PM</td>
<td>0.25 g/mi</td>
<td>0.003 g/mi</td>
<td>99%</td>
</tr>
<tr>
<td>Evap HC</td>
<td>1 g/mi</td>
<td>Zero</td>
<td>99+%</td>
</tr>
<tr>
<td>Lead</td>
<td>0.1 g/mi</td>
<td>Zero</td>
<td>99+%</td>
</tr>
<tr>
<td>CO₂</td>
<td>580 g/mi</td>
<td>310/360</td>
<td>47%/38%</td>
</tr>
</tbody>
</table>
Advanced Technologies Also Going on to Trucks and Nonroad Equipment

US EPA’S Emissions Standards for Diesel Trucks

Tier 4 Nonroad Diesel Emission Standards, 175-750 hp
India Has Stepped Up To The Challenge

Ultra Low Sulfur Fuels Entering the Market

Euro 6/VI Equivalent Cars, Trucks, Buses and 2-3 Wheelers Coming Soon (2020)

Progress on RDE Emissions Requirements

BS IV (2020) and BS V (2024) Standards Adopted For Nonroad Agriculture and Construction Diesels (BS V faster than US, Japan or China)
China Has Shown that Euro 6 Can Be Improved Upon
International Comparison
NMHC/NMOG + NOx (g/km)
Historical Fleet CO₂ Emissions Performance And Current Or Proposed Standards Show We Are Making Significant Progress.

* Note that Japan has already met its 2020 statutory target as of 2013.
With The Strongest Motor Vehicle Pollution Control Program in The World Over 50 Years, The US Has Made Great Progress.
But Serious Problems Remain

Number of People Living in Counties with Air Quality Concentrations Above the Level of the NAAQS in 2017

- One or more NAAQS: 110.9M
- Ozone (8-hour): 100.6M
- PM2.5 (annual and/or 24-hour): 38.4M
- PM10 (24-hour): 15.0M
- SO2 (1-hour): 4.0M
- Lead (3-month): 0.6M
- CO (8-hour): 0.0M
- NO2 (annual and/or 1-hour): 0.0M
Annual Production is Approaching 100 Million Units

Annual Production of Cars, Trucks and Buses

R-square = 0.89  # pts = 31
y = -3.04e+009 + 1.55e+006x
Vehicle Population Growth Has Been Remarkably Steady For Over 75 Years Making It An Important Pollution Source & Energy Consumer
Historical Fleet CO₂ Emissions Performance And Current Or Proposed Standards Show We Are Making Significant Progress But Not Enough

Extending the improvement curves at the same rate will not achieve the 80% reductions required by 2050

All Vehicles on the Road in 2050 @
180mpg
or
76L/km
or
1.3L/100km

Note that Japan has already met its 2020 statutory target as of 2013
Poor Compliance is a Major Challenge

- Goal: To eliminate the gap between certification and real-world vehicular emissions

**NO\textsubscript{x} EMISSIONS FROM EU CARS: REAL-WORLD VS OFFICIAL VALUES**

**Diesel cars: Nitrogen oxide (NO\textsubscript{x}) emissions (in g/km)**

- Euro 3 (MY 2000–2006): 0.5
- Euro 4 (MY 2005–2010): 0.25
- Euro 5 (MY 2009–2015): 0.18
- Euro 6 (MY 2014–2017): 0.08

**Petrol cars: Nitrogen oxide (NO\textsubscript{x}) emissions (in g/km)**

- Euro 3 (MY 2000–2006): 0.15
- Euro 4 (MY 2005–2010): 0.08
- Euro 5 (MY 2009–2015): 0.06
- Euro 6 (MY 2014–2017): 0.06

*On-road measured value, measurements taken between 2011 and 2017 (IVL, 2017)*

*Euro emission limit*
Diesel Car Sales Share in Five Major European Countries Dropped From 56% to 44% Since 2012

- Italy: 56%
- Spain: 46%
- France: 46%
- UK: 41%
- Germany: 37%

2012 average: 56%
At the time of Dieselgate: 53%

Dieselgate breaks

Month

Monthly share
12-month rolling mean
Electric Vehicles Seem To Be Key

Inherently Clean in the Urban Environment
Compliance is Not An Issue – They Work or they Don’t
Technology is Clearly Viable
  – Cars Already in Production With Adequate Range
But Clearly Issues Remain
  – Prices Still High
  – Green Electrons Necessary For Climate Benefits
  – Supply Issues (especially Cobalt)
  – Charging Infrastructure
Electric Vehicle Sales Share, New Registrations, And Charging Infrastructure in Europe 2014
Norway Stands Out
Very Strong Electric Vehicles Incentives

Exemption From The Normal Value-added Tax (Vat) And The One-time Registration Fee
High Fuel Savings (Gasoline & Diesel Expensive)
Free Toll Roads
Access To Bus Lanes
Free Parking
Extensive Charging Network, And Free Charging.
Cumulative EV Stock Exceeding 3 Million and Sales Accelerating

54% Increase Compared to 2016

Source: IEA 2018
As of June 2018, Now Approaching 4 Million
**China’s New Energy Vehicle Mandate Policy**

**17 Sales:**
7,000 Vehicles

**18 Expected:**
Million

- Rebate extended to 2020

<table>
<thead>
<tr>
<th>Item</th>
<th>Final Rule</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mandatory NEV Credits</td>
<td>2019: 10%, 2020: 12%</td>
</tr>
<tr>
<td>Small Volume Mfgs</td>
<td>&lt; 30,000</td>
</tr>
<tr>
<td>Technical Thresholds BEV</td>
<td>Electric Range &gt;100km Max Speed &gt;100 km/hr</td>
</tr>
<tr>
<td>Per Vehicle Credit BEV</td>
<td>(0.012xER+0.8)xAF 6max</td>
</tr>
<tr>
<td>Per Vehicle Credit PHEV</td>
<td>2xAF</td>
</tr>
<tr>
<td>Per Vehicle Credit FCV</td>
<td>(0.16xrated power)xAF 5 Max</td>
</tr>
</tbody>
</table>

Subsidy Modified as of June 11: BEV Range 400kms $7900, 400 Km minimum for any subsidy
Per-vehicle NEV credits for BEVs

Base per-vehicle NEV credit = 0.012 x electric range + 0.8 (Capped at 5)

Adjustment factor = 0.5

Adjustment factor = 1.2
Energy Sources And Life Cycle Greenhouse Gas Emissions In 2014 For Conventional And Electric Vehicles On Average U.S. And California Electric Grids

- **Biofuel, 7%**
- **Oil, 93%**
  - **Average U.S. car**: 400 gCO$_2$/mile
  - **Electric vehicle, U.S. average**: 233 gCO$_2$/mile
  - **Electric vehicle, California**: 106 gCO$_2$/mile

- **Renewable, 10%**
- **Nuclear, 20%**
- **Coal, 45%**
- **Natural gas, 23%**
- **Oil, 1%**
- **Coal, 1%**
- **Oil, 1%**
- **Natural gas, 55%**
Final Thoughts

Extraordinary Technology Progress Has Occurred But
- Air Pollution Remains Very Serious Around the World
- Climate Crisis Is Real and Already Underway

Technology Transformation is Underway
- Diesel in Clear Decline
- Electric Drive Technology Gaining Momentum

Roadblocks Remain
- Battery Cost (But Progress is happening fast)
- Supply Issues (especially Cobalt)
- Charging Infrastructure
Thank You