Daimler’s advances in fuel efficiency and zero emission activities

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Daimler AG
Brussels, 2016, Nov. 8
Do we need CO$_2$ limits for HDVs to fulfill European climate targets? An OEM perspective

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<td>3. Engine measures</td>
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<td>8. Aerodynamic Trailers</td>
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<td>10. Integrated approach</td>
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Validation of ICCT data: Truck industry with improvements of more than 20% since 1996 in fuel consumption

- **Validation of ICCT data (August 2016)**
  - **Vehicle 1** from 1996
    - Engine OM 442 LA
    - 436 hp, Euro I
  - **Vehicle 2** from 2003
    - Engine OM 501
    - 456 hp, Euro III
  - **Vehicle 3** from 2016
    - Engine OM 471, FEPO pkg.
    - 450 hp, Euro VI

  - **SK 1844 LS**
    - Average fuel consumption: 40.8 l/100 km
  - **Actros MP2 1846**
    - Average fuel consumption: 37.4 l/100 km
    - Reduction vs. vehicle 1: 3.4 l/100 km ≈ 8.3%
    - Reduction versus vehicle 2: 8.9 l/100 km ≈ 21.8%
  - **Actros SFTP 1845**
    - Average fuel consumption: 31.9 l/100 km
    - Reduction versus vehicle 1: 5.5 l/100 km ≈ 14.7%

**Comments:**
- No comparable figures due to changing test routes and different vehicles (4x2, 6x2, 8x4; 400-650hp)
- Different time frame for tests (traffic conditions differing)

**Real-life results** (Lastauto Omnibus, supervised by DEKRA):
- Within 20 Years: Reduction of nearly 22% diesel consumption
- Also a reduction of more than 95% NOx and PM
- If we could have used 1996 tires: Improvement would have been even more!
Improvement of thermal efficiency only in small steps; heavy-duty engines already close to their physical maximum

Research is under way to improve efficiency of heavy duty engine further.
- Cost efficiency as critical industrial parameter.

Continuous development work and improvement

Approaching 50% Brake Thermal Efficiency (BTE)

- WHR (Waste Heat Recovery)
- Parasitics
- Comp. ratio
- Air syst.
- EGR
- Downsizing

Baseline

50%  48%  47%  45%  44%

2025
7%
1970 - 2010

Source: Super Truck Project, DOE Report Feb 2012

MB Trucks: Latest engine update: 2 % fuel consumption improvement released in 2015/16

- Fuel injection system 2nd generation X-Pulse
- Reduced friction
- Proprietary asymmetric turbocharger
- Enhanced combustion
- Unique EGR valve technology
Efficiency as challenge: Fuel consumption reduced by up to -15% within 5 years! Average optimization: More than -1.5% per year

Introduction of further fuel efficiency measures in summer 2016

- Q4/2011: proven Actros Euro V
- Q4/2011: New Actros Euro VI
- Q4/2012: PPC

1) MB Trucks reference test track: Stuttgart-Hamburg, Hamburg-Stuttgart, 100% cruise control: 85 km/h
We look into each segment and strive for improvements

Daimler Trucks: E-mobility in distribution segments

Fuso eCanter for LD distribution

- Permanent magnet engine, 400 V
  - $P_{\text{max}}$: 110 kW
  - Max. torque: 650 Nm
  - Battery capacity: 48.4 kWh
  - Range: 100 km
  - Chassis: 7.5 t
  - Payload: 2 t

Mercedes-Benz Urban eTruck for HD distribution

- HV Electric Drive
  - ZF AVE 130-400 VAC modified
  - $P_{\text{Peak}}$ 2 x 125 kW / $P_{\text{Cont}}$ 2 x 60 kW
  - Max. torque: $M_{\text{max}}$ 2 x 500 Nm
  - Battery capacity: 212 kWh
  - Range: up to 200 km
  - Chassis: 25 t
  - Payload: 11 t
Despite other technologies in the diesel field we analyze all long-term options for long-haul

<table>
<thead>
<tr>
<th>Overhead Catenary</th>
<th>E-fuel, H₂</th>
<th>Biomass</th>
<th>BEV</th>
<th>Natural Gas Vehicles</th>
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<tbody>
<tr>
<td><img src="image1.png" alt="Image" /></td>
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- Do we need now a decision on the way beyond 2030?
- How will EU 27 power generation look like in 2030 and 2050?
- How much and how long will politicians support costly options?
If all stakeholders join forces, EU can achieve around -20% CO$_2$ emissions over the next 6 years: Annual reduction rate 3.5 %

By all these measures, we will contribute to European CO$_2$ reduction targets.
Without any regulation significant progress also in the European trailer industry – proven in the Efficiency Run 2

Fuel consumption/CO₂ emission reduction of up to 20% - compared to standard vehicle combination of 2014

- A-lable tires: 2 – 4 %
- PPC* up to 5 %
- Semi tractor up to 6 %
- Krone Profi Liner Efficiency trailer: more than 5%

* PPC: Predictive Powertrain Control

Up to 20% improvements and everything can be purchased today!
Forecasts expect growth in heavy-duty vehicle mileage
Effective growth rates much lower than forecasted

**EU 27 forecasts vehicle mileage EU 27 [bn. km] – Prognos forecasts**

**Adjustments / assumptions:**
- 2007 figures heavy-duty vehicles and light commercial vehicles; structure of WTR 2012 used to concentrate on heavy-duty vehicles
- WTR 2015 figures for EU 12; Structure of WTR 2012 used to extrapolate to EU 27

**EU 27 vehicle mileage still far below 2007 pre-crisis level – 2007 level will be reached again around 2030**
VECTO: Will bring further competition into each segment and therefore lead to significant CO₂ improvements

<table>
<thead>
<tr>
<th>Representative boundary conditions depending on vehicle class</th>
<th>Certified input data from OEM</th>
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<tbody>
<tr>
<td>(same for all OEMs)</td>
<td>(OEM-specific)</td>
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<tr>
<td>Cycles for each vehicle class</td>
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<tr>
<td>Long-haul: mainly highway operation and a small share of regional roads.</td>
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<tr>
<td>Regional delivery: inner city, suburban, regional roads</td>
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<tr>
<td>Urban delivery: inner city and partly suburban roads</td>
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<tr>
<td>Municipal utility: many stops, partly low vehicle speed</td>
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<tr>
<td>Construction: inner city, regional roads; minor share off-road driving</td>
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<tr>
<td>Slope</td>
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<td>Target speed</td>
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<td>Standard trailer / body specification</td>
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<tr>
<td>Certified engine fuel map</td>
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<tr>
<td>Cert. driving resistances: driven axle, transmission, air drag</td>
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<tr>
<td>OR standard values</td>
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<td>Weight ratios, tires</td>
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<td>Certified input data from OEM</td>
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<td>OEM specific values</td>
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VECTO simulation tool (same for all OEMs)

CO₂ and fuel consumption values
Do we need CO₂ limits for HDV to fulfill European climate targets? An OEM perspective

Some reflections ...

... on an European CO₂ regulation for heavy-duty vehicles

- Trucks and buses are not just bigger cars!
- No discrimination of vehicle segments
- VECTO must be the basis (cost effective improvement potential !)
- Component specific limits do not reflect cost effectiveness and thus to be rejected
- The heavy duty vehicle business is very dependent on economic cycles
- Improvements require long lead times
- ...
Summary and outlook

The heavy-duty truck industry in Europe is the leader in fuel economy – without any CO₂ regulation.

Within the last 8 years a tremendous progress has been made in the technology development of trucks and buses – reducing criteria pollutants and in parallel improving fuel economy.

Driven by TCO and competition the heavy-duty truck industry will continue to implement cost-effective technologies.

The EC simulation approach is the right way to go: simulating the fuel consumption of a specific vehicle by a robust and comparable procedure.

Europe should push other markets to adopt this simulation procedure as soon as possible.