COMMERCIAL VEHICLES, FUEL EFFICIENCY AND CO₂

Challenges & Possible solutions

IEA Freight Truck Fuel Economy Workshop
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ACEA Position

Fuel Efficiency is Market Driven

• Fuel efficiency is one of the most important competitive factors in developing and selling trucks and buses. Therefore, market forces ensure continuous progress in fuel economy and CO$_2$ emission reduction in the most efficient way.

• Our “Vision 2020” expects a 20% improvement of fuel efficiency by 2020 (compared to 2005) due to these market forces.

• Any product-oriented legal requirement regarding fuel efficiency and CO$_2$ emissions should aim to further strengthen these market forces.
Challenges with a regulatory approach

• Using the right metric for fuel efficiency
• Satisfying customers expectations on fuel efficiency
• The huge variety of complete heavy-duty vehicles
• Heavy-duty vehicles are often custom-built in several stages involving different manufacturers
• The high number of unique and different usage patterns
• Using test cycles that reflects actual vehicle usage
• The traditional use of the combustion engine is changing when operating in hybrid vehicles
Using the right metric for fuel efficiency

- "liter/100 km" is **not** a good fuel efficiency metric for commercial vehicles as it requires same duty cycles and vehicles with similar specifications.
- Metric based upon "Fuel Used/Work Done" is **more relevant**.
- "Work" with respect for transport of goods can be specified in "tonne-km" which focuses on the weight but as loading volume is becoming more important "cubic meter-km" is an option and for transport of people "passenger-km"

<table>
<thead>
<tr>
<th>GCW/GVW (ton)</th>
<th>Loading Capacity (ton)</th>
<th>Distance km</th>
<th>tonnekm</th>
<th>l/1000tonkm at 100% utilisation</th>
<th>CO2* g/tonkm at 100% utilisation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>URBAN DISTRIBUTION</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.5</td>
<td>1.5</td>
<td>100</td>
<td>150</td>
<td>80.0</td>
<td>210</td>
</tr>
<tr>
<td>7.5</td>
<td>4</td>
<td>100</td>
<td>400</td>
<td>35.0</td>
<td>92</td>
</tr>
<tr>
<td>12</td>
<td>7.2</td>
<td>100</td>
<td>720</td>
<td>23.6</td>
<td>62</td>
</tr>
<tr>
<td>18</td>
<td>11</td>
<td>100</td>
<td>1100</td>
<td>18.2</td>
<td>48</td>
</tr>
<tr>
<td><strong>LONG DISTANCE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>17</td>
<td>100</td>
<td>1700</td>
<td>13.5</td>
<td>36</td>
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<td>40</td>
<td>25</td>
<td>100</td>
<td>2500</td>
<td>12.0</td>
<td>32</td>
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<td>40</td>
<td>100</td>
<td>4000</td>
<td>10.0</td>
<td>26</td>
</tr>
</tbody>
</table>

*using the factor 2.63 to convert 1 litre diesel to kg CO₂
European goods transports on roads are characterized by:

- **High fuel prices**
- **High weights and volumes**
- **Relatively long distances**

Fuel efficiency has therefore since long been a 1\textsuperscript{st} priority because of its major impact on the Total Operating Costs.

**Challenges**
## Challenges

### Fuel consumption is a customer priority

<table>
<thead>
<tr>
<th>Western European Customers</th>
<th>Eastern European Customers</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rank</strong></td>
<td><strong>Criteria</strong></td>
</tr>
<tr>
<td>1</td>
<td>Reliability</td>
</tr>
<tr>
<td>2</td>
<td>Service quality</td>
</tr>
<tr>
<td>3</td>
<td>Fuel consumption</td>
</tr>
<tr>
<td>4</td>
<td>Spare part availability</td>
</tr>
<tr>
<td>5</td>
<td>Manufacturing quality</td>
</tr>
<tr>
<td>6</td>
<td>Safety</td>
</tr>
<tr>
<td>7</td>
<td>Mileage cost</td>
</tr>
<tr>
<td>8</td>
<td>Purchase price</td>
</tr>
<tr>
<td>9</td>
<td>TCO&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td>10</td>
<td>Down-times</td>
</tr>
</tbody>
</table>

Source: European Truck Customer 2010, Oliver Wyman Analysis  
2 TCO= Total cost of ownership
U.S. EPA has published performance requirements for Heavy-Duty vehicles.

Current European long-haul trucks have already better fuel efficiency** than the US 2017 target for long-haul Class 8 vehicles.

Compared to EPA 2010 baseline current European long-haul trucks show about a 30% better efficiency**.

*at 75% utilisation of loading capacity

** Recognising that difference in vehicle specification of long haul trucks is to the European advantage - 4x2 in Europe versus 6x4 in US and the location of the fifth wheel in US which results in a larger gap between cab and trailer
• Trucks and buses are often custom-built in several stages and adjusted to specific needs concerning load, driving patterns ...

• As there is an enormous variety of different vehicle designs and resulting payloads that have significant impact on CO₂ generation there are few uniform high-volume vehicle categories.

• This means that CO₂ emissions of trucks and buses cannot be addressed or influenced via one-size-fits-all policies.
Due to the importance of fuel efficiency, the performance of complete HD vehicles are evaluated as close as possible to their actual usage.
The World Transient Vehicle Cycle (WTVC)
The basis for evaluating air quality emissions from heavy-duty engines

The WTVC is not an appropriate cycle for specific vehicle configuration and mission deviating from the average one, therefore not recommended in a simulation to evaluate the fuel efficiency of complete vehicles in specific missions.
The role of the combustion engines will change when operating in hybrid vehicles.

**Parallel Hybrid**

- Combustion engine may be switched off for longer periods.

**Serial Hybrid**

- Engine operates principally as generator, which is very different from conventional engine operation.

This is the reason behind the OICA initiative to develop a certification procedure for **HD powertrains of HEVs with respect to NOx and PM**, based upon the Japanese HILS approach, as an annex to the existing WHDC GTR n°4 under the UN/ECE 1998 agreement.
1. Step 1: Labelling of the CO2 emissions from HDV engines as recorded by a standardised test procedure;

2. Step 2: Labelling of entire vehicles predicting the overall efficiency of a whole vehicle combination in operation.

3. Step 3: Labelling of vehicle components (such as superstructures, trailers and semi-trailers).

- Labelling of the fuel efficiency of tyres
- Revision of the Weights and Dimensions
- Market-Based Instruments
To satisfy a “labelling” (B2B) requirement ACEA promotes:

• The development of a method to calculate the fuel efficiency of complete heavy-duty vehicles **according to the “work done” principle** (g/tonkm, g/m3km or g/pass.km).

• Using **computer simulation**:  
  - allows a **large number of vehicle types** to be efficiently evaluated in **many different transport missions**.

• Using a **common** simulation tool:  
  - with **agree assumptions** and **specific input data generated by agreed methods** enables HDV manufacturers to provide the customers with a **certified declaration of fuel efficiency** for their different product offerings.

**A “Certified declaration of fuel efficiency” is the appropriate way to provide purchase guidance to professional customers**
ACEA organisation

WG-CO2HDV

TF1 Input Data and Validation
TF2 Scope and Mission
TF3 Simulation Tool
TF4 Green Public Procurement
TF5 CO2 Buses
ACEA and EUCAR developed a project proposal on a methodology to calculate fuel efficiency of HD Vehicles using computer simulation.

The project should:

- Define and develop **common metrics and methodologies**.
- **Matching vehicle classes** with missions and duty cycles.
- **Develop a tool** for calculating **fuel efficiency and CO₂ generation** of heavy-duty goods vehicles, buses and coaches.
Simulation tool

INPUT - VEHICLE MODULES

- Chassis or combination specification, weight
- Rolling resistance
- Air resistance
- Powertrain specification, hybrids
- Engine map
- Gear box
- ECO equipment
- COMMON CORE SIMULATION PROCESSOR

INPUT - TRANSPORT TASK MODULES

- Mission (Speed, Road, Load factors, Driver, Climate, Fuel, Traffic...)

- Input modules could be standardised, generic, or specific.
- With standardised interfaces to the core processor, input modules could be developed and improved over time.
- Transparent declaration of inputs and results.
- A tool generally available, (except with respect to proprietary data) to customers, manufacturers, authorities and researchers....

- **A tool that supports an integrated approach**
ACEA is supporting the development of two “demonstrators” for verifying the feasibility of the recommended approach. These “demonstrators” are based upon established simulation tools – **Autonomie** (ANL) and **CRUISE** (AVL).

In January 2011 Argonne National Laboratory released the “ACEA Demonstrator” on their website for download ([www.autonomie.net](http://www.autonomie.net)).

The “demonstrator” from AVL will be available in July 2011.
## Vehicle classes and missions

### ACEA proposal Vehicle segmentation trucks >= 7.49 t

<table>
<thead>
<tr>
<th>Axle configuration</th>
<th>Identification vehicle configuration</th>
<th>Class</th>
<th>Vehicle class</th>
<th>Cycle allocation</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 axles</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4x2</td>
<td>Rigid + (Tractor) 7.49t-10t</td>
<td>1</td>
<td>Long Haul</td>
<td>R/GVW</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>One daytrip</td>
<td>R/GVW</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>R/GVW</td>
<td>R/GVW</td>
</tr>
<tr>
<td></td>
<td>Rigid + (Tractor) &gt;10-12t</td>
<td>2</td>
<td>T/R+T/GCW</td>
<td>R/GVW</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>R/GVW</td>
<td>R/GVW</td>
</tr>
<tr>
<td></td>
<td>Rigid + (Tractor) &gt;12-16t</td>
<td>3</td>
<td>R/GVW</td>
<td>R/GVW</td>
</tr>
<tr>
<td></td>
<td>Rigid &gt;=16t</td>
<td>4</td>
<td>R+T/GCW</td>
<td>R/GVW</td>
</tr>
<tr>
<td></td>
<td>Tractor &gt;=16t</td>
<td>5</td>
<td>T/GCW</td>
<td></td>
</tr>
<tr>
<td>4x4</td>
<td>Rigid 7.49t-16t</td>
<td>6</td>
<td>T/GCW</td>
<td>R/GVW</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>R/GVW</td>
<td>R/GVW</td>
</tr>
<tr>
<td></td>
<td>Rigid &gt;=18t</td>
<td>7</td>
<td>R/GVW</td>
<td>R/GVW</td>
</tr>
<tr>
<td></td>
<td>Tractor &gt;=18t</td>
<td>8</td>
<td>T/GCW</td>
<td></td>
</tr>
<tr>
<td>3 axles</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6x2/2-4</td>
<td>Rigid all GVW</td>
<td>9</td>
<td>R+T/GCW</td>
<td>R/GVW</td>
</tr>
<tr>
<td></td>
<td>Tractor all GVW</td>
<td>10</td>
<td>T/GCW</td>
<td></td>
</tr>
<tr>
<td>6x4</td>
<td>Rigid all GVW</td>
<td>11</td>
<td>R+T/GCW</td>
<td>R/GVW</td>
</tr>
<tr>
<td></td>
<td>Tractor all GVW</td>
<td>12</td>
<td>T/GCW</td>
<td></td>
</tr>
<tr>
<td>6x6</td>
<td>Rigid all GVW</td>
<td>13</td>
<td></td>
<td>R/GVW</td>
</tr>
<tr>
<td></td>
<td>Tractor all GVW</td>
<td>14</td>
<td></td>
<td>T/GCW</td>
</tr>
<tr>
<td>4 axles</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8x2</td>
<td>Rigid all GVW</td>
<td>15</td>
<td></td>
<td>R/GVW</td>
</tr>
<tr>
<td>8x4</td>
<td>Rigid all GVW</td>
<td>16</td>
<td></td>
<td>R/GVW</td>
</tr>
<tr>
<td>8x6/8x8</td>
<td>Rigid all GVW</td>
<td>17</td>
<td></td>
<td>R/GVW</td>
</tr>
</tbody>
</table>

T = Tractor + Semitrailer  
R+T = Rigid + Body + Trailer  
R = Rigid + Body  
GVW = reference weight for FE simulation = vehicle individual GVW released by OEM but maximal up to legal limit (26 t for 3-axle rigid vehicle)  
GCW = reference weight for FE-simulation = vehicle individual GCW released by OEM but maximal up to legal limit (e.g. 40 t for 18t 4x2 Tractor or 60 t for 6x4 R+T)
### ACEA proposed cycles for truck >7.5 t GVW/GCW

<table>
<thead>
<tr>
<th>Vehicle cycle/mission</th>
<th>Description</th>
<th>Average yearly run distance (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long Haul</td>
<td>Delivery to international sites more than one day trip</td>
<td>135.000</td>
</tr>
<tr>
<td>One daytrip</td>
<td>Delivery to national/international sites on a 1 day trip.</td>
<td>115.000 (1 shift)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>160.000 (2 shifts)</td>
</tr>
<tr>
<td>Regional delivery/collection</td>
<td>Regional delivery from a central warehouse to local stores (innercity or suburban, also mountain road goods collection, …)</td>
<td>60.000</td>
</tr>
<tr>
<td>Urban delivery/collection</td>
<td>Distribution in cities or suburban sites of consumer goods from a central store to selling points.</td>
<td>40.000</td>
</tr>
<tr>
<td>Municipal utility</td>
<td>e.g. garbage trucks, road sweepers, …</td>
<td>25.000</td>
</tr>
<tr>
<td>Light off road- construction zone</td>
<td>Construction site vehicles on light mission (e.g. concrete mixers) 10% off-road</td>
<td>60.000</td>
</tr>
<tr>
<td>Off-road use - heavy off road</td>
<td>Construction site vehicles on heavy missions. 60% off-road</td>
<td>40.000</td>
</tr>
</tbody>
</table>
Drive cycles

Main target for drive cycles is to give **realistic** fuel consumption values for **all vehicle variants**. Therefore the cycles should be **defined as routes**.

This is the concept that most existing simulation tools have implemented.

Cycles could be created by **measurement of representative, real and long routes** and following **shortening process** with comparable slope, engine load and engine speed profiles. The length of routes depend on the vehicle classes.
Additional issues under evaluation

- Reference cycles for all truck and bus missions
- Fuel map certification process
- Determination of total vehicle drag
- Power consumption of auxiliaries
- Concept to cover control strategies
- General concept on trailers and bodies
Key factors for success

Develop a method to measure the fuel efficiency of complete heavy duty vehicle with sufficient precision.

“If you can’t measure it, you can’t manage it”

If it is not precise enough it will not guide customer and therefore not strengthen market forces

“Certified declaration of fuel efficiency” is also a validation activity of both the method and its precision
Possible solutions

ACEA objectives

Customer objective
by providing a
“Certified declaration of Fuel Efficiency”

Assist customers in choosing the optimal truck by quantifying relative fuel efficiency/CO2 of truck configuration/brand choices per application class

Authority objective
by supporting the development of a
“Computer tool capable of simulating an Integrated approach”

Enable monitoring and predicting effects of different road freight measures on fuel efficiency and CO2
Decoupling of CO2-emissions of road freight transport and economic growth can be achieved by an integrated approach.

Possible solutions

Integrated Approach

Road freight (2010)  Transport planning  Vehicle Operation  Road infrastructure  Alternative Fuels  New Vehicles  Road freight (2050)

-\%  -\%  -\%  -\%  -\%  -\%  -\%  -\%

- Improved logistic
- Freight consolidation
- Optimised packaging
- ...  
- Use higher capacity vehicles like the EMS
- Share Best Practices
- Improved utilisation
- Driver training
- Predictive driving
- ...
- Removal of bottlenecks
- Improved traffic flow (minimize stops)
- Telematic support
- ...  
- Biofuel mixing
- 2\textsuperscript{nd} and 3\textsuperscript{rd} generation biofuels
- ...
- Improved energy efficiency*
- ...

* Will also require changes of existing vehicle size and weight legislation
Low cost FE measures – ACEA survey

Chassis cab
- Biodiesel (B7+ advanced biofuels)
- Automatic gear shift logic
- Low rolling resistance tyres
- Super single

Body
- Aerodynamic improvements* – front, rear, side and top

Trailers
- Low rolling resistance tyres
- Super single
- Aerodynamic improvements* – front, rear, side, top and bottom
- Weight reduction

Vehicle usage
- Driver training
- Eco driving tool – Driver support
- Freight consolidation
- Higher capacity vehicles (Wider use of EMS)

Fuels
Fee/Tax related to the global warming potential of fuels

* Long haul
ACEA further supports

• Taking an integrated approach to further CO₂ emission reductions.

• Using cost-effectiveness as the basis for selecting policy measures for the different sectors.

• Studying the inclusion of road freight transport into an international, non-sector specific emission trading scheme.

• Pursuing globally harmonised policies for heavy-duty vehicles.
Vehicle manufacturers are already investing in new technologies to improve fuel efficiency and to reduce CO$_2$.

*Mercedes-Benz*  
H2 FC City Bus

*SCANIA*  
Ethanol Bus

*VOLVO*  
Hybrid Bus

*DAF*  
Hybrid Truck

*IVECO*  
Eurocargo Ibrido

*MAN*  
Hybrid Distribution Truck

Thank you for your attention!