PCRA/IEA - Workshop on Heavy-Duty Fuel Efficiency Regulations

The OEM view for India

Dr. Manfred Schuckert
Daimler – Automotive Regulatory Strategy
Head of Commercial Vehicles Emissions & Safety

PCRA/IEA - Workshop New Delhi - April 29th, 2015
HDV sector is a strongly cost-driven market

Fuel costs is the major driver in total cost of ownership (TCO) also in India

#1 Fuel cost: fuel price strongly influences cost of truck operation

- OEM are heavily motivated to address vehicles’ fuel consumption, as it is becoming more and more very important for customers
- When diesel prices come back to former levels, they will play an even more important role.
Effective regulation must strengthen market forces

Customer’s perspective is the key for real life improvements

#2 Vehicle operation: Knowledge of market, fleets and vehicle operation

Precondition for further emission reduction.
- Transparency and comparability of fuel consumption required
- Declaration of real-world Fuel Economy (FE) values
- Effective regulations need to be technologically neutral

Aspects to be considered

Vehicles:
- Operation
- Specific application depending on weight classes
- Use profiles (typical operation cycles)

Operators:
- Typical transportation companies
- Holding periods of vehicles
- Procurement of new/used vehicles?

Experiences from other markets

Customer Driven
(e.g. Europe today)

Regulation Driven
(e.g. Japan)

- Regulative framework should consider specific market conditions and real-world operations of haulers.
Upcoming changes of Indian economy to be considered

Transportation performance need to meet growing demands

#3 Market frame conditions: Population demands are growing together with economy

Transportation demands

- Economic growth goes in line with changing consumer behavior and demands of population

- Increasing and changing material flow and transportation of goods

Requirements to infrastructure

- Today’s road conditions result in low capacity of road network
- Has to improve - together with vehicle transportation performance

- Increase in transportation performance and average speed: improved emissions

- Growth of Indian’s Economy will change needs and behavior of population.
- To meet future needs, truck market and road freight transport will change clearly.
Transport Efficiency – backbone of developed countries

The World Bank Logistics Performance Index (LPI) – India placed on 54

Basis and categories of the ranking

LPI:

... assesses the performance of countries
... is based on a worldwide survey of multinational freight forwarders and main express carriers (scale 1-5)
... is an equally weighted average of six components

1. Customs: Efficiency of customs and border management clearance
2. Infrastructure: Quality of trade and transport infrastructure
3. Ease of arranging shipments: Ease of arranging competitively priced shipments
4. Quality of logistics services: Competence and quality of logistics services-trucking, forwarding, and customs brokerage
5. Tracking and tracing: Ability to track and trace consignments
6. Timeliness: Frequency with which shipments reach consignees within scheduled or expected delivery times

Ranking in 2014

Top Ten

- World Bank ranking confirms Europe highest logistic efficiency at competitive cost:
  Seven European countries under top ten – without any CO2-regulation for HDV

source: http://lpi.worldbank.org/international/global
Transport performance – each market is different
Contribution of vehicle fleet and usage of vehicles need to be known

#4 Segmentation CV fleet: Specific mileage and fuel consumption decisive for segment cycles

Segmentation
major influence on the overall CO₂ emissions of entire fleet:
- Specific mileage and fuel consumption
- Cycles within respective weight classes

Open questions:
- Where are the critical ‘hot spots’?
- Which segments contribute most?
- Which is the strongest lever for efficiency measures?

• In-depth knowledge about vehicle fleet and vehicle operation is a precondition to find out most effective measures to reduce fuel demand.
**HDV need a different CO₂ approach than pass. cars**

Variety of vehicle types and missions is tremendously higher

### Passenger cars: Entire vehicles

*Today:*

Measuring fuel consumption/CO₂ emissions on **roller test bench**

- Metrics in g CO₂/km
- Mercedes-Benz with some hundreds variants

- **Parameters:** weight, driving resistances
- **NEDC:** One driving cycle for pollutants and CO₂

### Trucks: Entire vehicles* and incomplete vehicles

*Today:*

- Emissions are measured on an engine test bench
- Widely diverse vehicle, wide range of GVW, built for resp. market
- Market specific metrics:
  - g CO₂/t km
  - g CO₂/t mile
  - km/l Diesel
  - I Diesel/km

- **Use specific driving cycles:**

  ![Driving cycles diagram](image)

- CO₂ emissions of trucks highly depend on design, use case and driving cycles.
- Any regulation must reflect these high variety to guarantee customer’s needs.

---

*Note: *HDV refers to Heavy Duty Vehicles.*
Addressing real world fuel consumption of a specific vehicle must be the aim of every cost-effective FC HDV regulation.

**Test method and measurement**

**Full vehicle approach**
(including spec. engine and trailer)

**Simulation tools**
allowing for flexible OEM input

**Fuel consumption test procedures**
affordable but robust

**Standardization**

**Mission specific**
vehicle segmentation and simulation

**Market specific**
test cycles incl. slope

- Simulation procedures should be defined in a way that real life fuel consumption and all (at least major) reduction technologies are reflected cost-effectively.
Overview on possible CO₂/fuel economy test methods
Approaches for Heavy Duty commercial vehicles

Characteristics and evaluation of test methods

<table>
<thead>
<tr>
<th>Approach</th>
<th>Road testing</th>
<th>Chassis dyno testing</th>
<th>Engine/ Power train testing</th>
<th>Component testing with FE simulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pros</td>
<td>• Measures complete vehicle</td>
<td>• Captures full drive train</td>
<td>• Less configurations to be tested</td>
<td>• Testing over multiple cycles</td>
</tr>
<tr>
<td></td>
<td>• Tech. innovations are captured</td>
<td>• Less complex method</td>
<td>• Less costly as chassis testing</td>
<td>• Results are repeatable and comparable</td>
</tr>
<tr>
<td>Cons</td>
<td>• Each vehicle to be tested</td>
<td>• Each vehicle type to be tested</td>
<td>• Additional component testing needed</td>
<td>• Most cost-effective method</td>
</tr>
<tr>
<td></td>
<td>• Results not comparable</td>
<td>• Additional component testing</td>
<td>• Very precise</td>
<td>• Detailed component testing</td>
</tr>
<tr>
<td></td>
<td>• Extremely costly</td>
<td>• Very costly</td>
<td>• Individual vehicle performance not covered</td>
<td>• Some technology innovations not (yet)covered</td>
</tr>
</tbody>
</table>

- Component testing with simulation of FE values is complex but most cost effective method, is repeatable, and can generate real-world FE values on a comparable basis.
GHG/FE test methods in place / planned

An overview

Test method application in major markets

<table>
<thead>
<tr>
<th>Approach</th>
<th>Road testing</th>
<th>Chassis dyno testing</th>
<th>Engine/ Power train testing</th>
<th>Component testing with FE simulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>In use / planned *</td>
<td>![Road testing image]</td>
<td>![Chassis dyno testing image]</td>
<td>![Engine/ Power train testing image]</td>
<td>![Component testing with FE simulation image]</td>
</tr>
</tbody>
</table>

- Limits based on Top Runner approach
- FE simulation only OEM specific drive train values
- Metric (km/l)
- Not all technologies considered
- Limits for vehicles & engines
- Default engine values for FE vehicle simulation → No real world figures
- FE simulation based on OEM data on only 5 technologies
- Chassis dyno test for “basic” vehicles – simulation for variants → high burden
- Specific technologies to improve FE difficult to integrate
- Measurement of components and full simulation of FE values
- Specific missions and cycles
- Proof of concept has shown high precision.

- EU approach is recommended: Simulated FE values match real-world consumption
- No expensive measurement method for each vehicle or type is needed.
Effectiveness of different classification & regulation principles
Japanese and Chinese regulations based on very different principles

**Japanese regulations**

<table>
<thead>
<tr>
<th>FES 2015</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Method:</strong> simulation, weighted JE 05 and highway cycle</td>
</tr>
<tr>
<td><strong>Variables:</strong> engine, transmission</td>
</tr>
<tr>
<td><strong>Vehicle:</strong> default values</td>
</tr>
<tr>
<td><strong>Limits:</strong></td>
</tr>
<tr>
<td><strong>Example:</strong> Rigid Truck &gt;20t GVW</td>
</tr>
<tr>
<td><strong>Example:</strong> Tractor &gt;20t GVW</td>
</tr>
</tbody>
</table>

* Unit of Japanese standard is km/l, values converted to l/km

**Chinese regulations**

<table>
<thead>
<tr>
<th>FC standard</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Method:</strong> simulation, C-WTVC Cycle</td>
</tr>
<tr>
<td><strong>Variables:</strong> engine, transmission, aerodynamic and tires variable</td>
</tr>
<tr>
<td><strong>Limits:</strong></td>
</tr>
<tr>
<td><strong>Example:</strong> Rigid Truck 20-25t GVW</td>
</tr>
<tr>
<td><strong>Example:</strong> Tractor 27-35t GVW</td>
</tr>
</tbody>
</table>

** Japan max. GVW for Rigid Trucks: 25t - compared values to corresponding Chinese segment 20-25t GVW
*** Japan max. GVW for Tractors: 36t - compared values to corresponding Chinese segment 27-35t GVW

- Different premises and regulations regarding CO₂ emissions with significant effects on vehicles.
- Setting default values may result in large deviations from ‘real world’ conditions.
Assessment of existing CO₂ standards

Critical issues and consequences

Critical aspects in existing legislations

- Engine separately considered
- Only 5 technologies chosen to include specific data
- Only drivetrain considered
- Metrics not suited to compare transport service efficiency
- Considering „basic vehicle version“ but no specific configurations and technologies
- Only one drive cycle applied

Consequences

- Fuel consumption displaying no real values
- Specific technologies to improve FE not considered
- Optimized use of reduction potential of each technology not possible
- No technology neutrality

Engineering effort would not focus on real condition → customer disadvantage

- Engineering optimization must focus on meeting regulatory performance requirements.
- Customers are confronted with sub-optimized fuel consumption under real world conditions.
Starting Point: Main components as starting point

Key measures to improve fuel economy in the long haul segment

<table>
<thead>
<tr>
<th>Aerodynamics</th>
<th>Engines</th>
<th>Tires and wheels</th>
<th>Various</th>
<th>Trailer</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Aerodynamics" /></td>
<td><img src="image" alt="Engine" /></td>
<td><img src="image" alt="Tires and wheels" /></td>
<td><img src="image" alt="Various" /></td>
<td><img src="image" alt="Trailer" /></td>
</tr>
</tbody>
</table>

- **Cd**
- **E**
- **Cr**
- **weight**
- **Cd**

* 40 t long haul, highway

Various components need to be considered to improve fuel consumption, but improvements very dependent on vehicle segment and use.
# Introduction of Euro IV SCR technology for India

Possible short-term measure with 3 to 4% improvement (EU experience)

**#1 Engine:** introduction of Euro IV SCR technology – easy to implement and highly effective

<table>
<thead>
<tr>
<th>Status today</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
<th>...</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Euro III</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Euro IV</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Euro V</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Euro IV nationwide to be implemented in India by 2017.
- At the latest with Euro V all manufacturers will likely be on SCR-technology
Influence of tires in fuel consumption measurement of HDVs

Outlook in tire development (EU boundaries)

#2 Tires: Rolling resistance with major impact on fuel consumption

- 10% improvement of rolling resistance results in 2.7% fuel efficiency improvement for the entire long haul vehicle – influence depending on selected cycle (driven speed).*
- Constant improvement in rolling resistance of tires with focus on improvements.

* calculated for European long-haul and distribution traffic cycle
EU: Introduction of VECTO and CO2 monitoring

Simulation based CO₂ declaration approach

ACEA Whitebook

Europe

Procedure developed in cooperation of EU, OEM/ACEA, TU Graz

- Entire vehicle approach
- Mission specific cycles (based on real routes)
- Real world fuel consumption
- Certified input data from OEM

Method fulfills customer’s and legislator’s needs

Generates realistic FE values with affordable effort

- There are 3 major pillars of a simulation based CO₂ declaration method:
  - certified OEM input data, representative boundary conditions and VECTO
There are 3 major pillars of a simulation based CO₂ declaration method:
- certified OEM input data, representative boundary conditions and VECTO
Adaption of long-haul cycle to real-world routes

ACEA initiated cycle validation activity for the long-haul cycle

The concept: Ensure realistic and representative cycle characteristics (slopes and speeds)

1. **Derive representative routes** for European long-haul road network based on statistical data

   • Selection criteria
     - geographical coverage,
     - traffic load
     - mountainous sections (Alps, Pyrenees)
   • 44 axes in total

2. **Measurement of slopes and speed profiles** on representative routes (>25,000 km)

3. **Compare speed and slope characteristics** with long-haul cycle. Make adoptions if needed.

   • Representative routes show lower slope profile than ACEA cycle
Simulation results vs. real measurement:

EC-simulation approach finalized with promising results

**Input Data used for simulation tool**

**Engine**
- steady-state fuel map with correction factor according CVD proposal (long-haul part of WHTC)

**Axle & Transmission**
- Full loss map at reference temperature of 60°C (according expert group proposals)

**Air drag**
- Determined by constant speed tests, evaluated according expert group proposals

**Shifting and acceleration/deceleration**
- ACEA proposals incl. early upshift and gear skipping

**Tire**
- Official label values with ACEA proposal for axle load shares

**Weight**
- According ACEA proposal

**Results simulation vs. real traffic**

**Simulation tool VECTO validated by road testing**

- Step 1: VECTO simulation tool validation
- Step 2: CO2 validation on constant speed
- Step 3: CO2 validation on real roads under real traffic conditions

**Route**
- Used for CO2 validation is comparable to ACEA cycle and typical standard application.

"Route" used for CO2 validation is comparable to ACEA cycle and typical standard application.

< 3% deviation

- EC measurements and simulations clearly show: a simulation based certification process gives realistic, reliable and reproducible results.
Full vehicle approach can become a blueprint for international harmonization of fuel consumption measurement of HDVs

**International harmonization of cycles, methods and simulation tool**

- **Cycle Definition**
- **Measuring Methods / Test Procedures**
  - UN-ECE: Aerodynamics, Tires, Fuel Maps
- **Simulation Tool**
  - Simulation tool (provided by legislative bodies)

**Cycles, depending on use-cases (missions)**
- Regional
- National

**Segmentation**
- with regional/national differences

- World-wide standards for measurement of HDV fuel consumption need to be developed.
- Regional aspects need to be taken into account (world-wide simulation/regional test cycles/vehicles/...)

*Application of internationally harmonized standards as basis for specifically required characteristics*
### Conclusion

<table>
<thead>
<tr>
<th>Recommendation for next steps</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Build-up knowledge regarding fleets and vehicle operation and reflect rapidly changing environment</td>
</tr>
<tr>
<td>• Develop simulation tool and cycles (‘Indian VECTO’)</td>
</tr>
<tr>
<td>• Stick to introduction dates of Euro IV (and later to Euro V) – it will reduce HDV fuel consumption</td>
</tr>
<tr>
<td>• Reflect tire improvement processes</td>
</tr>
</tbody>
</table>