DAIMLER

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

The OEM view for India

Mercedes-Benz FREIGHTLINER FUSO WESTERN STAR Thomas BUILT BUSES BHARATBENZ

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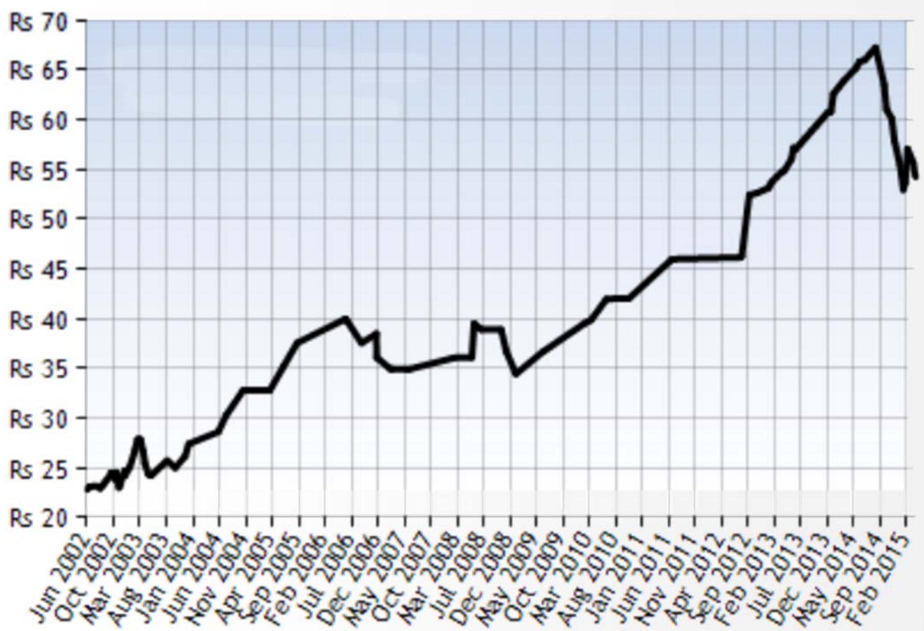
HDV sector is a strongly cost-driven market

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

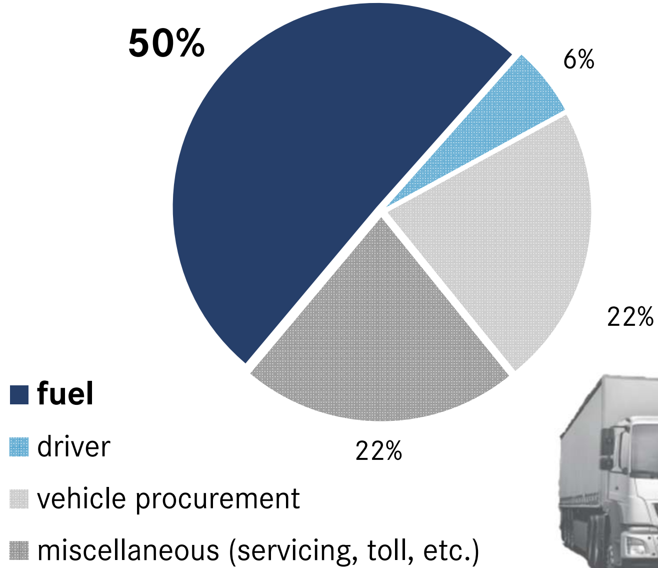
#1 Fuel cost: fuel price strongly influences cost of truck operation

History of Diesel fuel price (Mumbai)



Source: http://www.mypetrolprice.com/diesel-price-chart.aspx

TCO India



Rising oil and fuel prices and decreasing subsidies will result in even higher share of fuel cost within TCO

- **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:

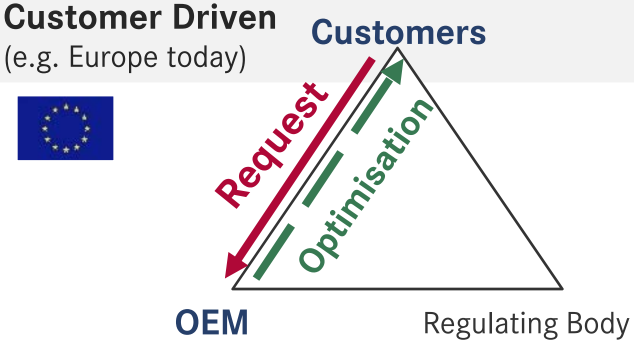
- Operation
- Specific application depending on weight classes
- Use profiles (typical operation cycles)

Operators:

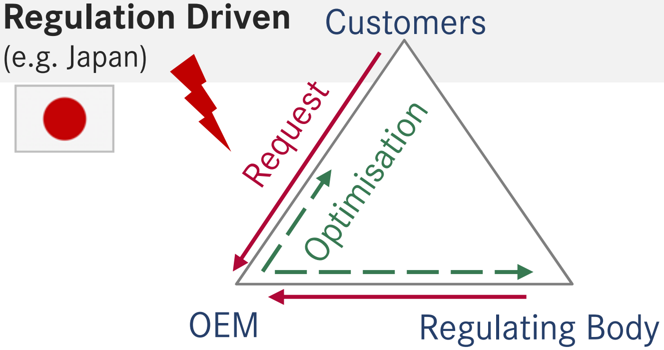
- Typical transportation companies
- Holding periods of vehicles
- Procurement of new/used vehicles?

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

relevant for CO_2 regulations

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

relevant for CO_2 regulations

Ranking in 2014

Top Ten

Country	Year	LPI Rank	LPI Score	International shipments
Germany	2014	1	4.12	3.74
Netherlands	2014	2	4.05	3.64
Belgium	2014	3	4.04	3.80
United Kingdom	2014	4	4.01	3.63
Singapore	2014	5	4.00	3.70
Sweden	2014	6	3.96	3.76
Norway	2014	7	3.96	3.42
Luxembourg	2014	8	3.95	3.82
United States	2014	9	3.92	3.45
Japan	2014	10	3.91	3.52
Ireland	2014	11	3.87	3.44
Canada	2014	12	3.86	3.46
France	2014	13	3.85	3.68
Switzerland	2014	14	3.84	3.58
Hong Kong,	2014	15	3.83	3.58
…				
Malaysia	2014		3.59	
Portugal	2014	26	3.56	3.43
United Arab Emirates	2014	27	3.54	3.20
China	2014	28	3.53	3.50
Qatar	2014	29	3.52	3.55
Turkey	2014	30	3.50	3.18
Poland	2014	31	3.49	3.46
Czech			[illegible]	3.59
…				
Malta	2014	51	3.11	
Bahrain	2014	52	3.08	
Indonesia	2014	53	3.08	2.87
India	2014	54	3.08	2.72
Croatia	2014	55	3.05	2.95
Kuwait	2014	56	3.01	2.69
Philippines	2014	57	3.00	3.00
Cyprus	2014	58	3.00	2.88

source: http://lpi.worldbank.org/international/global

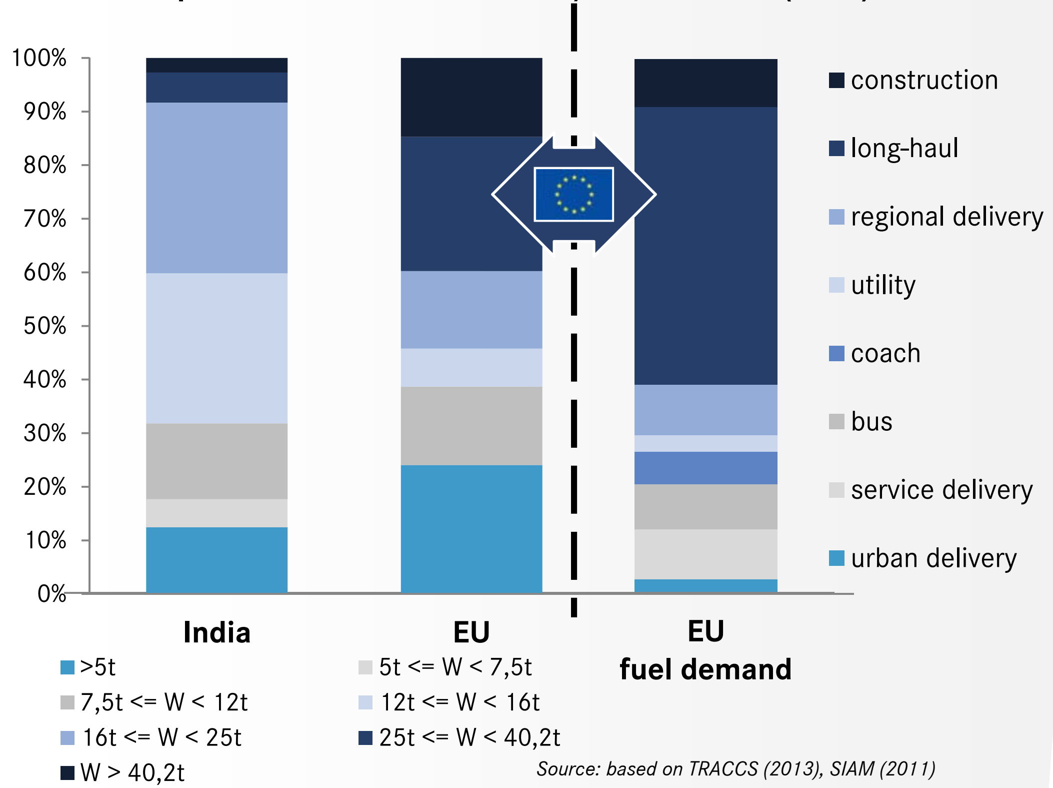
- **World Bank ranking confirms Europe highest logistic efficiency at competitive cost: Seven European countries under top ten – without any CO2-regulation for HDV**

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

Comparison of India and EU MDV/HDV markets (2010)



Source: based on TRACCS (2013), SIAM (2011)

Segmentation

major influence on the overall CO_2 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 CO_2 approach than pass. cars

Variety of vehicle types and missions is tremendously higher

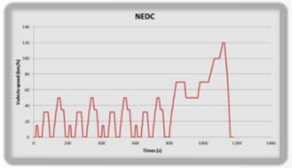
Passenger cars: Entire vehicles

Today:

Measuring fuel consumption/ CO_2 emissions on **roller test bench**

- Metrics in g CO_2/km
- Mercedes-Benz with some hundreds variants

- **Parameters: weight, driving resistances**
- **NEDC:** One driving cycle for pollutants **and** CO_2



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 CO_2/t km

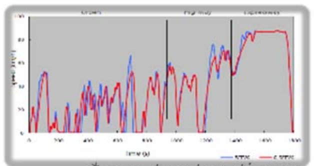
g CO_2/t mile

km/l Diesel

l Diesel/km

more than 4.500 variants of Mercedes-Benz Trucks

- Use **specific** driving cycles:



* e.g. tractor, tipper

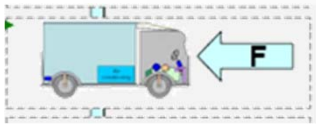
- **CO_2 emissions of trucks highly depend on design, use case and driving cycles.**
- **Any regulation must reflect these high variety to guarantee customer's needs.**

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)

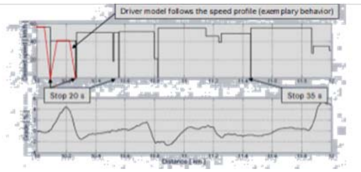
Simulation tools
allowing for flexible OEM input



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 leat major) reduction technologies are reflected cost-effectively**

Overview on possible CO_2/fuel economy test methods

Approaches for Heavy Duty commercial vehicles

Characteristics and evaluation of test methods

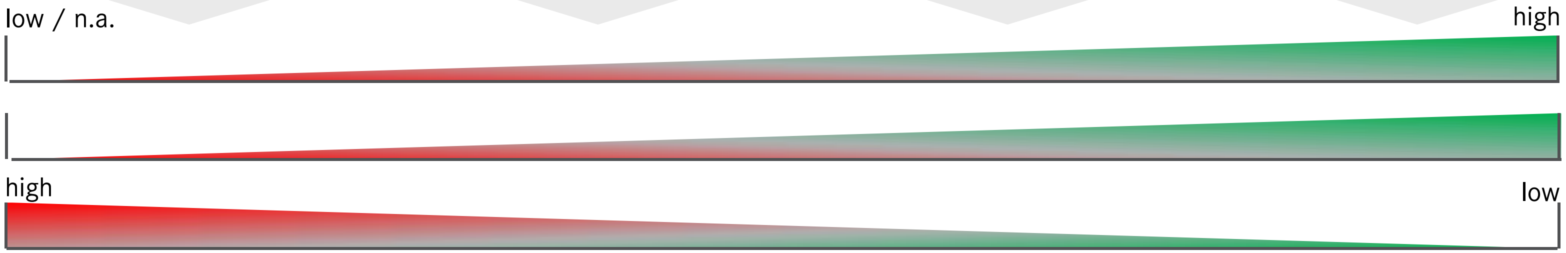
	Road testing	Chassis dyno testing	Engine/ Power train testing	Component testing with FE simulation
Approach				
Pros	• **Measures complete vehicle** • **Tech. innovations** are captured	• **Captures full drive train** • **Less complex** method	• **Less** configurations **to be tested** • **Less costly**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

Level of...

Simulation

Comparability

Costs



- **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

Approach

Road testing

Effort extremely high, not feasible!

Chassis dyno testing

Engine/ Power train testing

Component testing with FE simulation

In use / planned *

- 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.

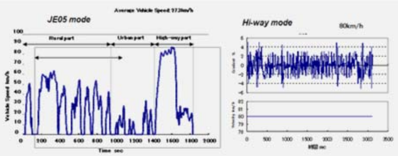
- **EU approach is recommended: Simulated FE values match real-world consumption**
- **No expensive measurement method for each vehicle or type is needed.**

Effectiveness of different classification & regulation principles

Japanese and Chinese regulations based on very different principles

Japanese regulations

FES 2015



Method: **simulation, weighted JE 05 and highway cycle**
Variables: **engine, transmission**
Vehicle: **default values**

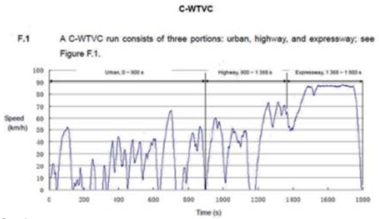
Limits:
Example: **Rigid Truck >20t GVW** **24.75** l / 100km*

Example: **Tractor >20t GVW** **49.75** l / 100km*

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

Chinese regulations

FC standard



Method: **simulation, C-WTVC Cycle**
Variables: **engine, transmission aerodynamic and tires variable**

Limits:
Example: **Rigid Truck 20-25t GVW** **37.5** l / 100km**

Example: **Tractor 27-35t GVW** **38.0** l / 100km***

** *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 CO_2 emissions with significant effects on vehicles.**
- **Setting default values may result in large deviations from 'real world' conditions.**

Assessment of existing CO_2 standards

Critical issues and consequences

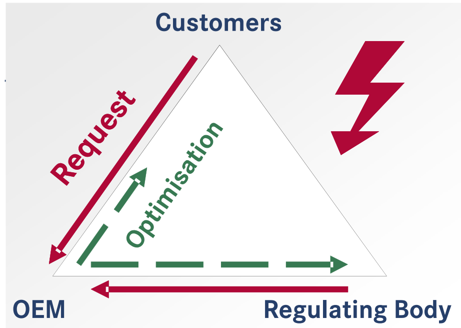
Critical aspects in existing legislations

- 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

Critical Situation



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**

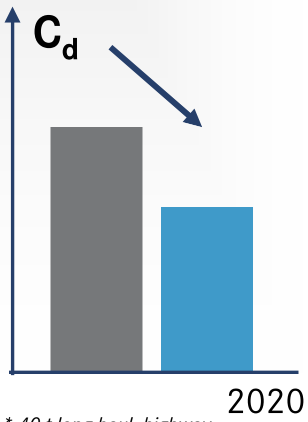
Engineering effort would not focus on real condition
*→ **customer disadvantage***

- **Engineering optimization must focus on meeting regulatory performance requirements.**
- **Customers are confronted with sub-optimized fuel consumption under real world conditions.**

Starting Point: Main componenets as starting point

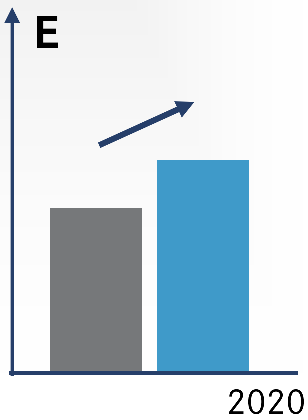
Key measures to improve fuel economy in the long haul segment

Aerodynamics

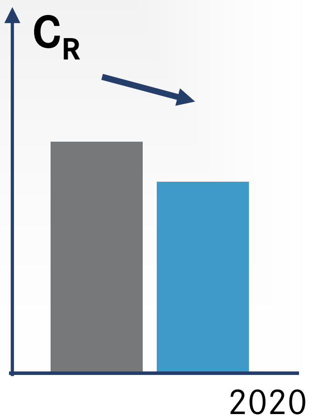


* 40 t long haul, highway

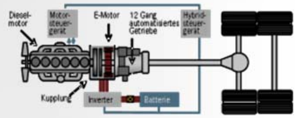
Engines



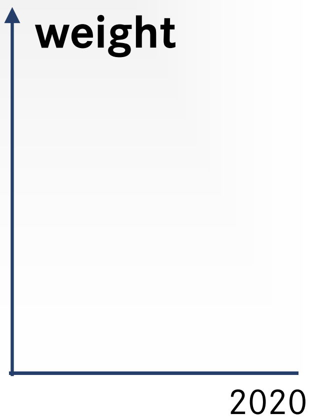
Tires and wheels



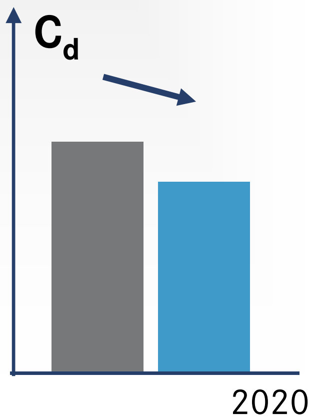
Various



Light weighting
Transmission
Management
…



Trailer

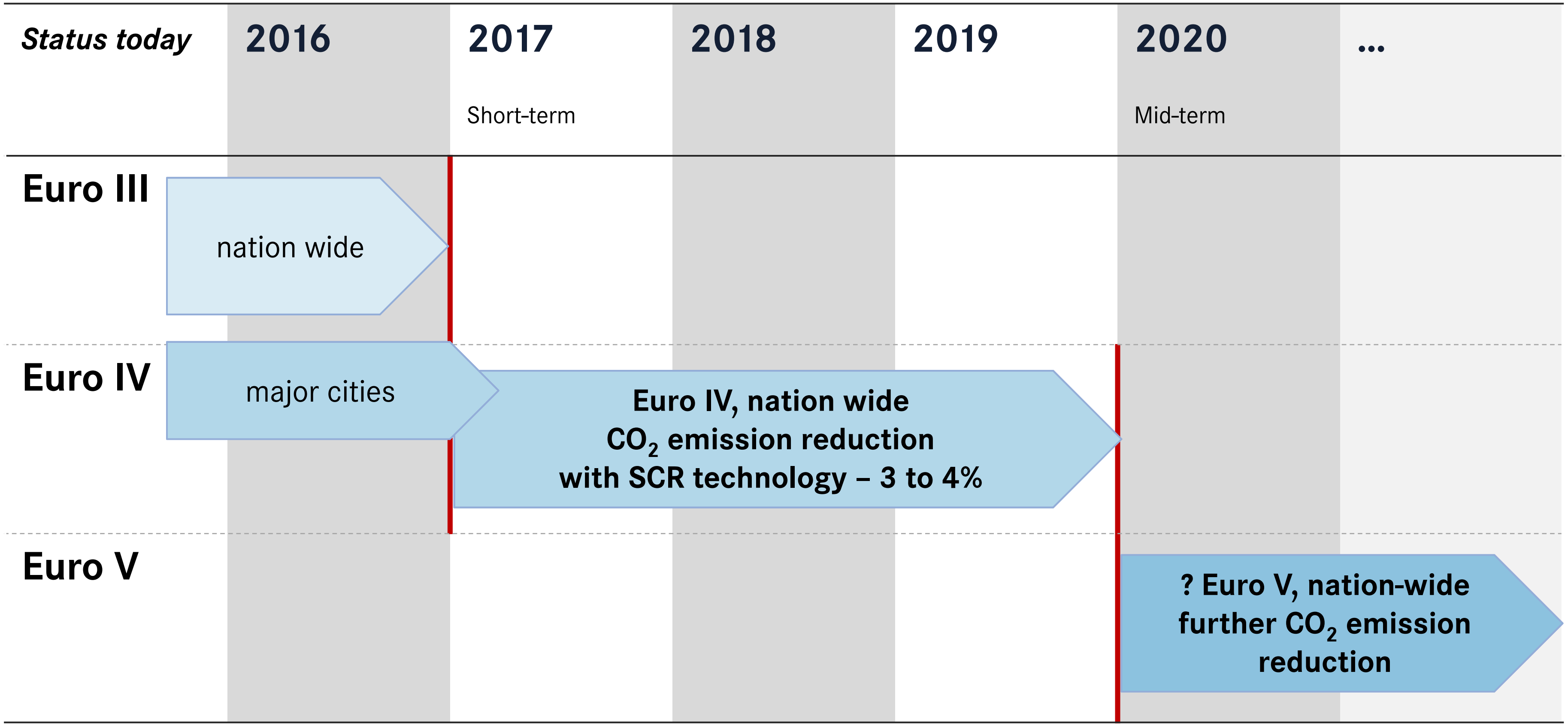


Various components need to be considered to improve fuel consumption, but improvements very dependent on vehicle segment and use.

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

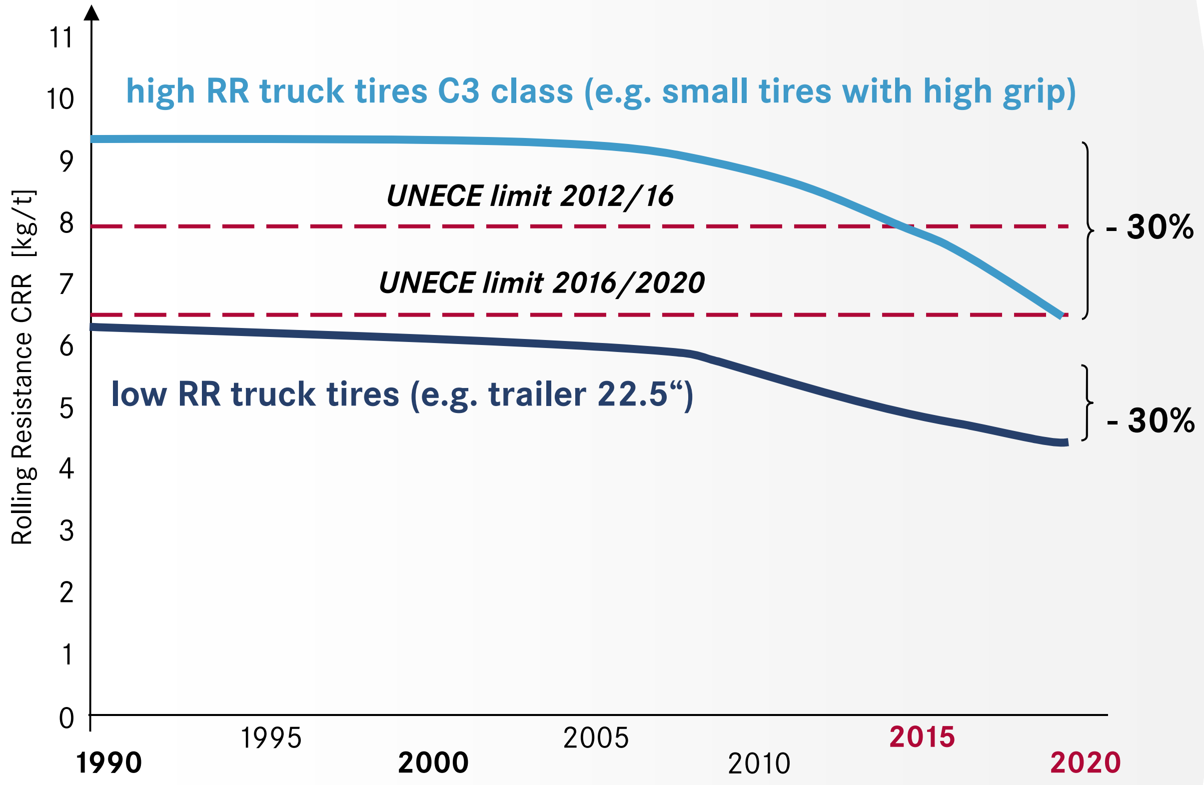


- **Euro IV nationwide to be implemented in India by 2017.**
- **At the latest with Euro V all manufacturers will likely be on SCR-technology**

Influence of tires in fuel consumption measurement of HDVs

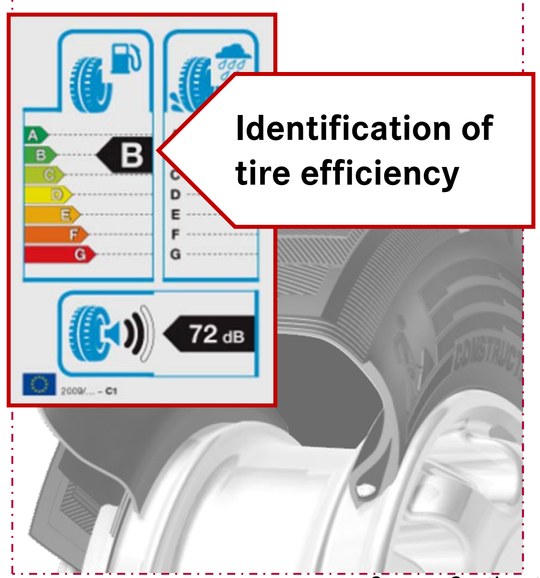
Outlook in tire development (EU boundaries)

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



European Tire Labeling
for customer information

Tire-labeling regulation (EC) 1222/2009:
all tires* **produced after June 2012** and on sale in the EU **from November 2012**



Source: Continental

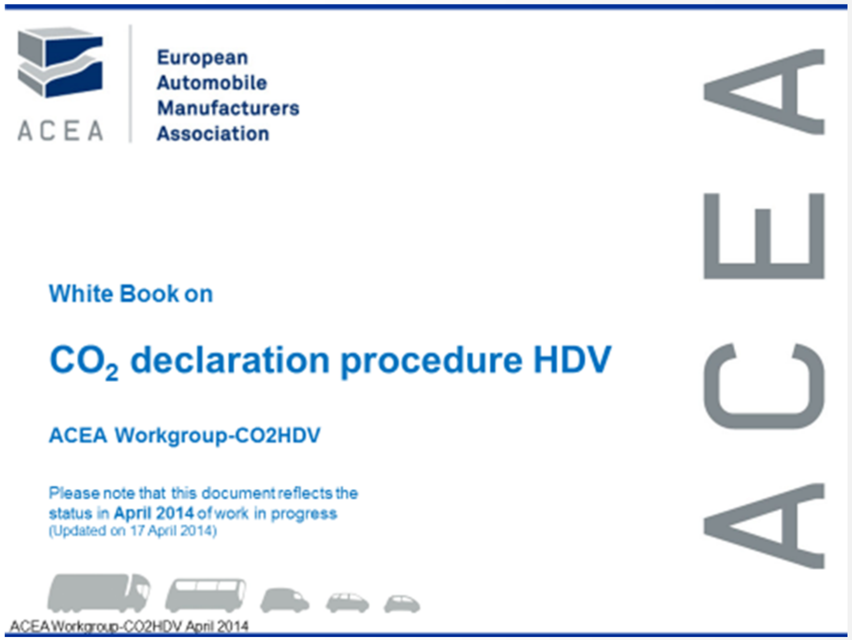
- **10% improvement of rolling resistance results in 2.7% fuel efficiency improvement for the entire long haul vehicle – influence depending on selected cycle (driven speed).***
- **Constant improvement in rolling resistance of tires with focus on improvements.**

* *calculated for European long-haul and distribution traffic cycle*

EU: Introduction of VECTO and CO2 monitoring

Simulation based CO_2 declaration approach

ACEA Whitebook



European Automobile Manufacturers Association

ACEA

White Book on

CO_2 declaration procedure HDV

ACEA Workgroup-CO2HDV

Please note that this document reflects the status in April 2014 of work in progress
(Updated on 17 April 2014)

ACEA Workgroup-CO2HDV April 2014

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 CO_2 declaration method:**
- **certified OEM input data, representative boundary conditions and VECTO**

Simulation based CO_2 declaration approach

+ Benefits by ECO-features

CO_2 values

Pillar 1: Vecto simulation tool

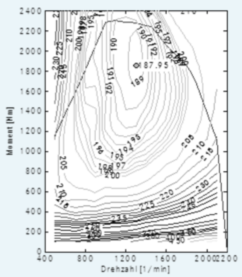
VECTO Vehicle Energy Consumption Calculation Tool

European Commission | JRC

IVT

TU Graz

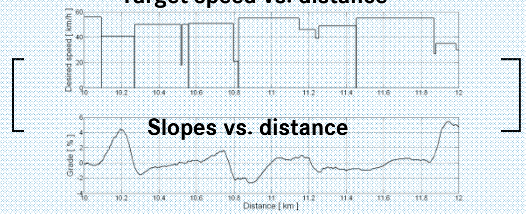
Pillar 2: Certified input data from OEM



Certified driving resistances	Certified engine fuel map	OEM specifics (Weight, ratios, ...)

Pillar 3: Representative boundaries implemented in simulation tool

Cycles for each vehicle class



Trailer / body specification

Metrics

Weight definition

There are 3 major pillars of a simulation based CO_2 declaration method:

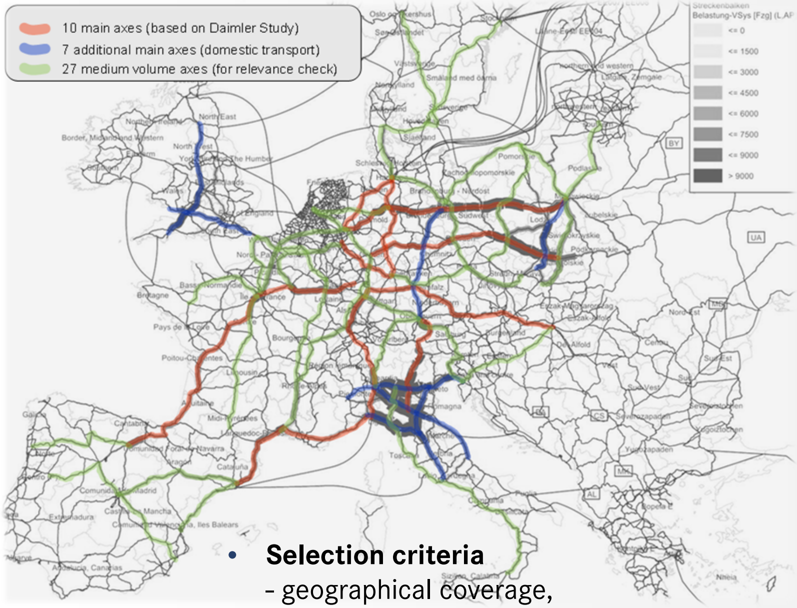
- **certified OEM input data, representative boundary conditions and VECTO**

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)

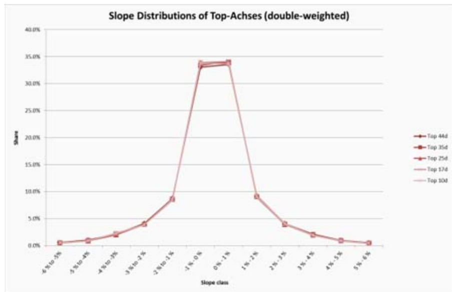
1. **Derive representative routes** for European long-haul road network based on statistical data



- **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 adaptions if needed.



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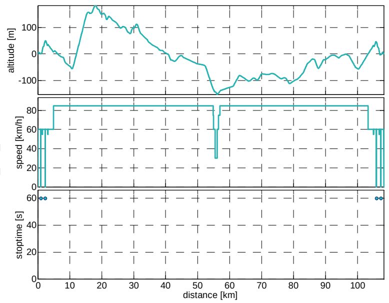


✓

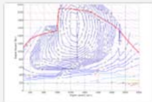
- **Representative routes show lower slope profile than ACEA cycle**

Simulation results vs. real measurement:

EC-simulation approach finalized with promising results

Input Data used for simulation tool

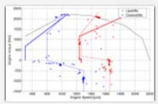
Engine
steady-state fuel map with correction factor according CVD proposal (long-haul part of WHTC)



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



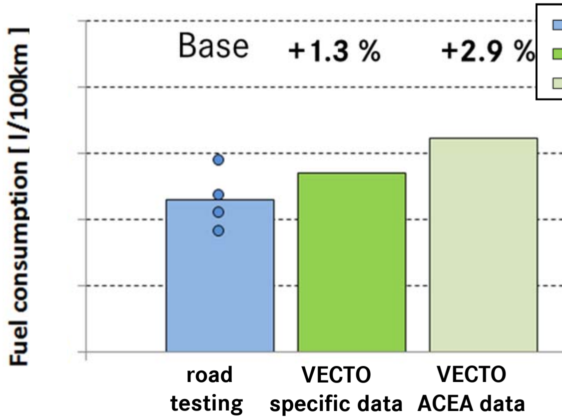
Tire
Official label values with ACEA proposal for axle load shares

Weight
According ACEA proposal

Results simulation vs. real traffic

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

Simulation tool VECTO validated by road testing



Route

"Route" used for CO_2 validation is comparable to ACEA cycle and typical standard application.

< 3% deviation

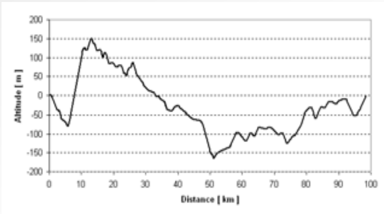
- **EC measurements and simulations clearly show: a simulation based certification process gives realistic, reliable and reproducible results.**

Full vehicle approach can become a blueprint for international harmonization of fuel consumption measurement of HDVs

International harmonization of cycles, methods and simulation tool

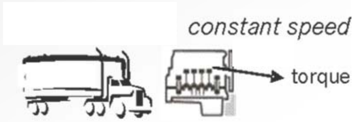
Cycle Definition

Slope
Load



Measuring Methods / Test Procedures

UN-ECE:
Aerodynamics
Tires
Fuel Maps



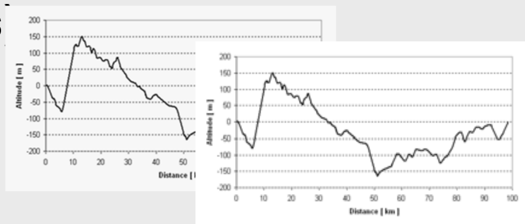
Simulation Tool

Simulation tool
(provided by legislative bodies)

Application of internationally harmonized standards as basis for specifically required characteristics

Cycles, depending on use-cases (missions)

Regional
National



Segmentation

with regional/ national differences

City delivery	
Delivery / communal	
Heavy delivery	
Long haul	
One Overnight	
On-road construction	
Heavy construction	

- **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/...)

Conclusion

Recommendation for next steps

- **Build-up knowledge regarding fleets and vehicle operation and reflect rapidly changing environment**
- **Develop simulation tool and cycles (‘Indian VECTO’)**
- **Stick to introduction dates of Euro IV (and later to Euro V) – it will reduce HDV fuel consumption**
- **Reflect tire improvement processes**