Heavy-duty vehicle fuel economy policies and opportunities

Drew Kodjak and ICCT heavy-duty vehicle team

GFEI Global Networking Meeting
UNESCO Annex, 1 rue Miollis
9 – 10 June, 2016
Paris France

THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

Key messages

1. To date, only four countries have adopted fuel economy standards for heavy-duty vehicles
2. Globally, energy consumption from heavy-duty trucks and buses is nearly equivalent to passenger vehicles.
3. While the vehicle segment is diverse, a small number of vehicle types dominate fuel consumption in each market (e.g., tractor trailers, straight trucks, delivery trucks).
4. Given high fuel consumption, heavy-duty vehicles are extremely attractive targets for policy action as fuel savings offset increases in technology costs.
5. Key regulatory elements have already been developed – regulatory design, test cycles and protocols, simulation models – thus paving the way for accelerated policy adoption.

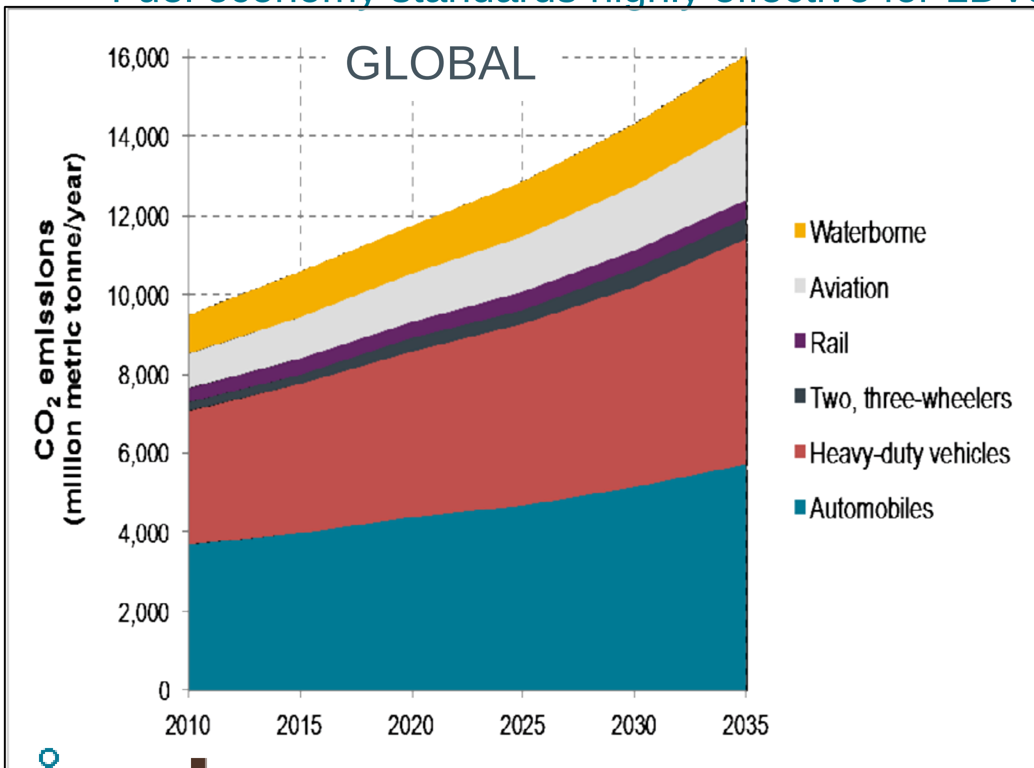
Global context

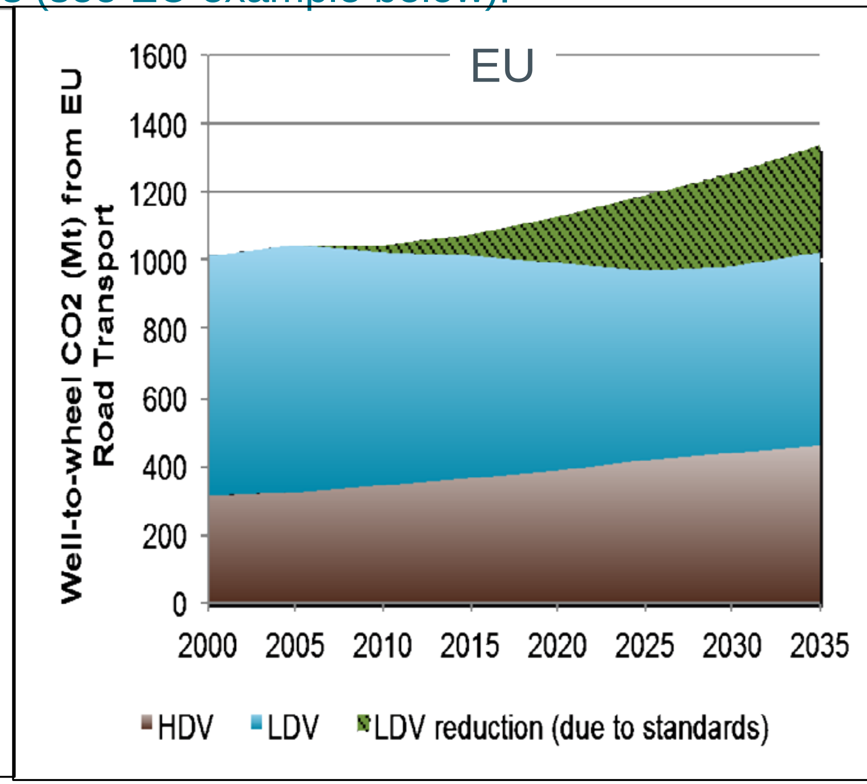
Inventories

Policy landscape

Growing Importance of HDVs

- Growth in HDV energy use forecast at 72% increase 2010-2030 outstripping other modes.
- HDVs responsible for approximately 45% of on-road CO2 emissions over the next 35 years,
- Current LDV efficiency standards cover over 83% of global sales with only 47% of sales are covered for HDVs policies.
- Fuel economy standards highly effective for LDVs (see EU example below).





Source: The ICCT Roadmap Model (2014)

icct
THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

HDV Global Fuel Efficiency Standards Landscape

- Four countries in the world currently have HDV CO2/efficiency standards (10 countries/regions have LDV standards)
- Standards are not harmonized or equivalent (differences include stringency levels, segments covered, technologies covered, simulation models)

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Japan				**Phase 1**										**Phase 2**
U.S.			**Phase 1**					**Phase 2**						
Canada			**Phase 1**					**Phase 2**						
China	**Phase 1**		**Phase 2**						**Phase 3**					
EU						**Certification, Monitoring, Reporting**								
India									**Phase 1**					
Mexico									**Phase 1**					
S.Korea									**Phase 1**					

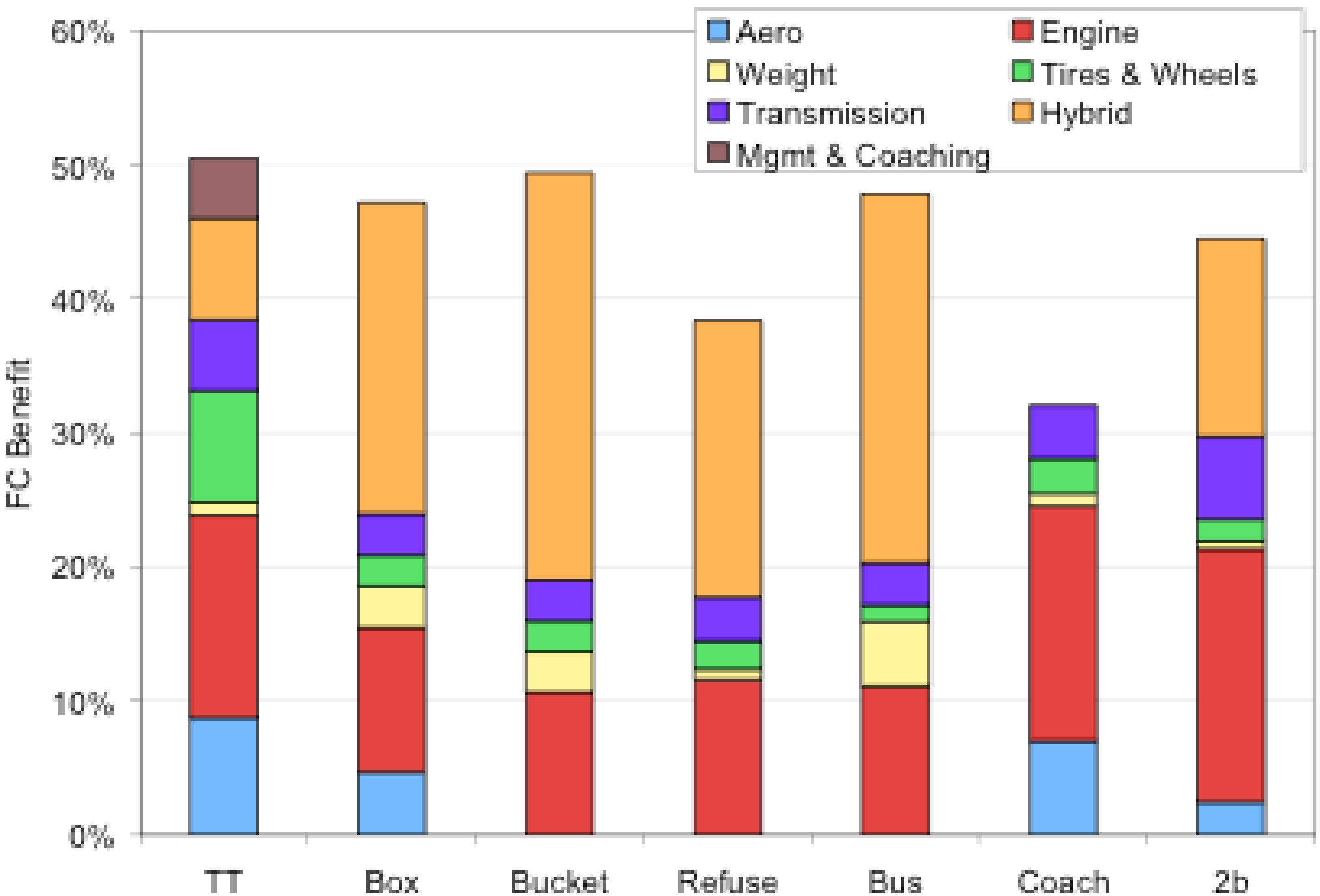
Hashed areas represent unconfirmed projections of the ICCT

Case study

U.S. & Canada HDV GHG rules

Foundational Research for U.S. HDV GHG Regulations:

National Academy of Sciences Report found 35 – 50% improvement could be achieved in the 2015 to 2020 timeframe.



National Academy of Sciences (2010) FIGURE S-1 Comparison of 2015-2020 New Vehicle Potential Fuel Savings Technology for Seven Vehicle Types: Tractor Trailer (TT), Class 3-6 Box (Box), Class 3-6 Bucket (Bucket), Class 8 Refuse (Refuse), Transit Bus (Bus), Motor Coach (Coach), and Class 2b Pickups and Vans (2b). Also, for each vehicle class, the fuel consumption benefit of the combined technology packages is calculated as follows: % FCpackage = 1 – (1 - %FCtech 1)(1 - %FCtech2)(1 - %FCtech N) where %FCtech x is the percent benefit of an individual technology. SOURCE: TIAX (2009) ES-4.

icct THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

Strategy: Prioritize Vehicle Segments with High Fuel Use

Class 7/8 Tractors

Class 2B/3 Pickup Trucks and Vans

Everything Else!

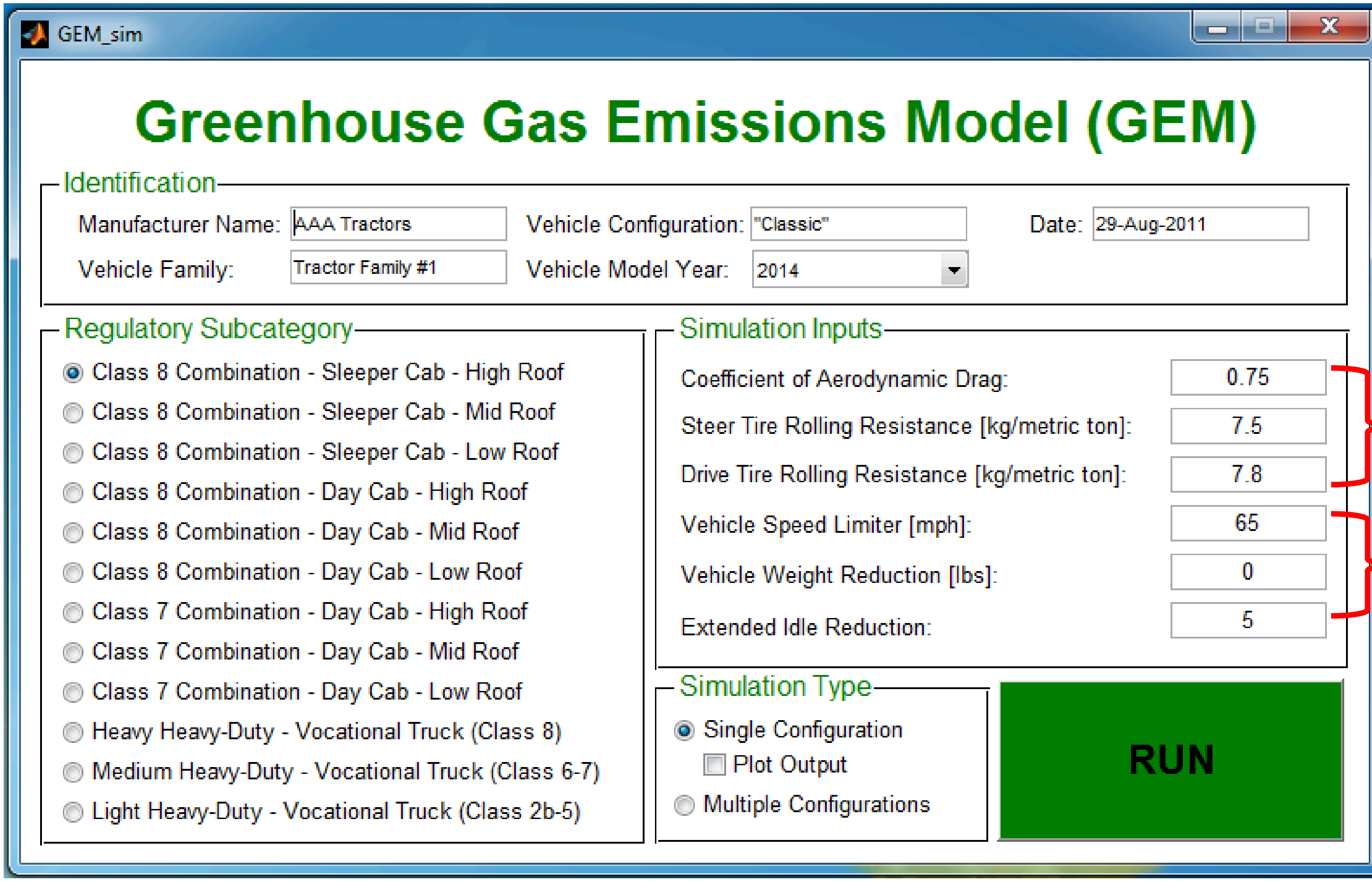
US program is 4 rules bundled together: Engine, Tractor, Vocational, Pickups and Vans.

Vehicle Type	Subclass		Engine	Vehicle only	Vehicle + Engine
Tractors	Day Cabs	Class 7 Low/mid Roof	6%	4%	10.3%
		Class 7 High Roof	6%	7%	13.0%
		Class 8 Low/mid Roof	6%	3%	9.1%
		Class 8 High Roof	6%	8%	13.6%
	Sleeper	Class 8 Low Roof	6%	12%	17.5%
		Class 8 Mid Roof	6%	12%	18.0%
		Class 8 High Roof	6%	17%	23.4%
Vocational	Light HD	Class 2b - 5	9%	0%	8.6%
	Medium HD	Class 6 - 7	9%	0%	8.9%
	Heavy HD	Class 8	5%	1%	5.9%
Pickups & Vans	Gasoline				12.0%
	Diesel				17.0%

Largest reductions – and regulatory attention – focus on the vehicle categories that use the most fuel. In HD sector, combination tractors and pickup trucks use about 70% of the fuel.

icct THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

Compliance Example: U.S. Simulation Tool



Determined by testing

“yes/no” parameters

THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

Compliance Example: Tractor Trailer

"Classic" style

Drag inducing features: flat grill and bumper, protruding elements

Frontal area

Drag coefficient

Step 1: coastdown testing to determine $C_d * A$

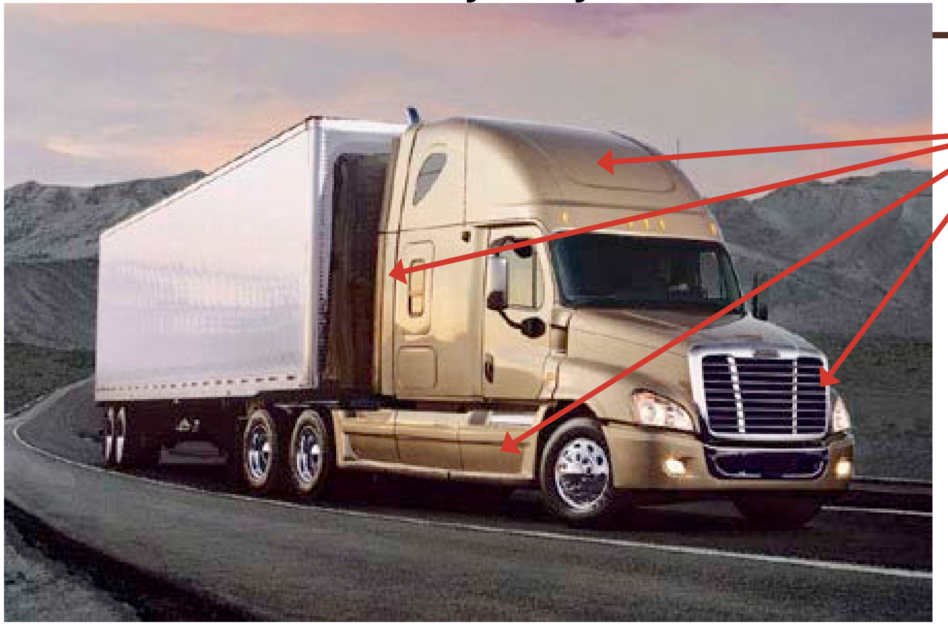
$C_d * A = 7.7$ → this tractor belongs to "Bin I"

	Class 7	Class 8	
	Day Cab	Day Cab	Sleeper Cab
	High Roof	High Roof	High Roof
Aerodynamic Test Results (C_dA in m^2)			
Bin I	≥ 8.0	≥ 8.0	≥ 7.6
Bin II	7.1 – 7.9	7.1 – 7.9	6.7 – 7.5
Bin III	6.2 – 7.0	6.2 – 7.0	5.8 – 6.6
Bin IV	5.6 – 6.1	5.6 – 6.1	5.2 – 5.7
Bin V	≤ 5.5	≤ 5.5	≤ 5.1

icct THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

Compliance Example: Tractor Trailer

"SmartWay" style



Drag reducing features: smoothed front grill and bumper, roof fairing, chassis fairings, side extenders, etc.

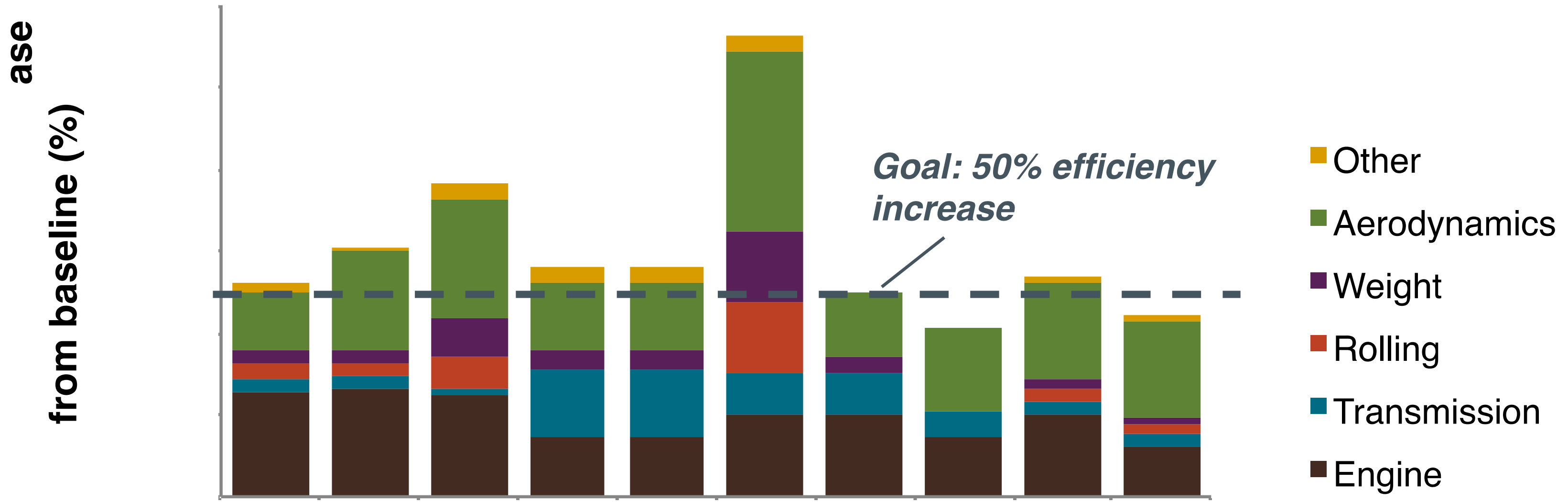
In the coastdown test, Smartway Tractor will have a lower drag result than Classic Tractor because of all of these aerodynamic enhancements

	Class 7	Class 8	
	Day Cab	Day Cab	Sleeper Cab
	High Roof	High Roof	High Roof
Aerodynamic Test Results (C_dA in m^2)			
Bin I	≥ 8.0	≥ 8.0	≥ 7.6
Bin II	7.1 – 7.9	7.1 – 7.9	6.7 – 7.5
Bin III	6.2 – 7.0	6.2 – 7.0	5.8 – 6.6
Bin IV	5.6 – 6.1	5.6 – 6.1	5.2 – 5.7
Bin V	≤ 5.5	≤ 5.5	≤ 5.1

ICCT THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

U.S. Super Truck Program Informs Phase 2 Proposal

- Goal: Demonstrate 50% increase in freight efficiency (e.g., ton-mi/gal)
  - For a given payload, this would approximately result in 10 mpg tractor-trailers (from 6-7 mpg baseline)
- Progress to date:

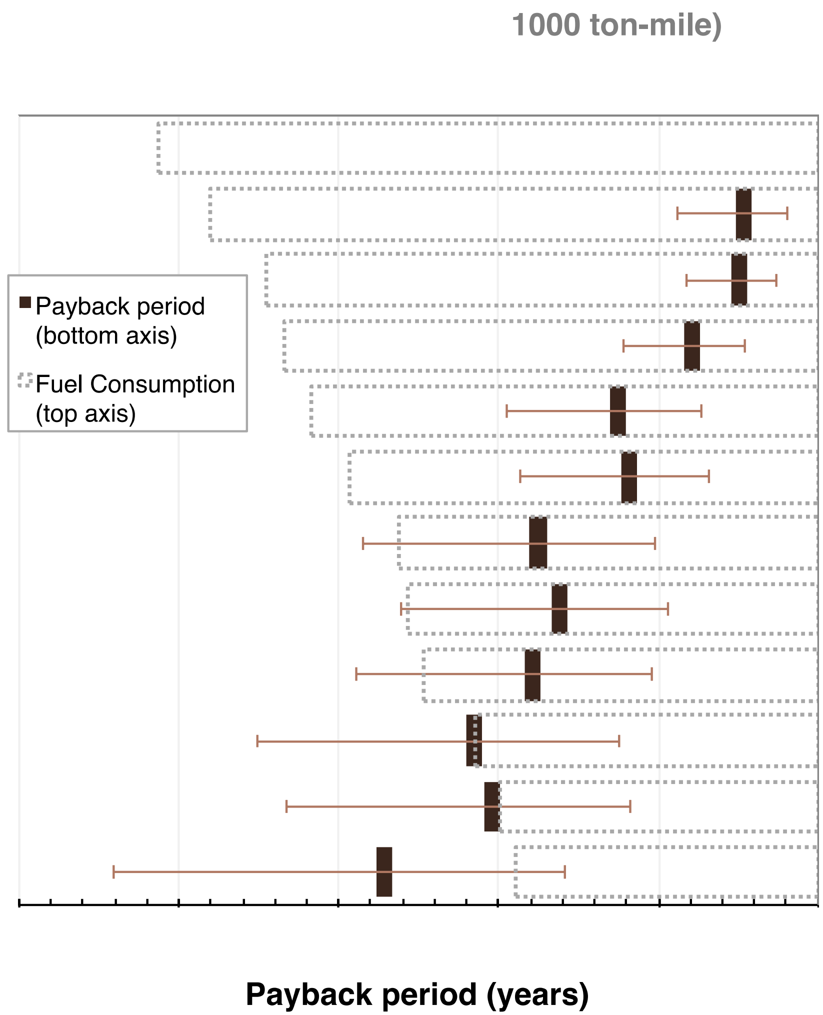


Energy category breakdown is based on US DOE Annual Merit Review reports; Freight efficiency of Cummins and Daimler are based on representative real-world routes and include weight reduction and increased payload

ICCT Analysis of Technology Potential and Payback Periods for Phase 2 Rule Proposal

Mid-term, technologies: 0.5-1 yr payback

Long-term technologies: 1-1.5 yr payback

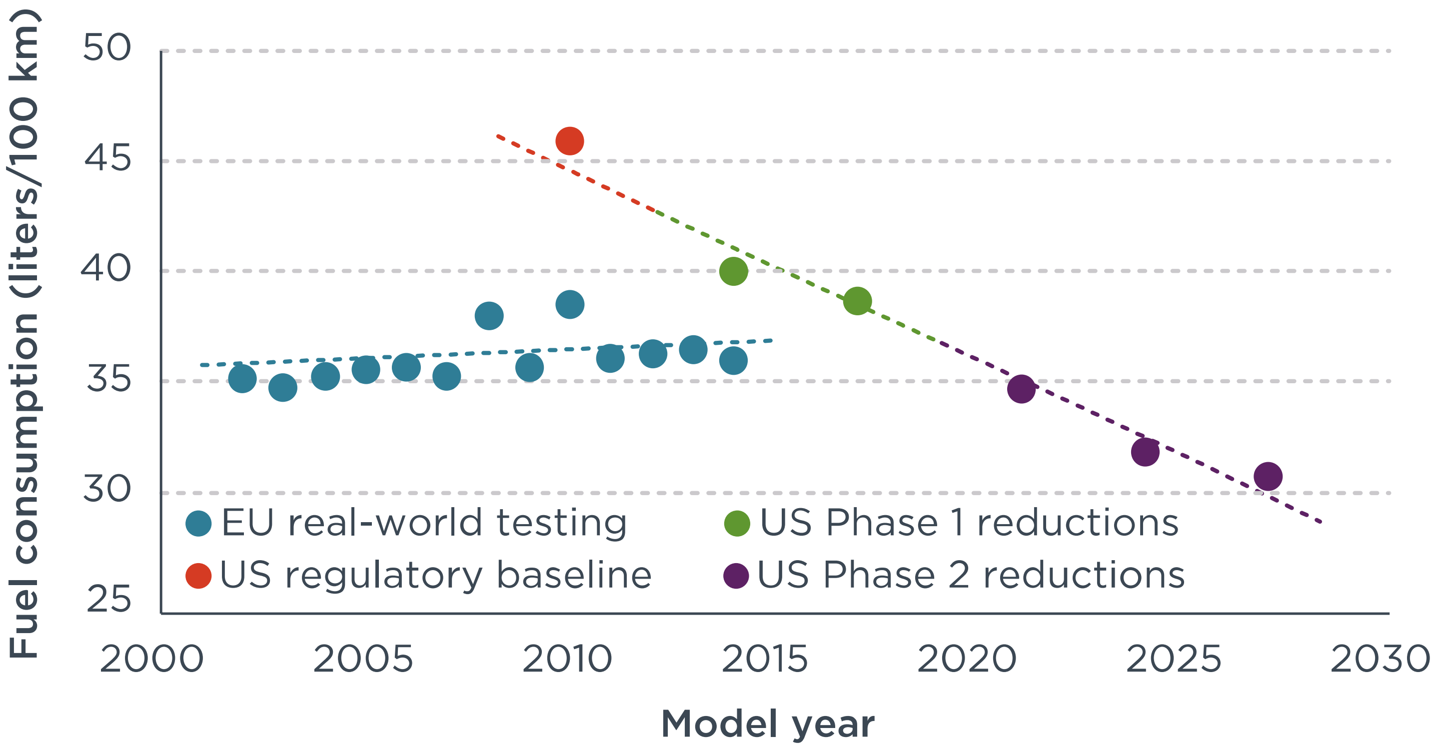


Meszler et al (2015). http://theicct.org/us-tractor-trailer-tech-cost-effectiveness
"Error" bars reflect range of estimates for varying technology cost, fuel price (US EIA AEO 2014 forecast, Low $3.10 to High $5.40 per gallon), and discount rates (3%-10%).

icct
THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

US trucks are expected to overtake EU in energy efficiency in part due to US fuel economy regulations

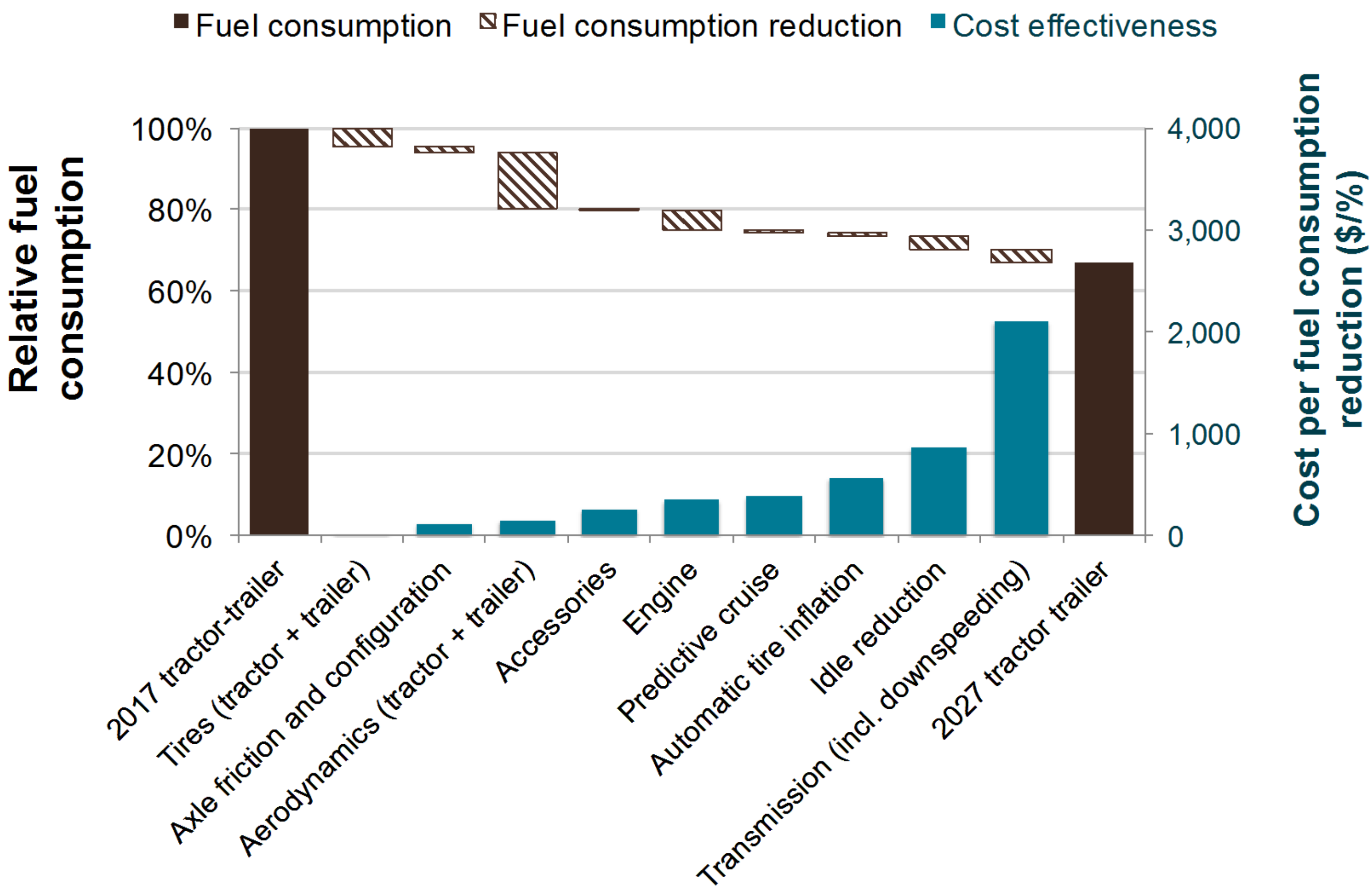
Fuel consumption of tractor-trailers EU vs. US:



http://www.theicct.org/overview-heavy-duty-vehicle-market-and-co2-emissions-european-union

Phase 2 Sample Compliance Pathway

New tractor + trailer fuel consumption reduction of 34% from 2018 to 2027



Muncrief, R (2015). Parsing Phase 2: Tractor-trailers in the proposed regulation[*http://www.theicct.org/blogs/staff/parsing-phase-2-tractor-trailers-proposed-regulation*](http://www.theicct.org/blogs/staff/parsing-phase-2-tractor-trailers-proposed-regulation)

ICCT Research For FIA Foundation

Baseline fuel economy

Technology potential

THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

Project methodology

- **Objective:**
  - To develop a global fuel consumption baseline for heavy-duty vehicles coupled with potential efficiency improvements based on technology and cost assessment.
  - Based on this information, the ICCT will make recommendations to GFEI on how to establish a global fuel economy target similar to the passenger vehicle target.
- **Methodology:**
  - **Select representative vehicles.**
    - Five markets: Brazil, China, EU, India, and US.
    - Two segments: tractor-trailer and rigid trucks (these two segments cover the vast majority of on-road freight hauling).
  - **Gather engine and vehicle data to create a baseline.**
    - Engine maps
    - Vehicle parameters (tires, aerodynamics, mass, etc.)
    - Operation (speed profile, grade, payload)
  - **Simulate technology potential of known technologies**
    - "End point" technology packages equivalent to US SuperTruck (advanced technology demonstration project) technology level
    - This analysis does not include "future" zero emissions technology (significant electrification or fuel cell)
  - **Map remaining world markets**
    - To the most appropriate market
    - Use ICCT roadmap model to estimate sales-weighted reductions that are possible.

icct
THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

Duty cycles, payloads, and other assumptions

- Payloads and duty cycles listed below (kept constant throughout years of analysis)
- Assume no significant change to vehicle configuration, engine size
- Assume no significant change to logistics, infrastructure, etc

		Duty cycle	Average speed (km/h)	Maximum Payload (tonnes)	Representative Payload (tonnes)
Tractor-trailer	Brazil	Brazil - WHVC	76.3	19.5	19.5
	China	China - WHVC	72.7	25	25
	Europe	ACEA Long Haul	77.3	25.5	19.3
	India	India - WHVC	32.9	27.2	27.2
	US	US Phase 2 cycles	99.1	21.3	17.2
Rigid trucks	Brazil	US Vocational Multipurpose	36	6.5	3.2
	China	WHVC-China	51.3	6.2	3.1
	Europe	ACEA Urban / Regional	49	5.5	2.7
	India	ARB Transient	24.6	8	4
	US	US Vocational Multipurpose	36	5.3	2.6

Typical tractor-trailer characteristics in each region

	Brazil	China	Europe	India	US
Gross vehicle weight (tonnes)	36	40	40	40	36
Vehicle curb weight (tonnes)	16.7	15	14.5	13	14.7
Maximum payload (tonnes)	19.3	25	25.5	27	21.3
Volume capacity (m^3)	135	84	93	110	112
Axle configuration	6x2	6x4	4x2	4x2	6x4
Trailer axle number	3	3	3	3	2
Engine Displacement (liters)	13	10	12.8	5.9	15
Engine power (kW)	324	250	350	134	340
Transmission type	AMT	MT	AMT	MT	MT
Transmission gears	12	10	12	6	10
Transmission gear ratios	11.32-1	14.8-1	14.9-1	9.19-1	12.8-0.73
Rear axle ratio	4.38	4.11	2.64	6.83	3.7
Tire size	295/80R22.5	12R22.5	315/80R22.5	10R20	295/75R22.5
Engine criteria pollutant emission standard/vehicle fuel efficiency standard	Proconve 7	China IV	Euro VI	Bharat III	EPA 2010
Vehicle fuel efficiency standard	NA	Stage 2	NA	NA	GHG 2014

Comparison of HDVs in different markets (tractor trailers)

	Brazil	China	EU	India	US
					
Axel config.	6x2	6x4	4x2	4x2	6x4
Curb weight (tractor)	9.7t	10t	7.4t	6t	8.5t
GVW	35t	40t	40t	40t	36t
Trans-mission	AMT, 12 spd.	MT, 10 spd	AMT, 12 spd.	MT, 6 spd.	MT, 10 spd.
Engine Displ.	13L	11L	13L	6L	15L
Engine Power	~325kW	~250kW	~350kW	~135kW	~340kW
Emissions std.	Proconve 7	China IV	Euro VI	Bharat III	US EPA 2010

Key Messages

- Heavy-duty trucks and buses are a major contributor to global CO2 emissions and oil use, particularly in emerging markets.
  - HDV sector is behind LDV sector in implementation efficiency standards
- Regulatory action to address CO_2 emissions and fuel use from heavy-duty vehicles is accelerating around the world.
  - Japan, US, China and Canada currently have programs while India, Mexico, Korea and Europe are actively developing programs.
- Low volumes of heavy-duty vehicles and engines create economic incentives for global alignment of standards.
  - Global harmonization of regulatory programs is challenging due to diverse vehicle types and drive cycles, but shared use of simulation models holds promise.
- Supported by FIA Foundation, the ICCT is developing a global baseline for heavy-duty vehicle fuel economy and technology potential in 2030.
  - According to our research, fuel economy policies could substantially accelerate adoption of technology in the HDV sector, leading to ~ 30 GT of carbon reductions by 2050 cumulatively.

Thank you

Drew Kodjak

drew@theicct.org

www.theicct.org

THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION