New Study on Technology Potential for EU Tractor-Trailers

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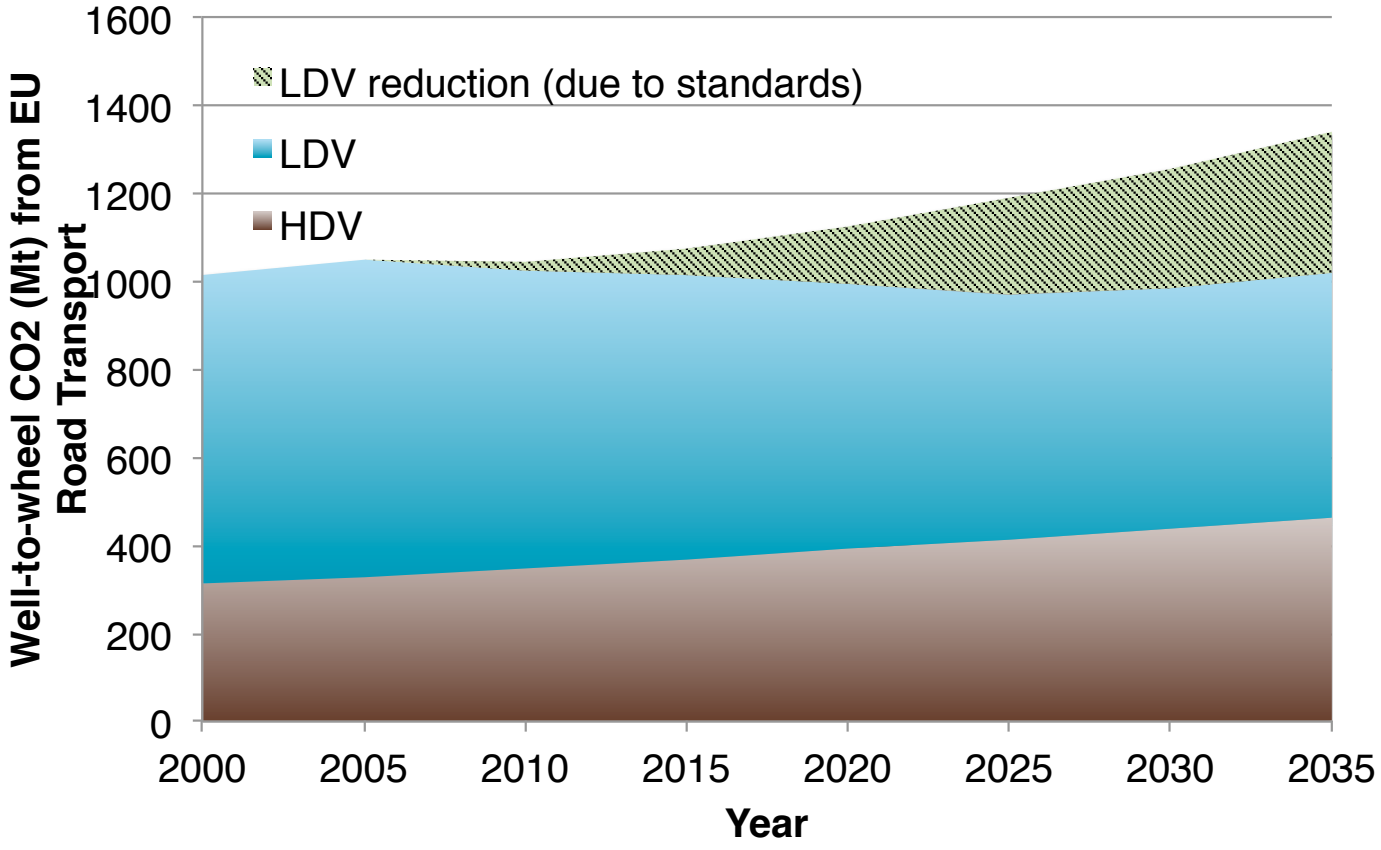
THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

Key messages

1. To date, 4 regions / countries have adopted fuel economy standards for heavy-duty vehicles. Europe is the largest HDV market without standards. **EU will fall behind the US in tractor-trailer efficiency in 2020 based on our analysis.**
2. Globally, energy consumption from heavy-duty trucks and buses is on par with passenger vehicles. **In the EU 45% of on road CO2 emissions are projected to come from HDVs in 2030**.
3. While the HDV segment is diverse, a small number of vehicle types dominate fuel consumption in each market (e.g., tractor trailers)**. Benefits of a targeted, modest, but early standard outweigh the benefits of waiting.**
4. Given high fuel consumption, heavy-duty vehicles are extremely attractive targets for policy action (e.g., in many cases, consumer payback in 6 months to 3 years). **There is significant technology potential to improve HDV efficiency in the EU**.
5. Key regulatory elements have already been developed - regulatory design, test protocols, simulation models – thus paving the way for accelerated policy adoption**. It is not necessary to wait for baseline data to move forward with a standard.**

CO_2 emissions from the on-road fleet in the EU

- Efficiency policies currently in place only target the LDV fleet
- 45% of on-road CO2 projected to come from HDVs by 2030



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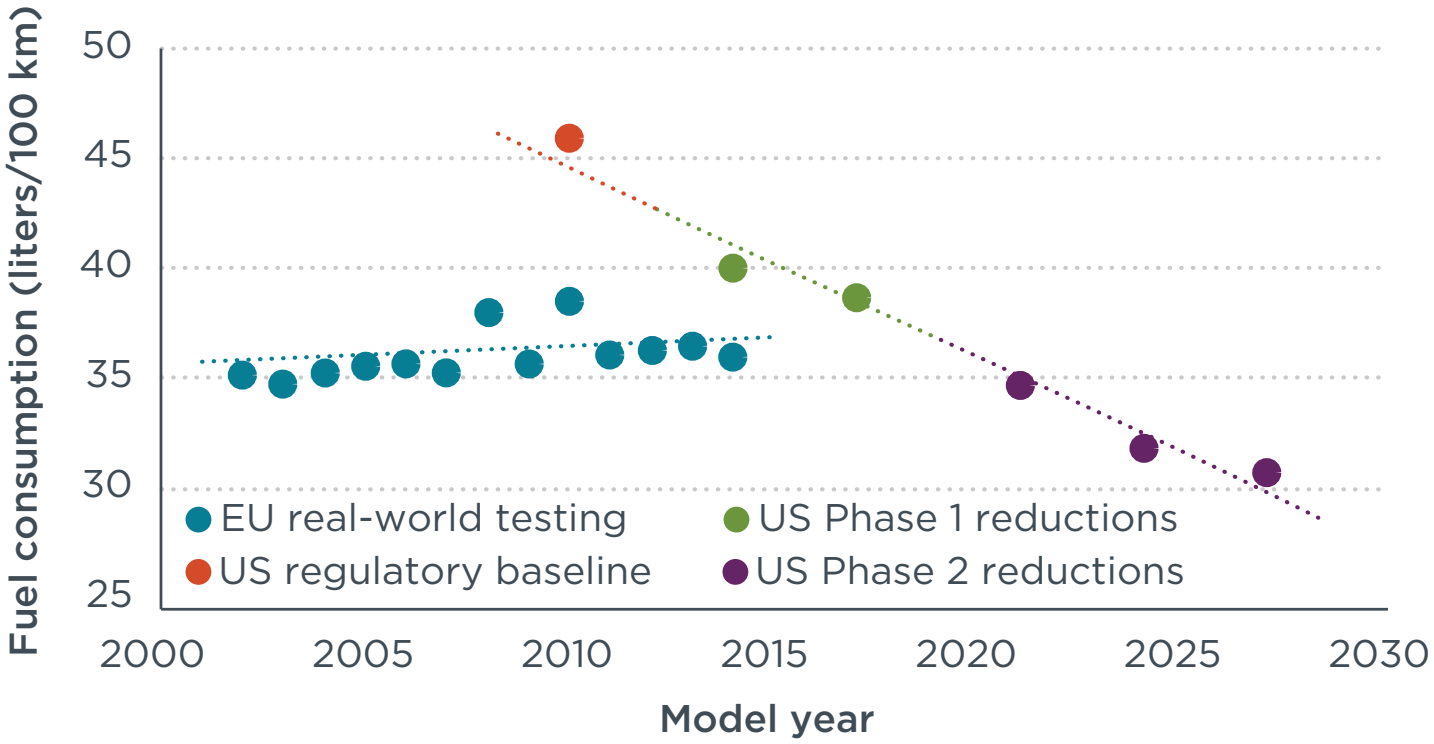
Source: ICCT Roadmap model

Efficiency standards drive technology adoption

- Real world fuel consumption for EU tractor-trailers has been flat for the past 13+ years
- Standards are driving fleet-wide efficiency improvements in the US
- Higher cost of fuel in the EU is not enough to drive significant technology adoption across the fleet



Source: LastAuto Omnibus (EU), US Phase 1 and (proposed) Phase 2 regulations

Previous studies on EU tractor-trailer technology potential

- Previous studies on technology potential for tractor trailers
  - Range of potential from 15-52% in the 2020-2030 timeframe
  - Some studies include more technologies than others, methodologies differ
- Technology potential is not equivalent to sales weighted average potential

Study Author	Study Year	Baseline	Technology potential	Technologies and Methodology
AEA/Ricardo	2011	2010 Euro V	50% (full package)	Potential improvement over 20 years from 2010 to 2030. Literature review, aggregation based on multiplicative method
TIAX	2011	2015 Euro VI	41%-52%	Potential improvement over 15 years 2015 to 2030. Literature review, aggregation based on multiplicative method
IFEU/TU Graz	2015	2015 Euro VI	21-24%	Potential improvement from 5+ years 2015 best in class to 2020's. Literature review, aggregation based on vehicle simulation method
T&M Leuven	2015	2014 Euro VI	15-17%	Potential improvement over 6 years from 2014-2020. Survey and literature review, aggregation based on multiplicative method

Sources:
http://ec.europa.eu/clima/policies/transport/vehicles/docs/ec_hdv_ghg_strategy_en.pdf
http://www.theicct.org/sites/default/files/publications/ICCT GHG Reduction Potential_final.pdf
http://www.umweltbundesamt.de/sites/default/files/medien/378/publikationen/texte_32_2015_summary_future_measures_for_fuel_savings.pdf
http://www.tmleuven.be/project/hgvco2/ACEAReportonHDVemissionreductionmeasuresv9.pdf

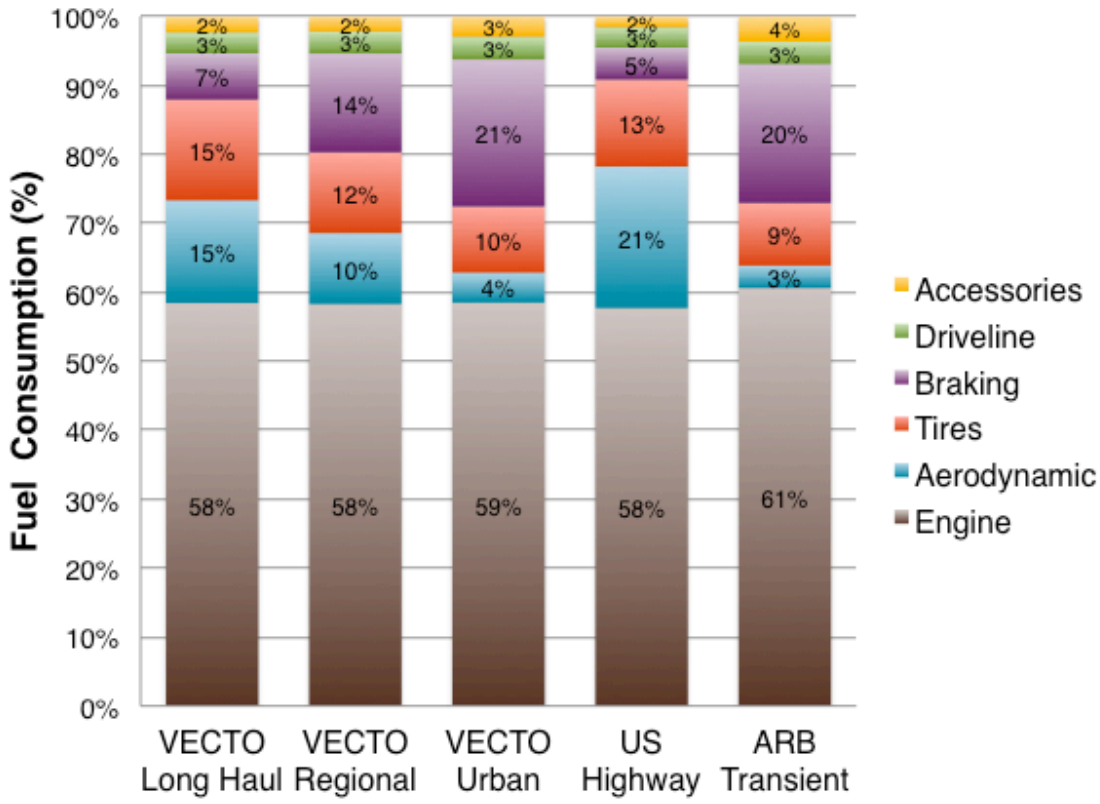
2015 Baseline EU tractor-trailer

- Key parameters needed to define and simulate the "representative" baseline vehicle
- Data collection from literature, discussion with experts, data purchases

Component	Parameter	Value
Chassis	Total weight (kg)	33,700
	Tractor-trailer curb weight (kg)	14,400
	Payload (kg)	19,300
	Aerodynamic drag coefficient (-)	0.6
	Frontal area (m^2)	10
Transmission	Type	AMT
	Number of gears	12
	Gear ratios	[14.93-1.0]
	Gear max. efficiency	98% direct, 97% indirect
Axle	Axle configuration	4x2
	Final drive ratio (-)	2.64
	Axle efficiency	96%
Engine	Fuel map	Euro VI, 12.8L, 350kW
	Peak BTE (%)	~45%
Electric Acc.	Power (kW)	1
Mechanical Acc.	Power (kW)	4.5
Tires	Drive tire CRR (kg/t)	C (6-7)
	Steer tire CRR (kg/t)	B (5-6)
	Trailer tire CRR (kg/t)	B (5-6)
	Wheel radius (m)	0.52

Simulation modeling results for baseline tractor-trailer over multiple duty cycles

- Energy audit indicates where largest opportunities are for improvement
- Fuel consumption and energy audit depends on **test cycle** and **payload**

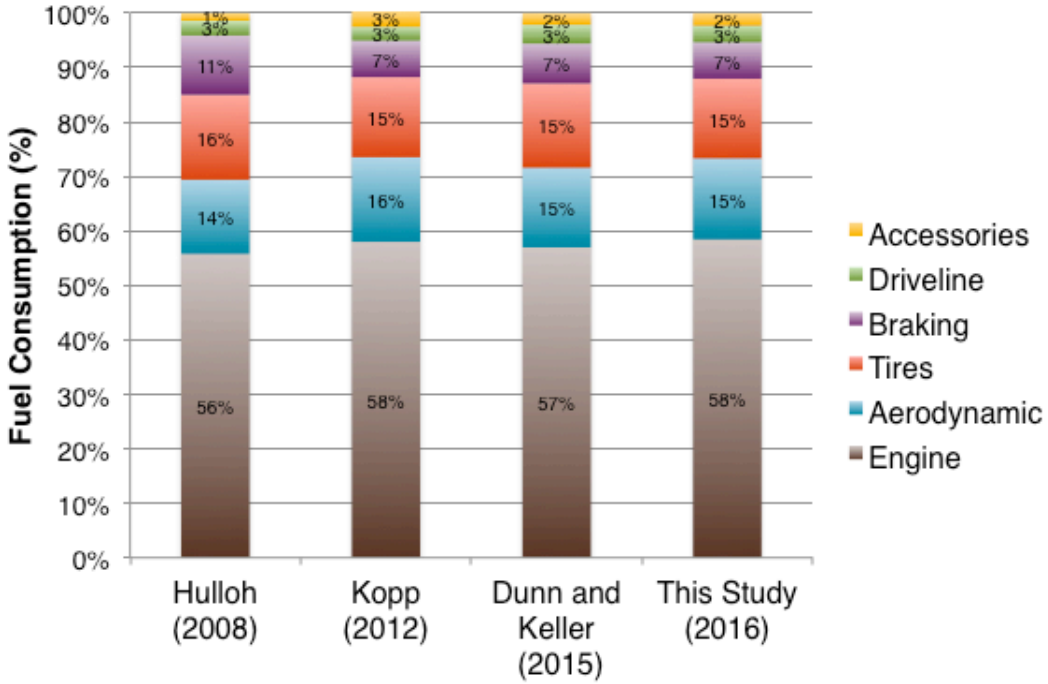


Cycle	Avg. Speed (km/h)	FC (L/100km)
VECTO Long haul	73	33
VECTO Regional	60	42
VECTO Urban	33	50
US Highway	96	39
ARB Transient	24	54

Energy audit for baseline tractor-trailer at 19.3t payload over different duty cycles

Model validation

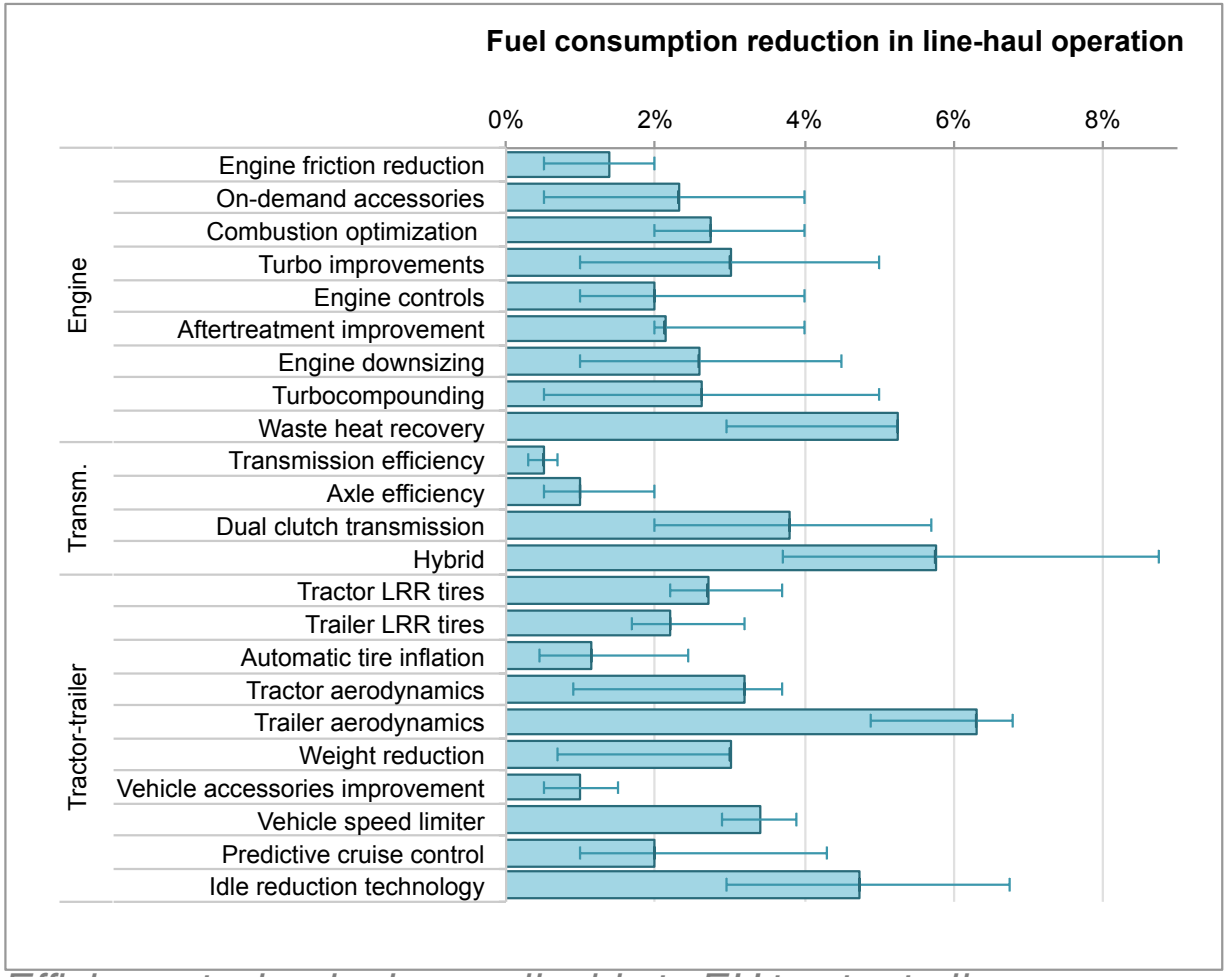
- Baseline validation
  - Compare energy audit with other studies
  - Compare modeled fuel consumption with measured values from testing



Long-haul tractor-trailer energy audit comparison of various sources and ICCT study

Applicable technologies (preliminary results)

- Many engine, transmission, and tractor-trailer technologies available
- All of them are available or expected to be commercially available in the 2020-2025 timeframe.
- Blue bars represent the best available data based on our research. Error bars represent the range of values found in the literature

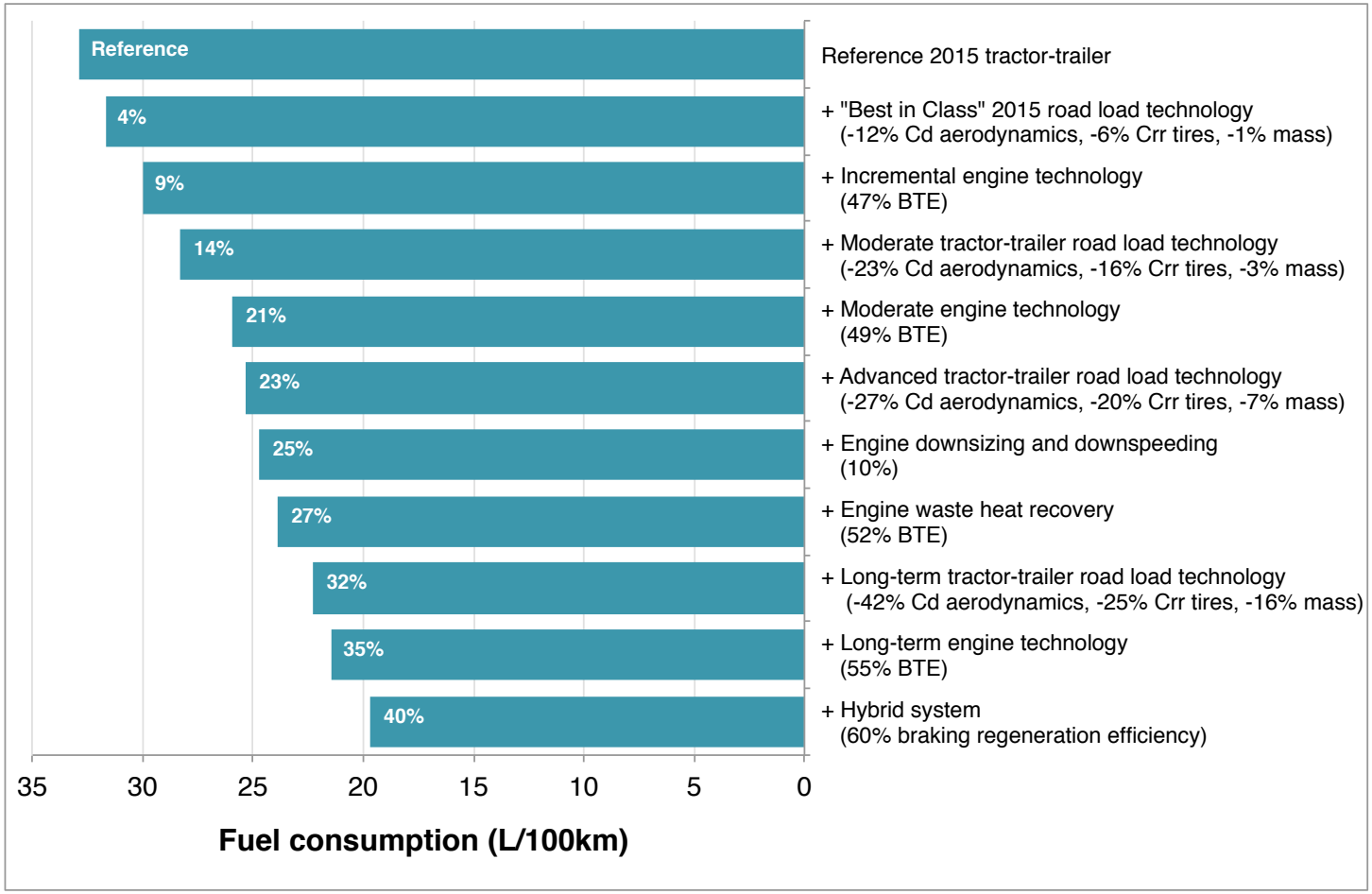


Efficiency technologies applicable to EU tractor-trailers

Results: fuel consumption from selected efficiency technology packages

Mid-term (2020-2025) technology tracking

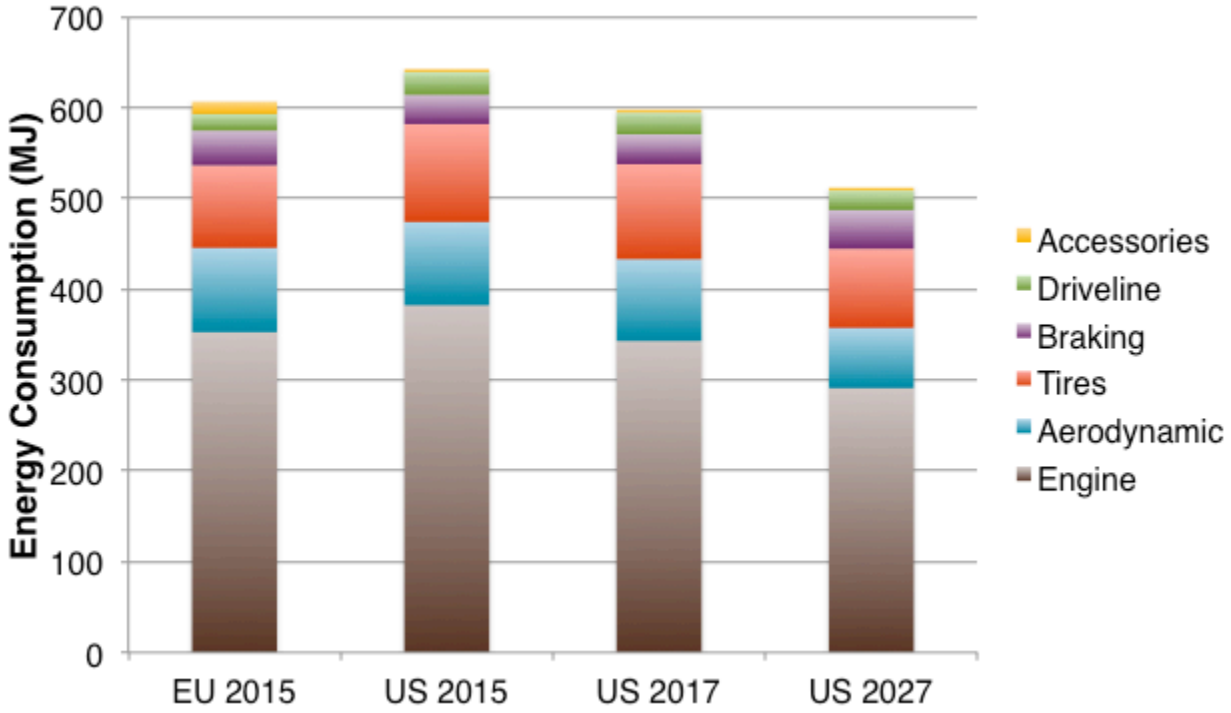
Long-term (2030) technology forcing



Potential fuel consumption reduction from selected tractor-trailer efficiency technologies in the 2020-2030 timeframe over the VECTO long haul cycle.

Standards impact fleet-wide technology adoption

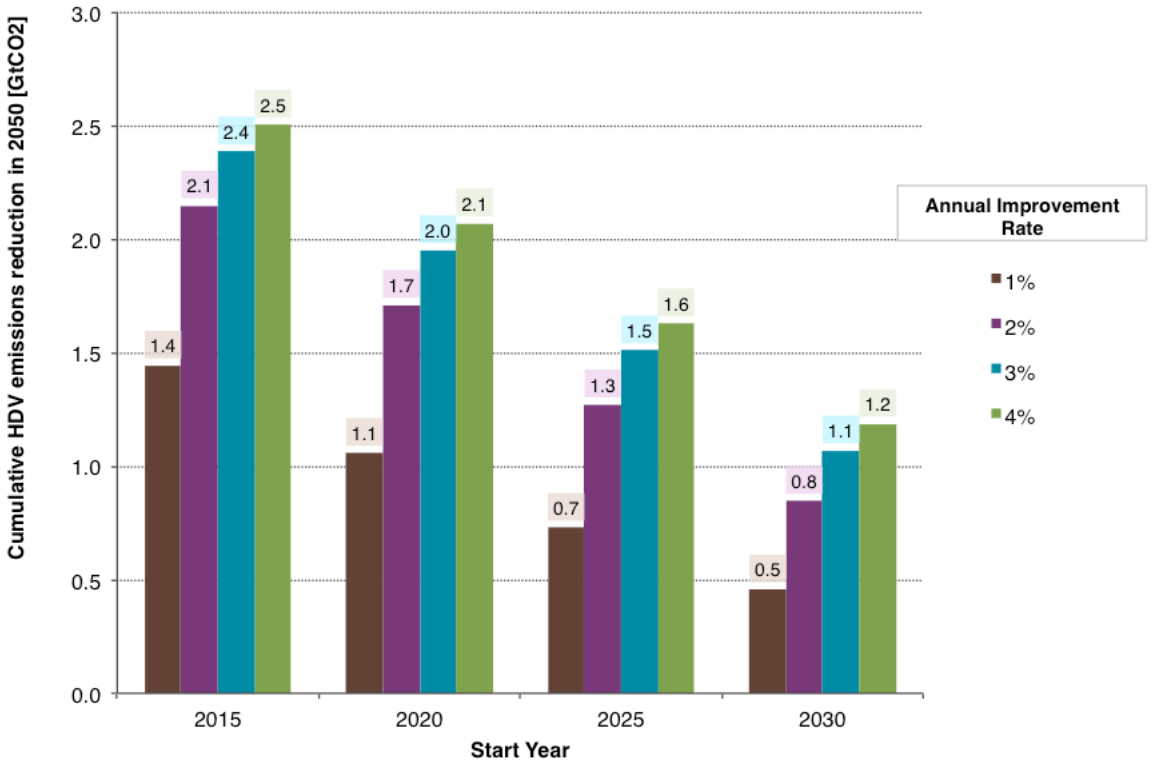
- US Phase 1 (2017) will put US tractor-trailers on par with current EU tractor-trailers.
- Proposed US Phase 2 (2027) will make US tractor-trailers 16% more efficient than those in the EU.



Energy consumption of EU baseline tractor-trailer compared to current and future US tractor-trailers. (19.3t payload, VECTO Long Haul cycle)

Impacts of timing and stringency

- To achieve identical cumulative benefits in 2050
  - Standards starting in 2020 with a 2% annual improvement rate
  - Standards starting in 2025 with a >4% annual improvement rate
- For reference, US HDV standards have a ~2.5% annual improvement rate



Summary/Conclusions

1. *Technology potential* –
   - Available and emerging technologies can reduce new tractor-trailer fuel use by 27% from the baseline 2015 technology in the 2020-2025 timeframe.
   - Longer-term load-reduction and engine technologies can achieve at least a 40% reduction from baseline 2015 technology in the 2025-2030 timeframe. These technology levels require technology-forcing regulations and sufficiently long lead-time.
2. *Competitiveness* – US tractor-trailers will be 16% more efficient than EU tractor-trailers in the 2027 timeframe if EU does not act. This translates into more efficient and lower cost freight delivery.
3. *CO_2 Targets* – EU pledge of 30% CO_2 reduction from non-ETS sectors. HDVs must be included for transport contribute a proportional share
4. *Regulations warranted* – Efficiency regulations could be utilized to obtain guaranteed, real-world heavy duty vehicle efficiency improvements.

thank you

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