CO_2 standards for HDV in the EU

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ICCT

Stakeholder meeting - Impact Assessment on Heavy-Duty Vehicle CO2 emission standards

16.01.2018

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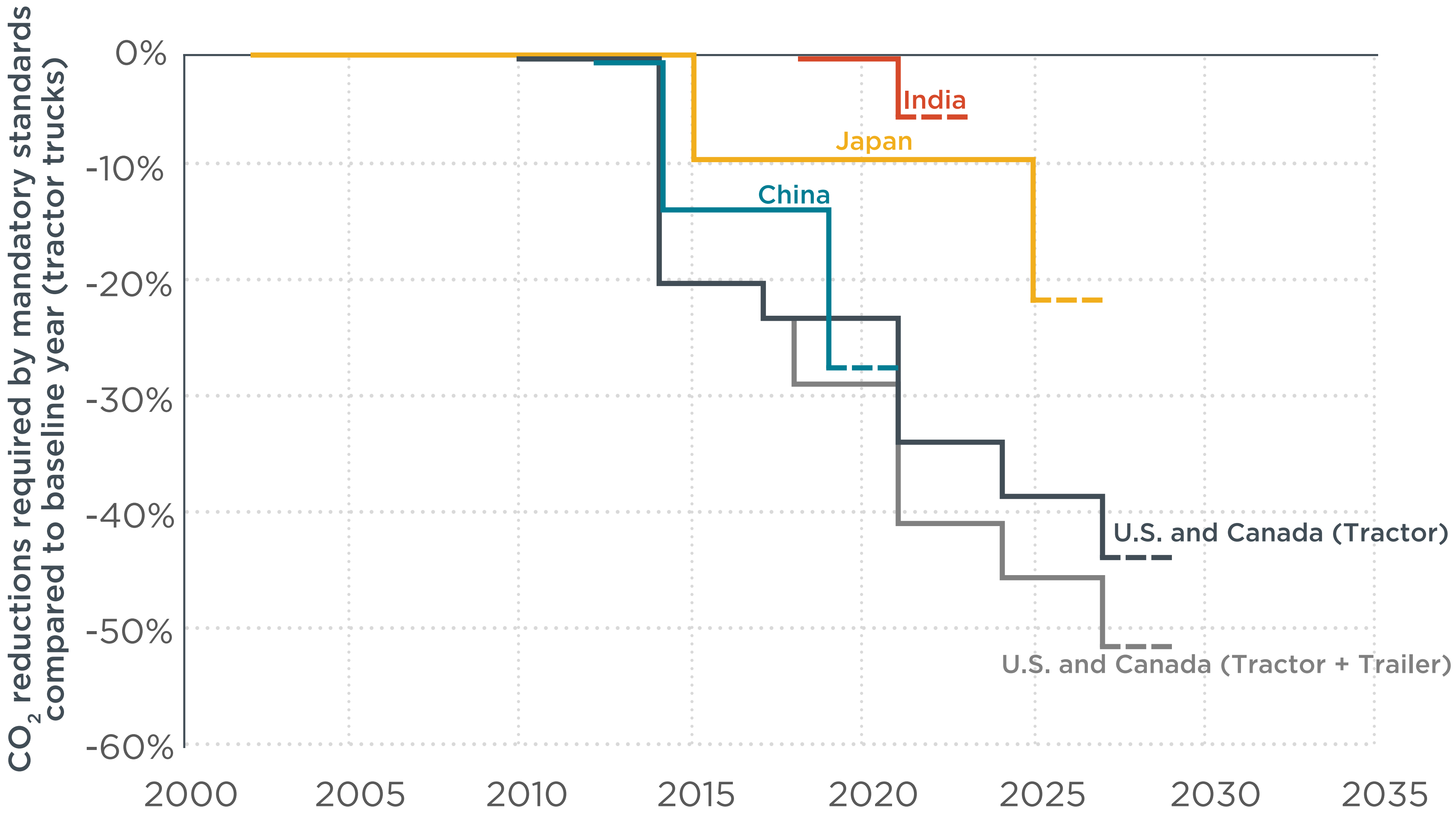
THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

The EU will be the last major economy to introduce HDV efficiency standards



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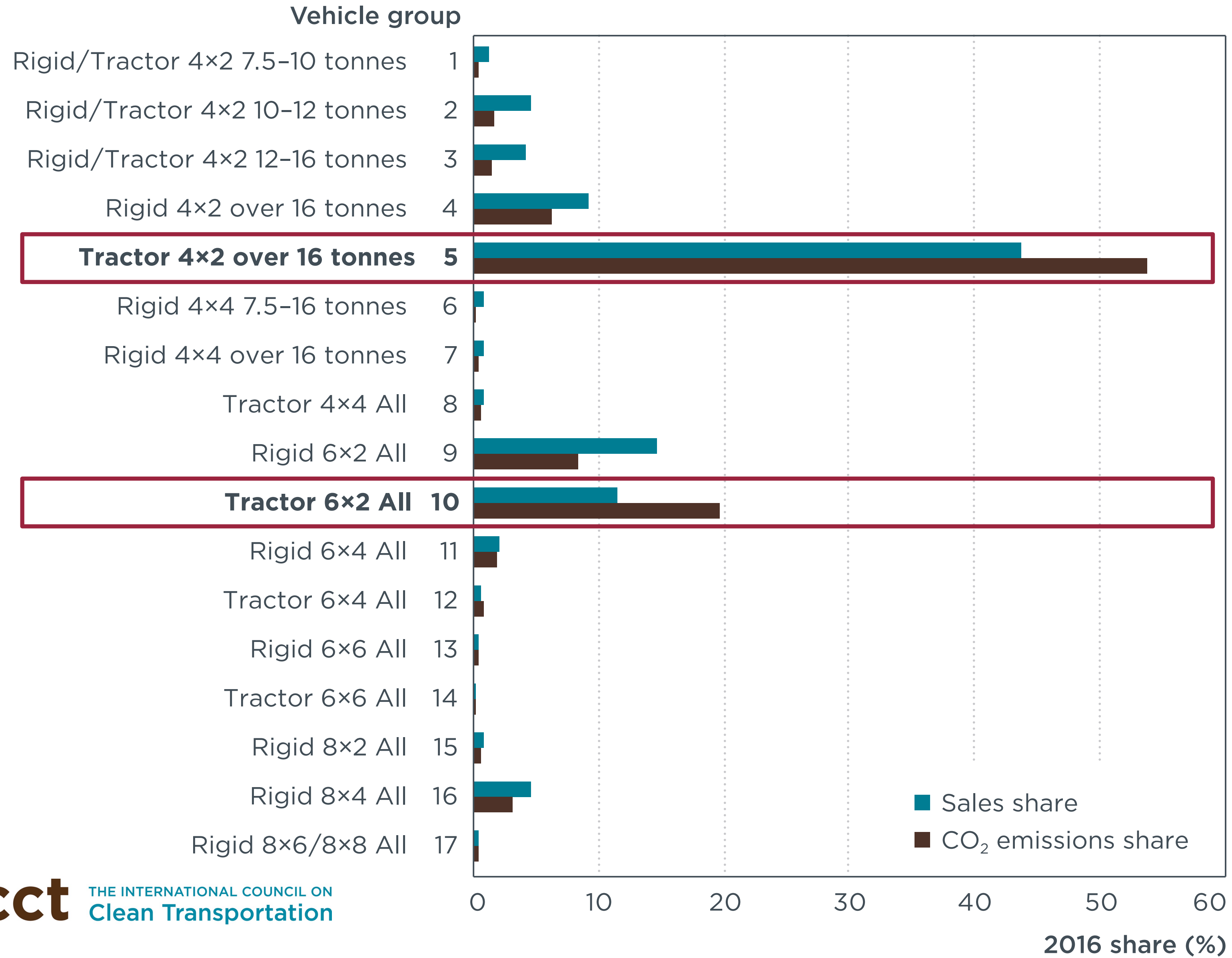
Tractor-trailers account for the majority of HDV CO_2 emissions



Vehicle groups 5 and 10 (i.e., tractor-trailers) account for over 70% on the CO_2 emissions of on-road HDVs

Source: Delgado, O., Rodríguez, F., & Muncrief, R. (2017). *Fuel Efficiency Technology in European Heavy-Duty Vehicles: Baseline and Potential for the 2020–2030 Time Frame*. International Council on Clean Transportation.

http://www.theicct.org/EU-HDV-fuel-efficiency-tech-2020-2030

4 key barriers delay technology uptake

Uncertain return on investment

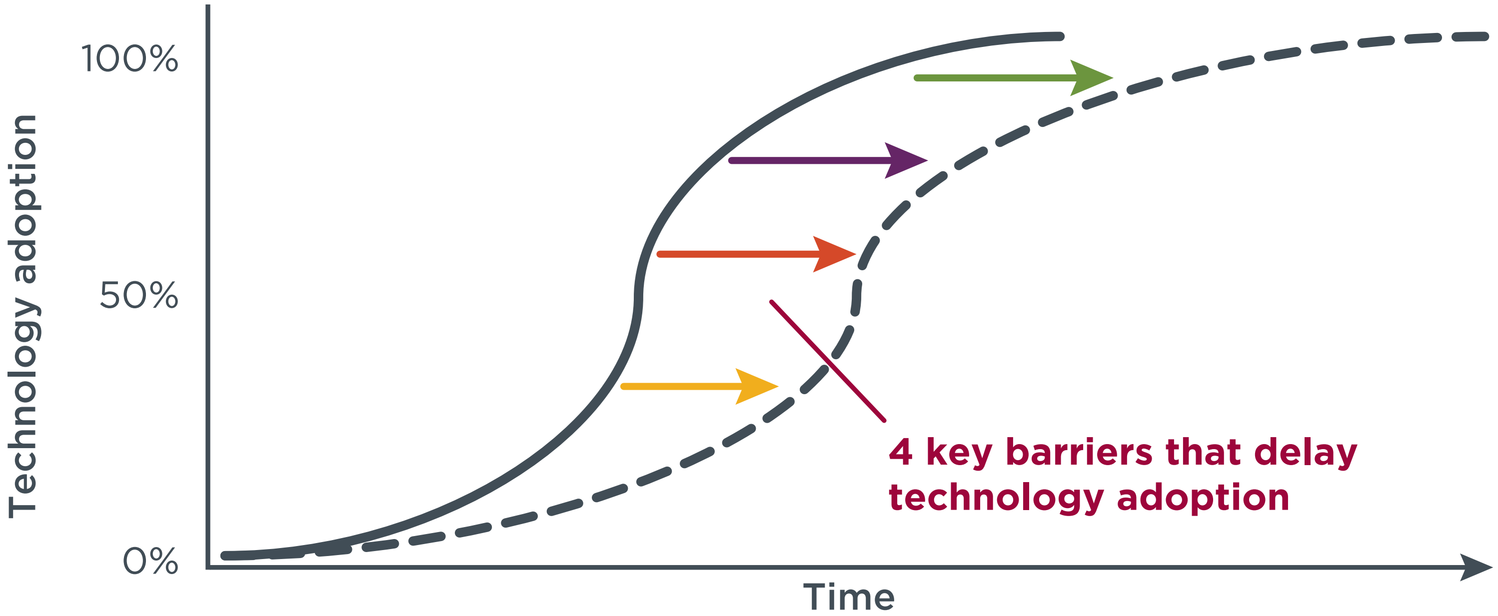
Will the technologies perform as expected?

What will fuel prices be in the future?

Capital cost constraints

Can the fleet get access to additional capital?

Sharpe, B. (2017). Barriers to the adoption of fuel-saving technologies in the trucking sector. [http://theicct.org/barriers-to-fuel saving-technologies-trucking-sector](http://theicct.org/barriers-to-fuel-saving-technologies-trucking-sector)



Split incentives

Are the equipment owner and operator different entities with different motivations?

Who makes the technology purchase vs. who pays for fuel?

Lack of technology availability

Are the technologies available in the market?

Are they available from a preferred supplier?

Cost-effective technology potential

Key message: **Cost-effective potential = 43%**

1. How efficient can diesel long-haul tractor trailers be in the future?

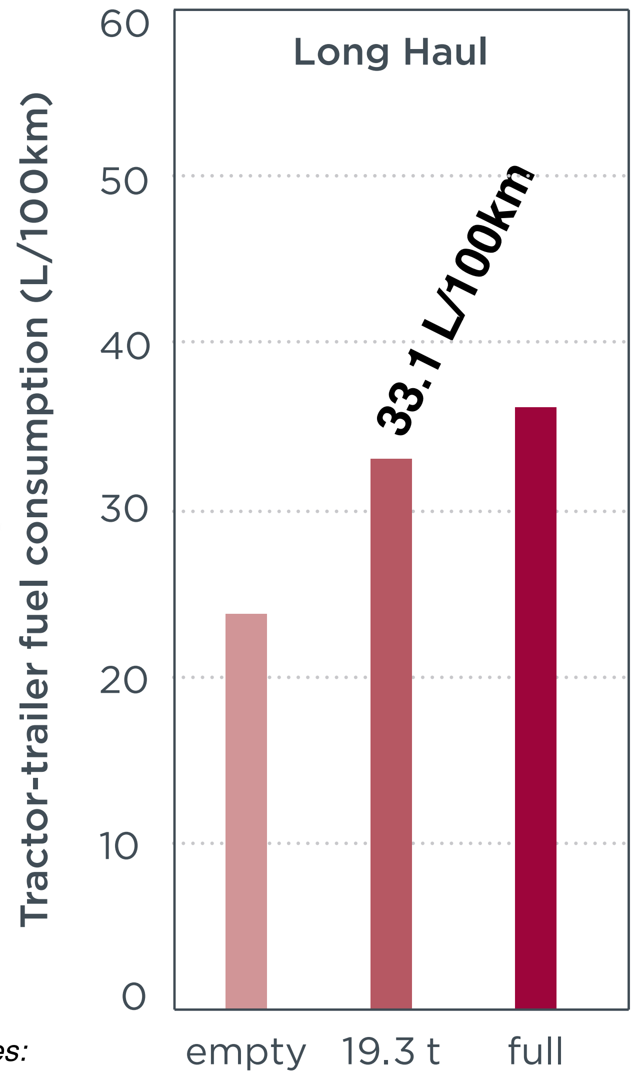
   For 2030, ICCT's analysis shows a 43% technology potential of diesel powered tractor-trailers

2. What will be the payback time of the fuel saving technologies needed in the year 2030?

   To achieve 43% reduction, a payback between 1.4 to 2.7 years is expected, depending on the assumed discount rate and fuel price

Reference 2015 tractor-trailer used for our analysis

Baseline specifications	Tractor-trailer
Gross vehicle weight (t)	40
Vehicle curb weight (t)	14.4
Axle configuration	4×2
Aerodynamic drag area (m²)	6.0
Tire rolling resistance (N/kN)	5.5
Engine emissions	Euro VI
Engine displacement (L)	12.8
Engine power (kW)	350
Engine peak BTE (%)	44.8
Transmission type	AMT
Transmission gear number	12
Transmission gear ratios	14.93–1.0
Rear axle ratio	2.64
Accessory power (kW)	5.6



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List of technologies considered in analysis

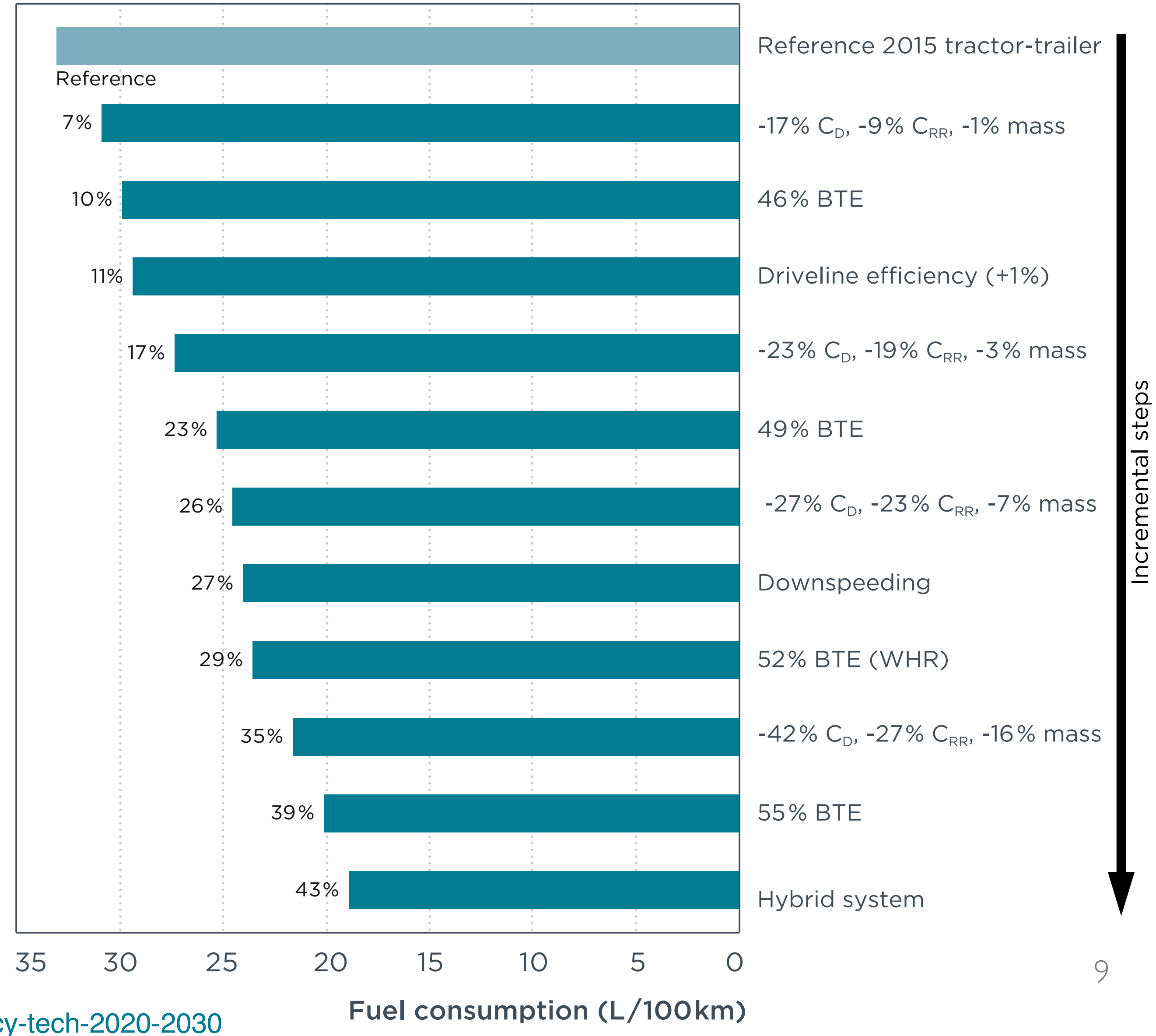
Engine	Aerodynamics	Rolling resistance	Mass reduction area / system	Driveline / Transmission	Auxiliaries	Driver assistance systems	Hybridization
Combustion optimization	Roof spoiler	Low rolling resistance tires	Engine	Automated man. transmission	Variable speed cooling fan	Stop-start / idle reduction	Integrated Mild Hybrid
Advanced turbocharging	Cabin side turning vanes	Single wide tires	Coolant circuit	Dual clutch transmission	Variable/clutched air compressor	Eco-roll	Parallel hybrid
EGR reduction / advanced SCR	Tractor/truck side skirts	Tire pressure monitoring	Fuel circuit	Downspeeding	LED lighting	Speed limiter	48-V electric architecture
Friction reduction	Active grille shutter	Automatic tire inflation	Exhaust system	Improved mech. efficiency	Electro-hydraulic power steering	Predictive cruise control	24-V brake energy recovery
On demand / improved pumps	Cabin underbody devices		Transmission	Top-torque control	High efficiency HVAC	Adaptive cruise control	
Turbocompound	Rearview cameras		Electrical system	Engine/trans. deep-integration	High efficiency alternator		
Waste heat recovery	Air dam		Chassis				
	Tractor side panels		Suspension				
	Wheel covers		Braking				
	Vented mud-flaps		Wheels				
	Trailer side skirts		Cabin				
	Trailer rear-end device		Trailer Body				
	Trailer underbody devices						

Not captured by VECTO	Partially captured by VECTO	Captured by VECTO

43% CO_2 reduction possible for long-haul tractor-trailers by 2030

How efficient can diesel long-haul tractor trailers be in the future?

- Engine: 55% peak efficiency
- Aerodynamic drag: 0.35
- Rolling resistance: 4 N / kN
- Lightweighting: -2300 kg
- Hybrid: P2, 120 kW, 2 kWh



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Engine: 55% peak efficiency

The Supertruck II program from the US department of energy aims to show pathway to **55%** brake thermal efficiency. Participants include Cummins, Daimler, Navistar (VW), Volvo, Paccar (DAF).

Daimler, Cummins, Navistar, and Volvo already demonstrated 50%+ peak eff.

The pathway to 55% peak efficiency could include the use of waste heat recovery (WHR), variable valve timing, back-pressure reduction, low EGR/high SCR concepts, low high peak combustion pressures, optimized combustion bowl, optimized injector, closed-loop injection rate shaping, reduced heat transfer, reduced friction in piston ring pack and bearings, opposed piston architecture, low temperature combustion, among others.

Engine: 55% peak efficiency

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Cummins aims to boost heavy-duty diesel efficiency to 55%

16-Nov-2015 02:17 EST

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Developing a 55% BTE Commercial Heavy-Duty Opposed-Piston Engine without a Waste Heat Recovery System

2017-01-0638

Published 03/28/2017

Neerav Abani
Achates Power Inc.

Nishit Nagar, Rodrigo Zermeno, Michael chiang, and Isaac Thomas
Achates Power Inc

CITATION: Abani, N., Nagar, N., Zermeno, R., chiang, M. et al., "Developing a 55% BTE Commercial Heavy-Duty Opposed-Piston Engine without a Waste Heat Recovery System," SAE Technical Paper 2017-01-0638, 2017, doi:10.4271/2017-01-0638.

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Optimization of an Advanced Combustion Strategy Towards 55% BTE for the Volvo SuperTruck Program

Jacqueline O'Connor, Meghan Borz, Daniel Ruth, Jun Han, Chandan Paul, Abdurrahman Imren, and Daniel Haworth
Pennsylvania State University

Jonathan Martin and Andre Boehman
University of Michigan

Jian Li, Kevin Heffelfinger, Samuel McLaughlin, Richard Morton, Arne Andersson, and Anders Karlsson
Volvo Group Trucks Technology

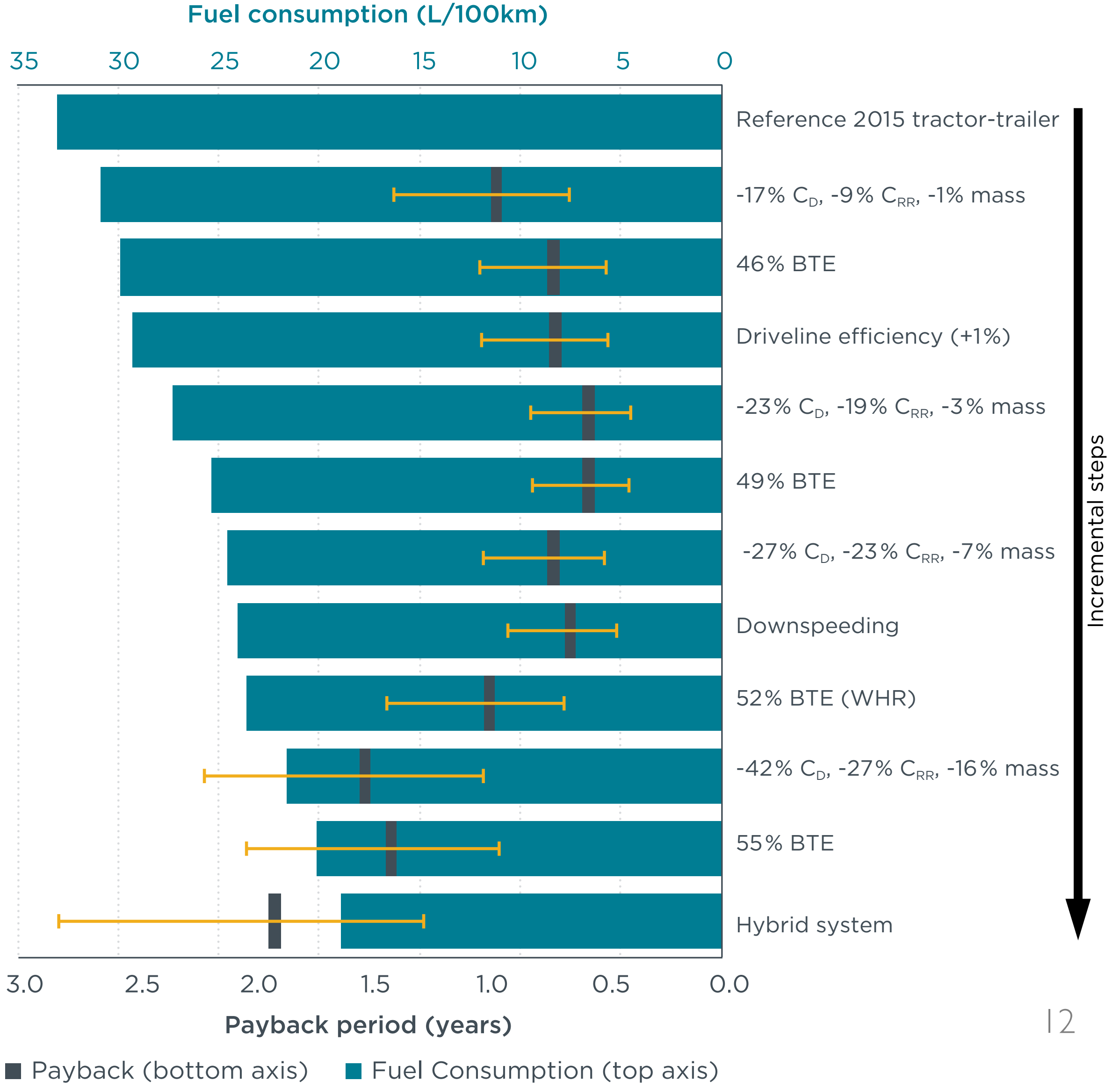
The technologies for 43% reduction will have a payback between 1.4 to 2.7 years in 2030

Main study assumptions:

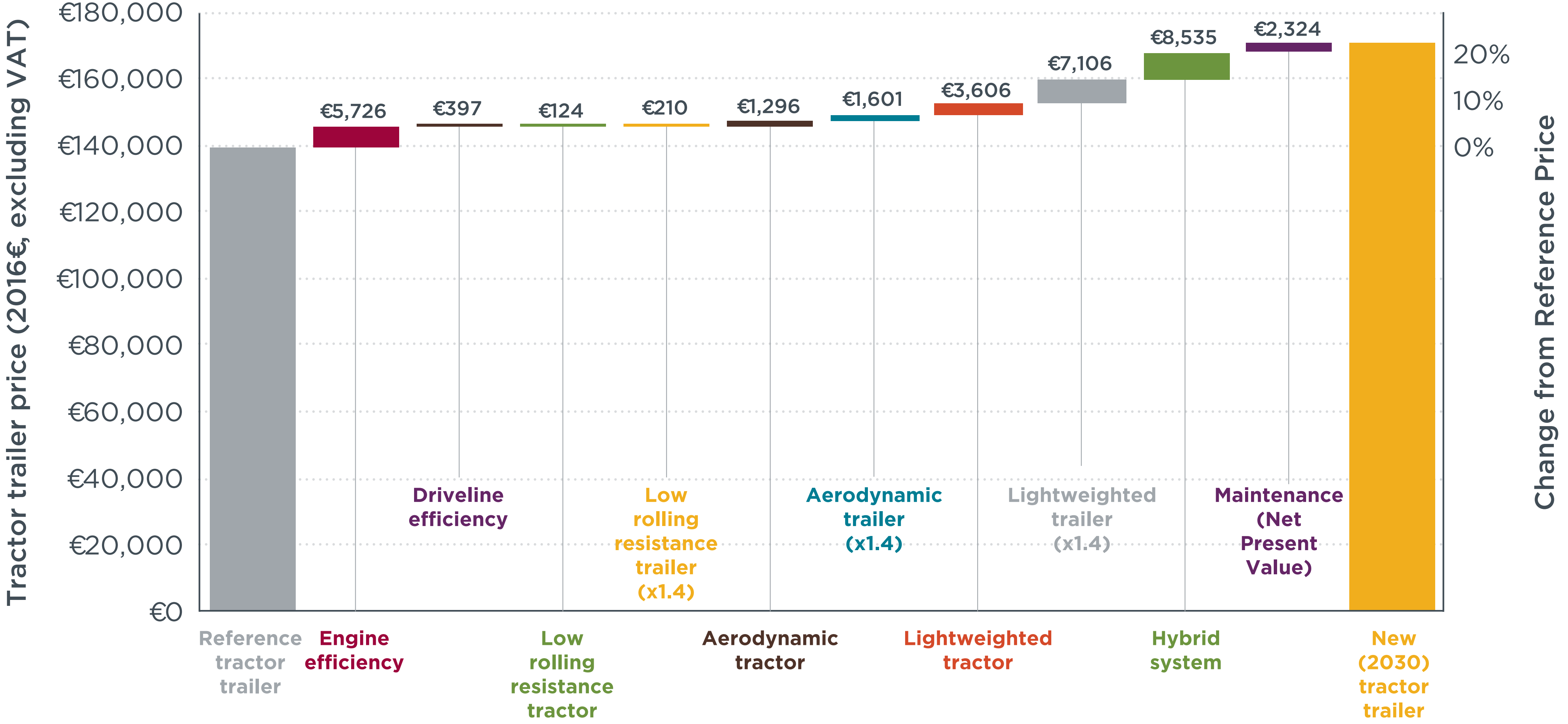
- Fuel price: 0.7 to 1.4 €/L
- Discount rates: 4% to 10%
- Evaluation years: 2025 and 2030
- Trailers per tractor: 1.4
- Vehicle lifetime: ~1 M km
- First owner annual use: ~110k km

Source: Meszler, D., Delgado, O., Rodriguez, F., & Muncrief, R. (2018). *European Heavy-Duty Vehicles – Cost effectiveness of fuel efficiency technologies for long-haul tractor-trailers in the 2025-2030 timeframe*. International Council on Clean Transportation.

http://theicct.org/publications/cost-effectiveness-of-fuel-efficiency-tech-tractor-trailers



The technologies for 43% reduction increase the tractor-trailer cost by approximately 20%



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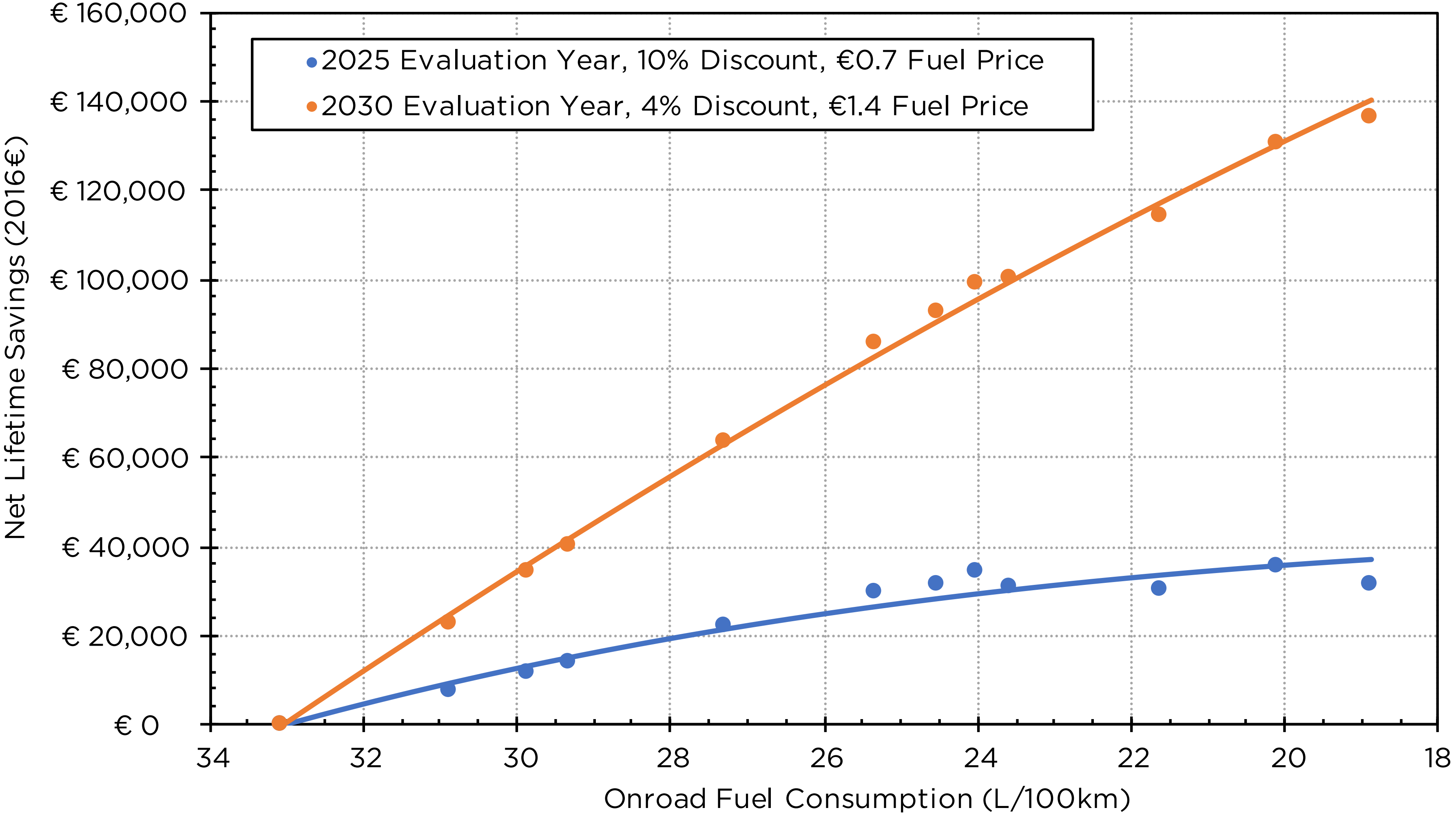
Despite higher capital investment, the 43% technology package offers a net of economic benefit between €31k and €136k



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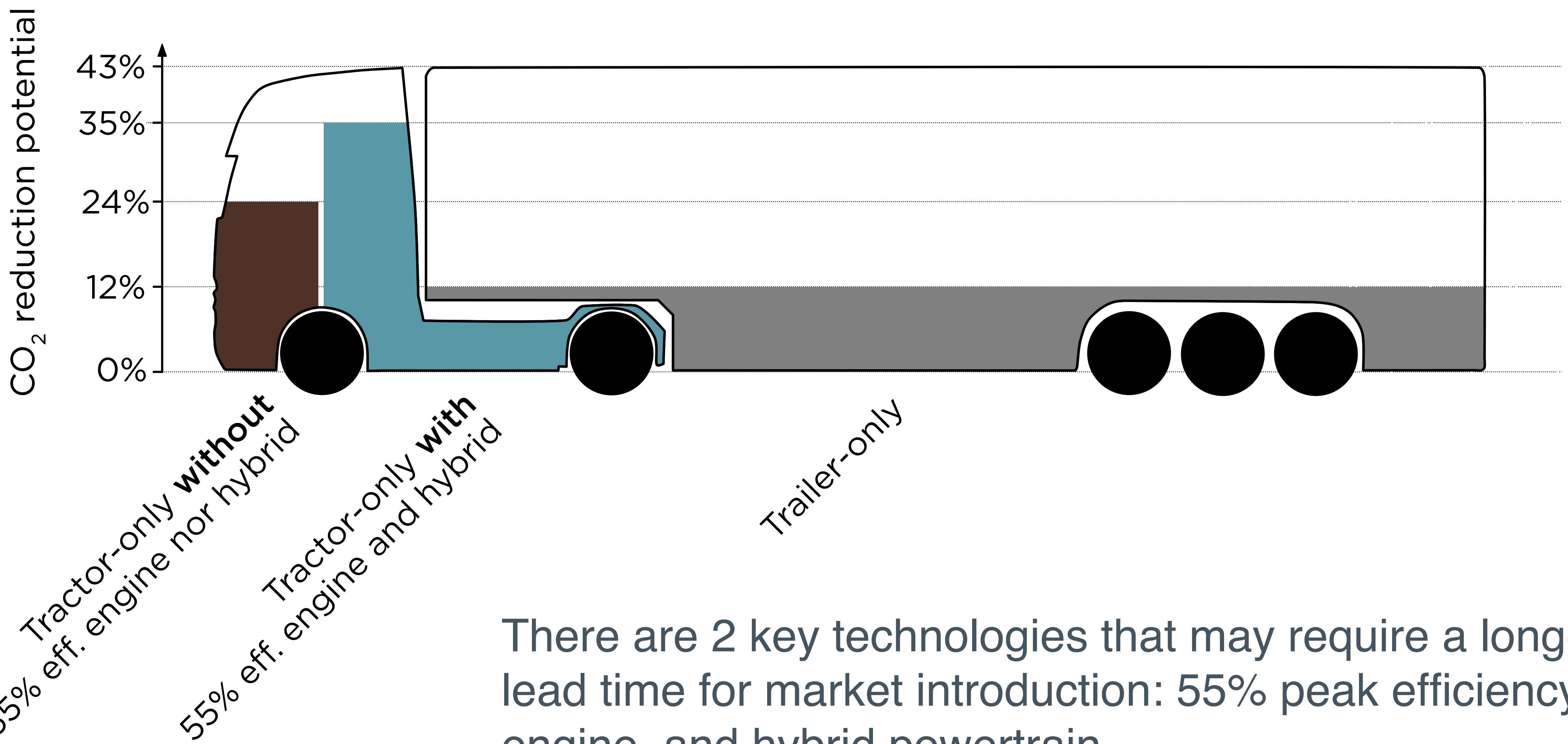
Policy recommendations

Key messages

1. ICCT's studies indicate a potential for long-haul tractor trucks (without including trailer technologies) of **35% by 2030**.
2. Long-term technology forcing standards guarantee the CO_2 emissions reductions needed to meet EU's targets, while providing enough lead-time for industry to develop the required technologies.
3. Complementary efficiency standards for trailers and engines would lead to additional CO_2 savings

Tractor-only technologies: 35% CO_2 reduction potential by 2030

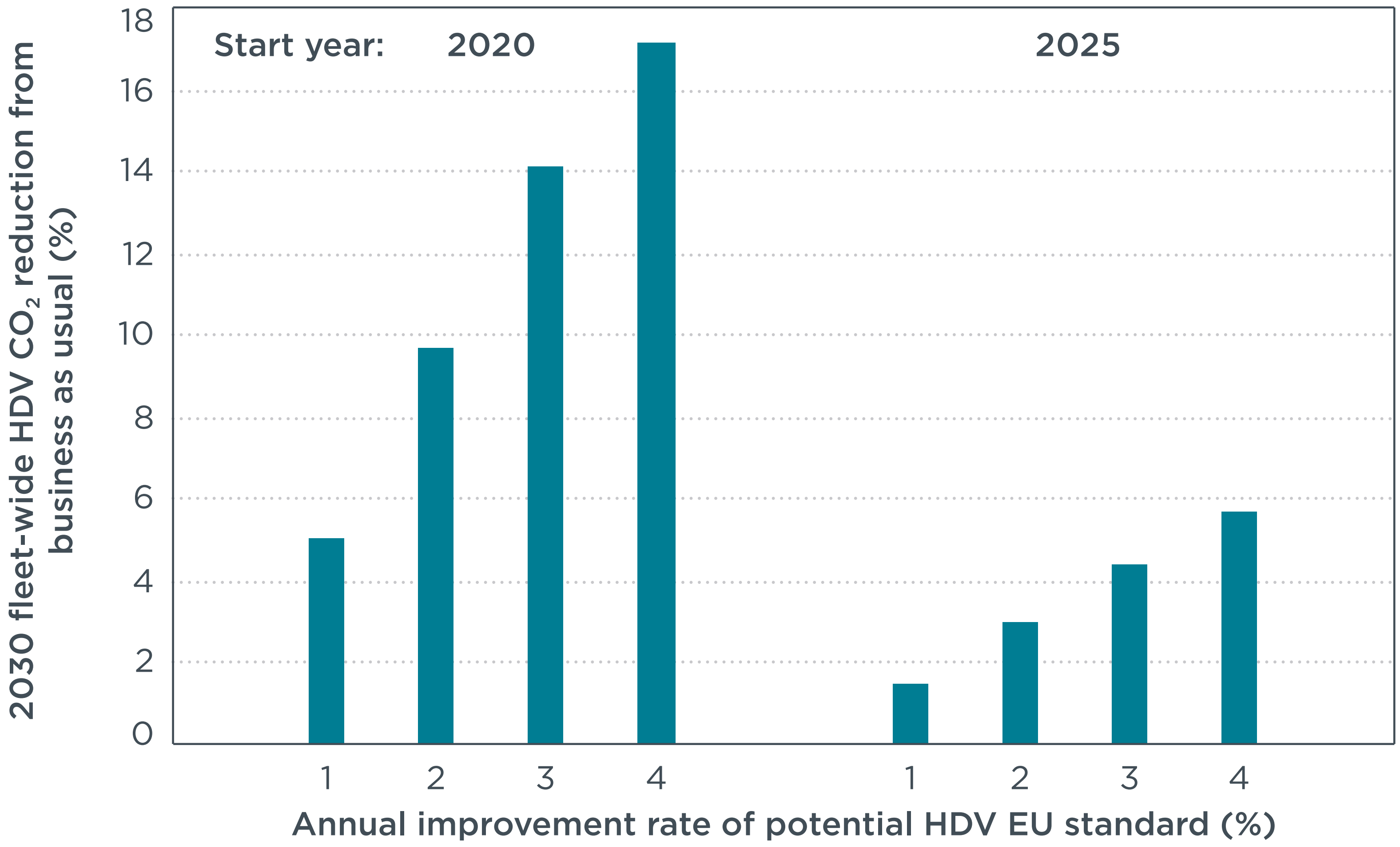


There are 2 key technologies that may require a longer lead time for market introduction: 55% peak efficiency engine, and hybrid powertrain

Timing and stringency should maximize the benefits by 2030, to meet EU targets

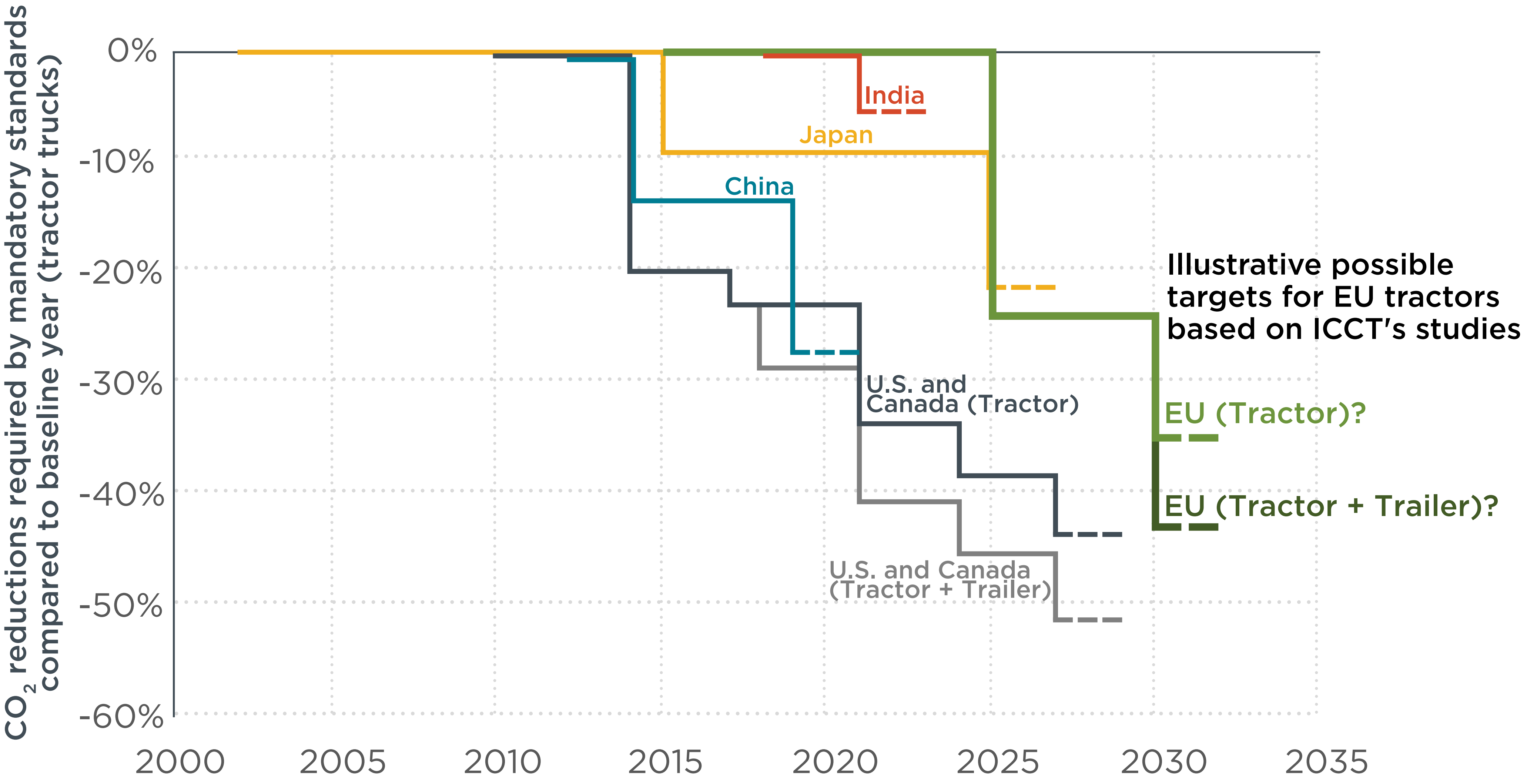
Standard should start impacting new HDVs as soon as possible to achieve benefits by 2030.

A delayed introduction of a stringent standard has lower benefits than the early introduction of a less stringent standard



Source: Muncrief, R. (2016). Europe should set binding CO2 reduction targets for trucks (Blog). International Council on Clean Transportation. https://www.theicct.org/blogs/staff/europe-should-set-binding-co2-reduction-targets-trucks

The upcoming EU HDV CO_2 standards will set a benchmark for other G20 economies considering HDV standards



For more detail, see ICCT's studies on HDVs in the EU (1/2)

- European Heavy-Duty Vehicles – Cost effectiveness of fuel efficiency technologies for long-haul tractor-trailers in the 2025-2030 timeframe
  http://theicct.org/publications/cost-effectiveness-of-fuel-efficiency-tech-tractor-trailers
- Fuel Efficiency Technology in European Heavy-Duty Vehicles: Baseline and Potential for the 2020–2030 Time Frame
  http://www.theicct.org/EU-HDV-fuel-efficiency-tech-2020-2030
- Heavy-duty vehicles technology potential and cost study
  https://www.theicct.org/publications/heavy-duty-vehicles-technology-potential-and-cost-study
- A roadmap for heavy-duty engine CO2 standards within the European Union framework
  http://www.theicct.org/publications/roadmap-heavy-duty-engine-co2-standards-within-european-union-framework
- Market Penetration of Fuel Efficiency Technologies for Heavy-Duty Vehicles in the EU, US and China
  http://www.theicct.org/market-penetration-HDV-fuel-efficiency-technologies
- Barriers to the adoption of fuel-saving technologies in the trucking sector
  https://www.theicct.org/publications/barriers-adoption-fuel-saving-technologies-trucking-sector
- Certification of CO2 emissions and fuel consumption of on-road heavy-duty vehicles in the European Union
  http://www.theicct.org/hdv-co2-certification-eu-policy-update-20170731
- Shell game? Debating real-world fuel consumption trends for heavy-duty vehicles in Europe
  https://www.theicct.org/blogs/staff/debating-EU-HDV-real-world-fuel-consumption-trends

For more detail, see ICCT's studies on HDVs in the EU (2/2)

- Europe should set binding CO2 reduction targets for trucks
  https://www.theicct.org/blogs/staff/europe-should-set-binding-co2-reduction-targets-trucks
- The European Union's leadership void on heavy-duty vehicle GHG standards
  https://www.theicct.org/blogs/staff/EU-leadership-void-HDV-GHG-standards
- Europe's global leadership on vehicle emission standards at risk in the truck sector
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- Overview of the heavy-duty vehicle market and CO2 emissions in the European Union
  https://www.theicct.org/publications/overview-heavy-duty-vehicle-market-and-co2-emissions-european-union
- Literature review: Real-world fuel consumption of heavy-duty vehicles in the United States, China, and the European Union
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