Heavy-Duty Vehicle Efficiency
Global status and current research

Oscar Delgado, Senior Researcher

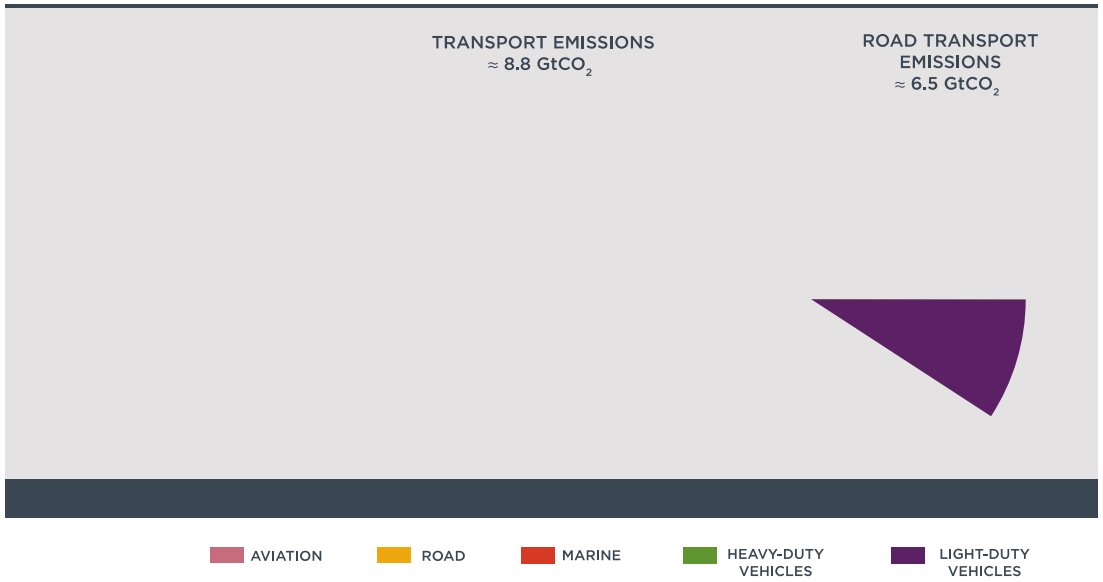
GFEI Fuel Economy State of the World – Jan 11 2016

icct
THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

Outline

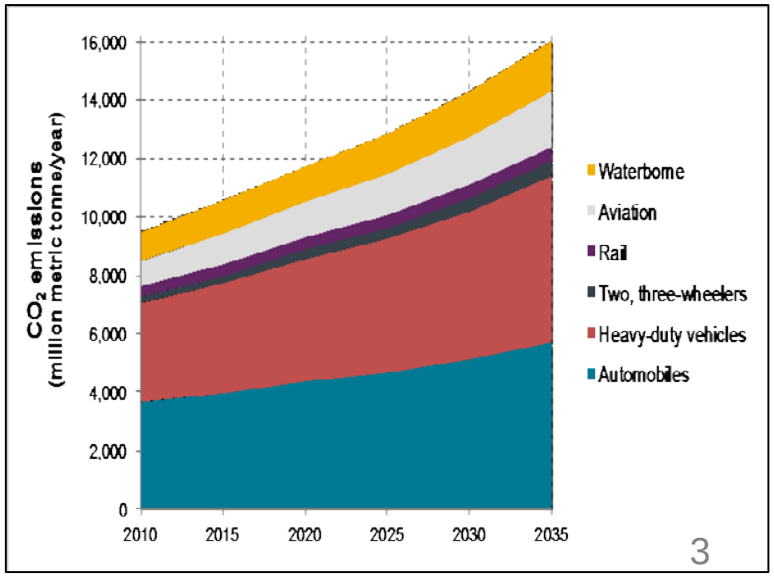
- Relevance of HDVs and status of regulations
- ICCT research on US technology potential
- Global technology potential project

Relevance of heavy-duty vehicles



- HDV represents 8% of total energy consumption and CO_2 emissions.

- Growth in HDV energy consumption and CO_2 emissions predicted to outpace growth in other modes.
- Forecasted 72% increase from 2010-2030.

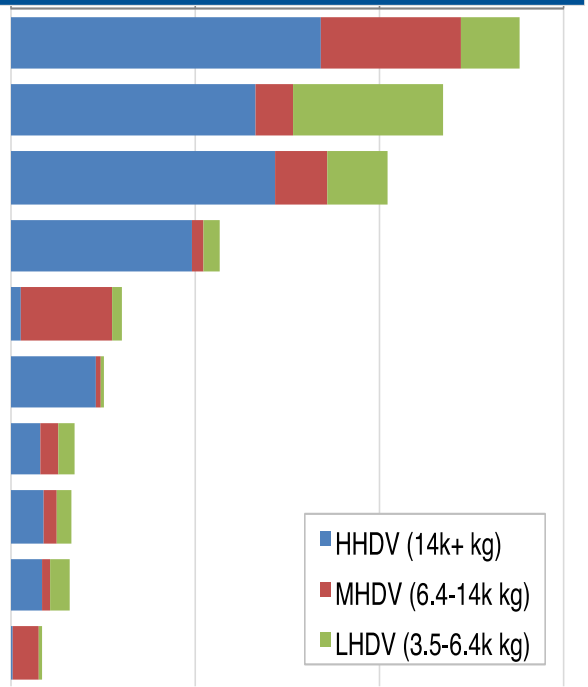


icct THE INTERNATIONAL COUNCIL ON Clean Transportation

HDV Global Regulatory Landscape

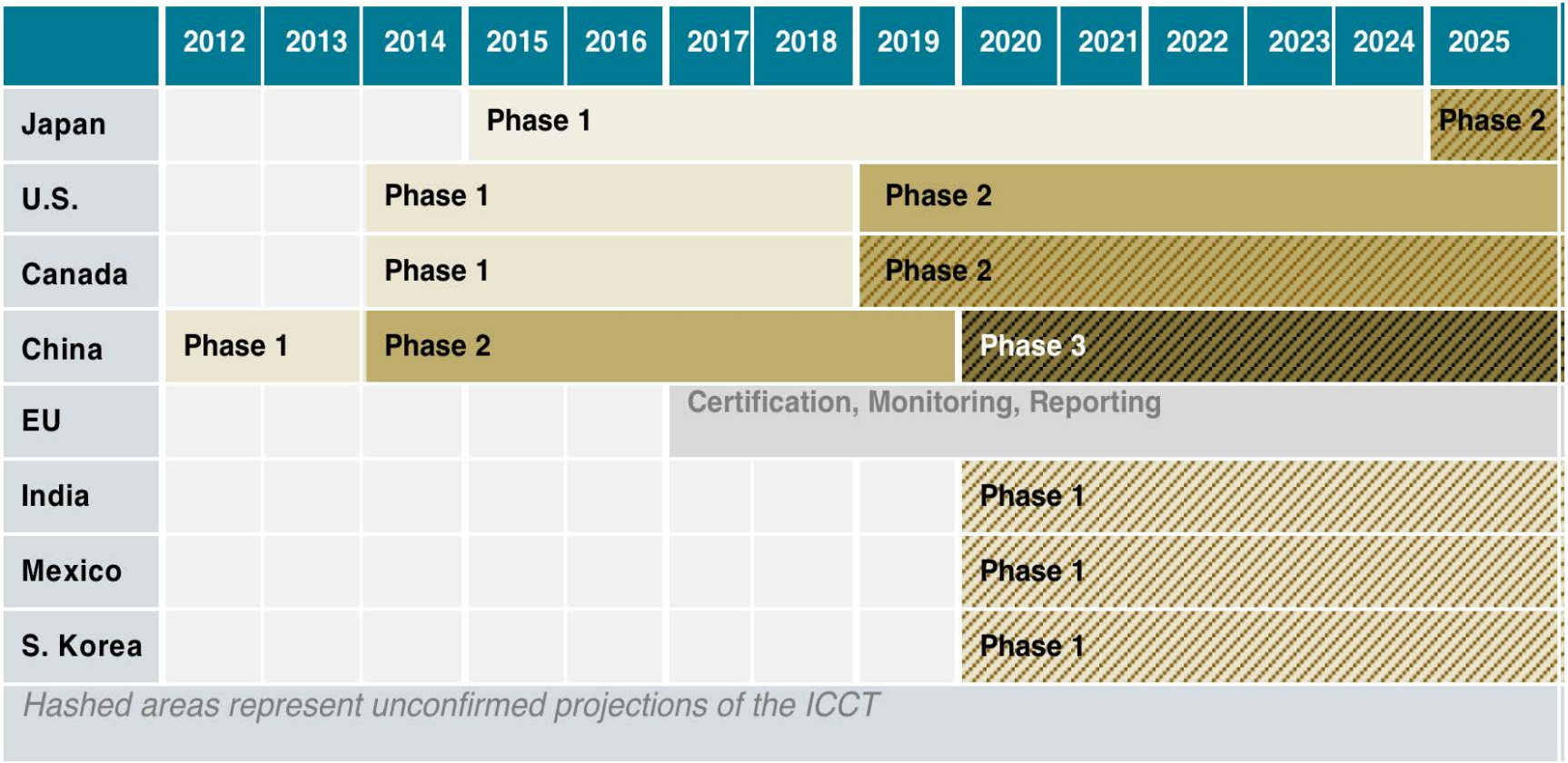
- Major markets shown cover over 75% of freight ton-km and energy use
- Only four countries in the world currently have HDV CO_2/efficiency standards

	HDV efficiency regulation in place	Regulations under consideration
U.S.	✓	✓
China	✓	✓
EU-27		✓
India		✓
Japan	✓	✓
Brazil		✓
Canada	✓	✓
Russia		
Mexico		✓
S. Korea		✓

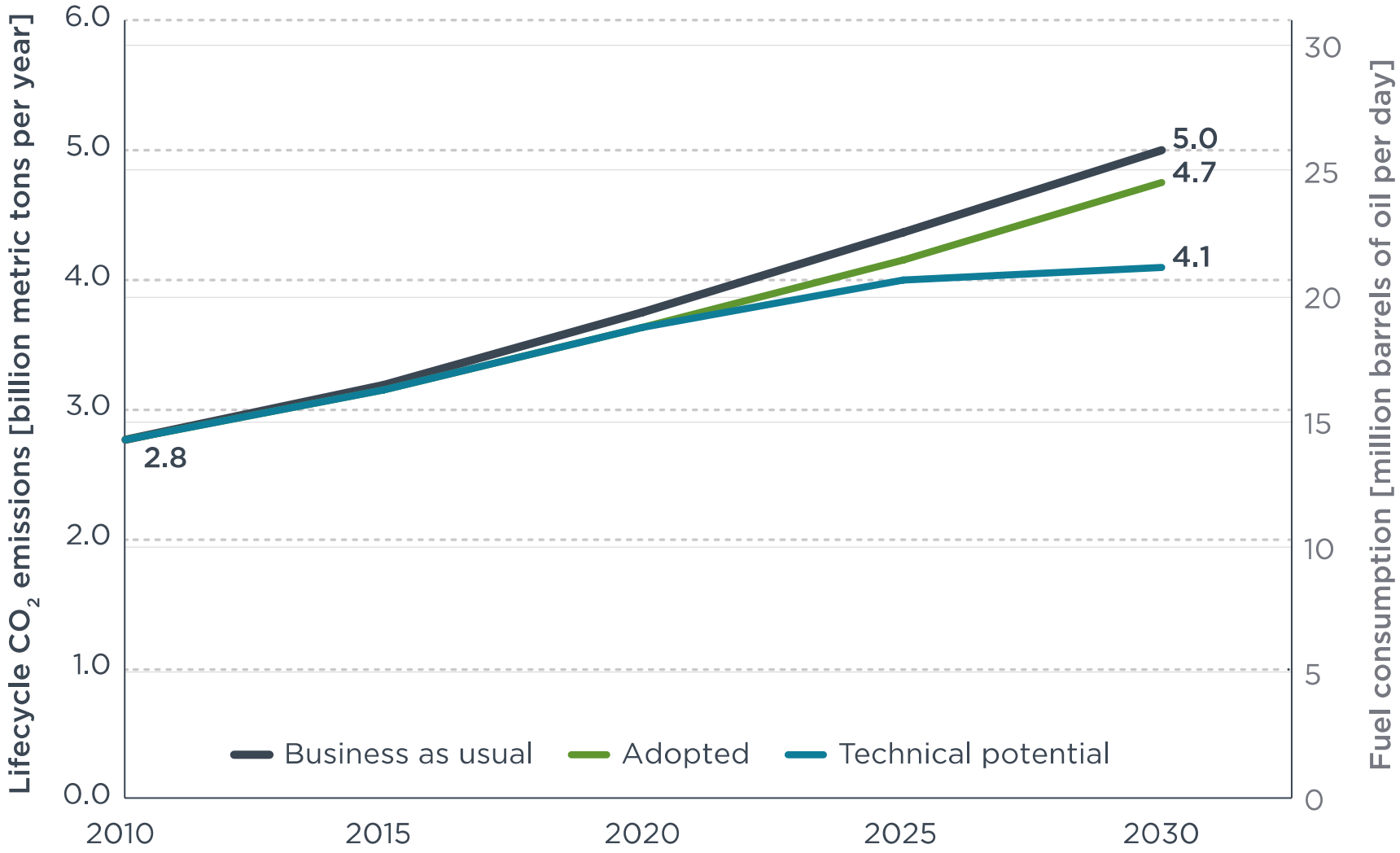


HDV Global Regulatory Landscape

- Four countries in the world currently have HDV CO2/efficiency standards
- Others are working towards standards



Impact of heavy-duty efficiency standards on global CO_2 emissions



ICCT Research: Tractor-trailer technology potential

- Objective:
  - Assess US heavy-duty tractor-trailer efficiency potential in the 2020-2030 timeframe.
  - Develop state-of-the-art model that models the system interactions between engine, transmission, aerodynamics, rolling resistance, lightweighting efficiency technologies
  - Develop flexible modeling capabilities for vehicle vehicle types, different vehicle test cycles, different baseline markets
- Project steps
  - Engine laboratory data collection and energy audit.

http://www.theicct.org/heavy-duty-vehicle-diesel-engine-efficiency-evaluation-and-energy-audit

  - Stakeholder workshop to solicit input from key industry players

http://www.theicct.org/stakeholder-workshop-report-tractor-trailer-efficiency-technology-2015-2030

  - Full-vehicle system technology modeling using vehicle simulation software (Autonomie) + development of Advanced Truck Technology Efficiency Simulation Tool (ATTEST)

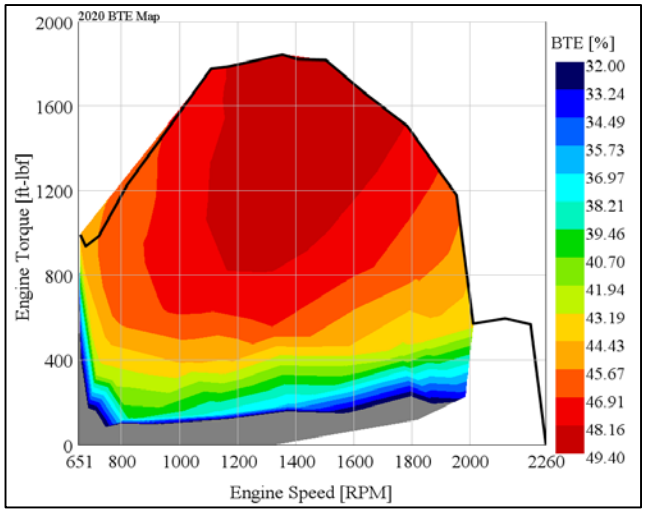
http://www.theicct.org/us-tractor-trailer-efficiency-technology

  - Cost assessment

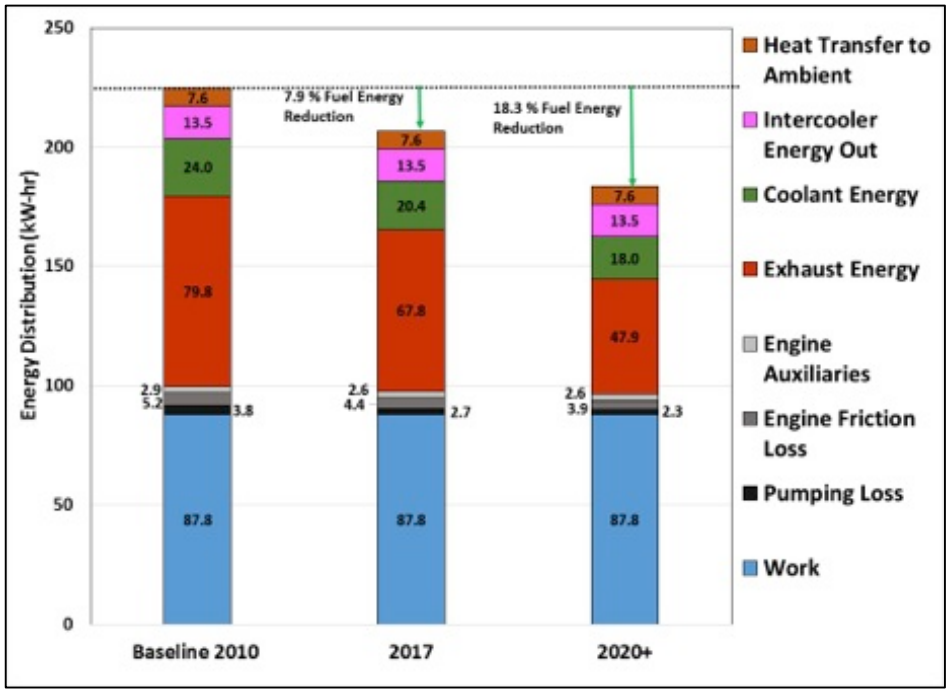
http://www.theicct.org/sites/default/files/publications/ICCT_tractor-trailer_tech-cost-effect_20150420.pdf

Engine analysis

- In collaboration with West Virginia University
- Data collection for engine compliant with US EPA 2010 regulations
  - Engine fuel consumption map (fuel use, vs torque, rpm)
  - Energy audit: breakdown of engine loss characteristics
  - Advanced improved energy efficiency potential in energy loss areas



Engine Maps

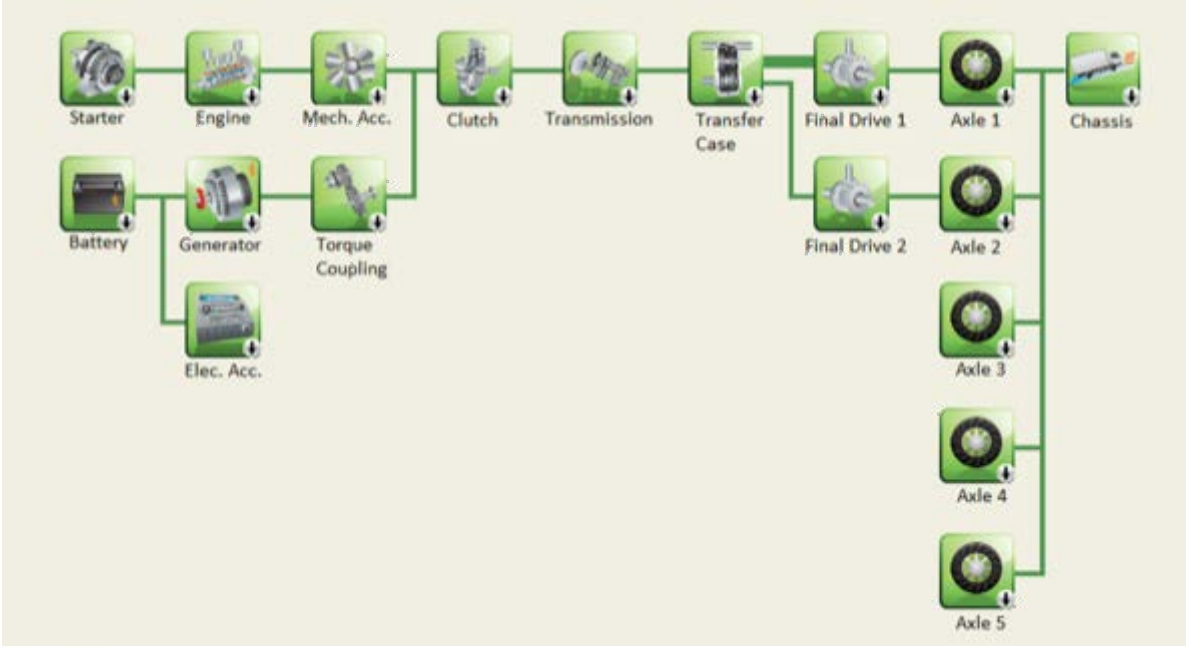


Engine audit, and projections

Thiruvengadam, et al. (forthcoming). Heavy-Duty Vehicle Diesel Engine Efficiency Evaluation and Energy Audit. West Virginia University.

Tractor-trailer vehicle simulation

- Full-vehicle systems modeling of engine, transmission, and road load efficiency technologies on tractor trailers
  - Utilize the widely-used Autonomie modeling framework to handle system interactions
  - Augment the Autonomie model for new engine map; improved engine, transmission technologies; improved road load technologies (aero, tires, weight)
  - Vehicle propulsion architecture shown:

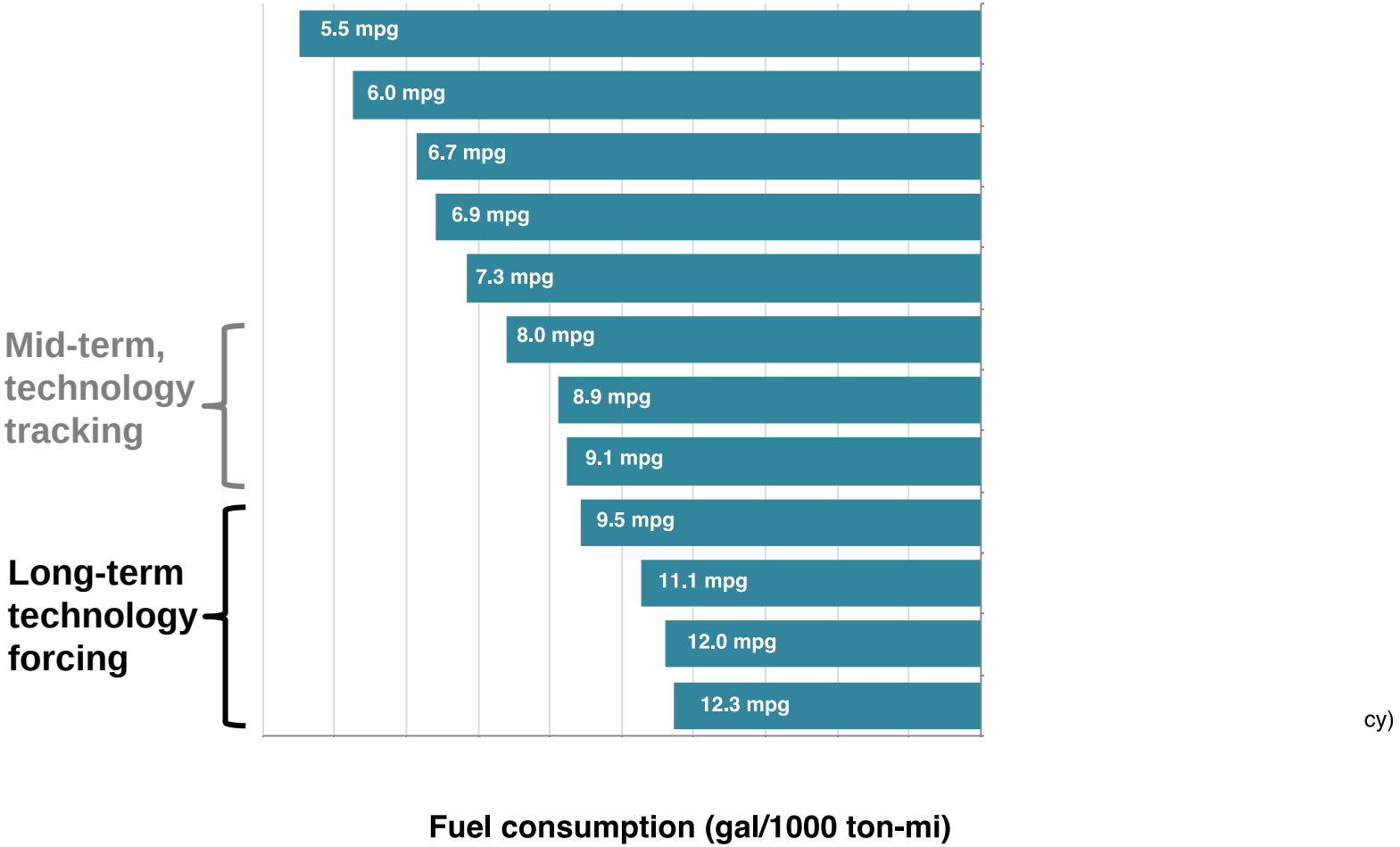


See Argonne National Laboratory (ANL). (2014). Autonomie. http://www.autonomie.net

ATTEST Tool Structure

User input
Autonomie simulation
Multiplicative aggregation of reduction
ATTEST Output

Results: Fuel consumption from selected efficiency technology packages



Next step: Global assessment

- Objective:
  - Conduct technical analysis to incorporate HDVs into the GFEI.

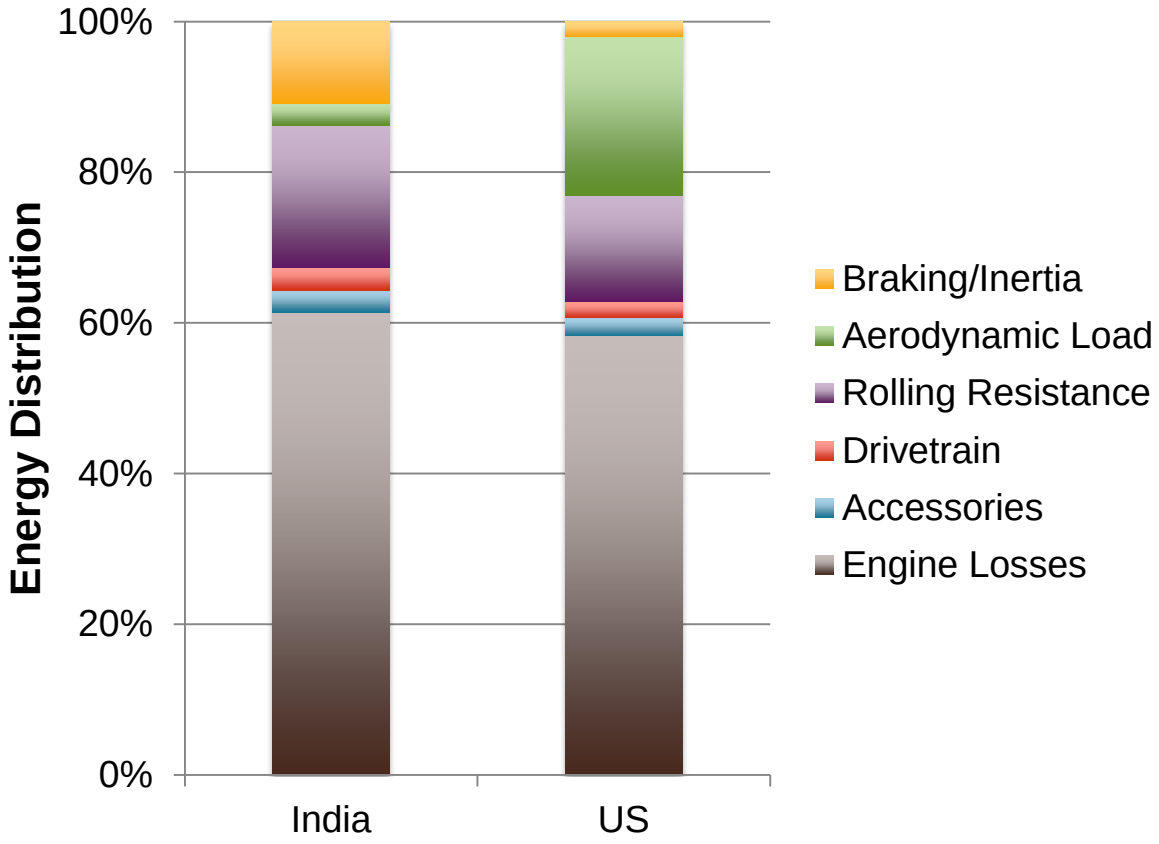
- Methodology:
  - Select representative vehicles.
    - Five markets: Brazil, China, EU, India, and US.
    - Two segments: tractor-trailer and rigid trucks.
  - Gather engine and vehicle data to create a baseline.
    - Engine maps
    - Vehicle parameters (tires, aerodynamics, mass, etc.)
    - Duty cycle (speeds, grade, payload)
  - Simulate technology potential to 2030
    - Equivalent to US SuperTruck technology level for US and EU
    - Equivalent to US Phase 2 technology level for Brazil, China, India
  - Map remaining world markets
    - To the market which they are most similar
    - Use ICCT roadmap model to estimate sales-weighted reductions that are possible.

Comparison of HDVs in different markets (preliminary)

	Brazil	China	EU	India	US
					
A	6x2	6x4	4x2	4x2	6x4
B	9.7t	10t	7t	6t	8t
C	35t	33t	40t	40t	36t
D	MT	MT	AMT, 12 spd.	MT, 6 spd.	MT, 10 spd.
E	13L	< 11L	13L	< 6L	15L
F	~325kW	~260kW	~325kW	~135kW	~340kW
G	Proconve 7	China IV	Euro VI	Bharat III	US EPA 2010

A: axle configuration, B: tractor curb weight, C: GVW,
D: Transmission type, E: engine displacement,
F: engine power G: emission standard

Comparison of HDVs in different markets (preliminary)



Energy audit for representative tractor-trailers in India and US.

Observations and conclusions

- Regulatory action needed to address CO_2 emissions and fuel use from heavy-duty vehicles.
  - Japan, US, China and Canada currently have programs while India, Mexico, Korea and Europe are actively developing programs.
- Country-specific analysis required to evaluate technology potential.
  - Complexity added by differences in market structure, baseline fleet, and duty cycles.
  - However, shared use of simulation models holds promise.
- Strong compliance programs required
  - Conformity of production and in-use verification requirements are needed to ensure that regulatory requirements translate to real-world.

Thank you!

oscar@theicct.org