Heavy-duty vehicle technology potential around the world

Ben Sharpe

IEA-PCRA workshop on heavy-duty vehicle fuel efficiency regulations

New Delhi, India

April 29, 2015

THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

Outline

- Big picture: regulatory development globally
- Heavy-duty vehicle (HDV) energy balance examples
- Technology potential studies for North America and Europe
- Comparing technology potential in different regions around the world and preliminary observations for India
- Conclusions

The International Council on Clean Transportation

- Non-profit research organization incorporated in 2005
- Roughly 35 full-time staff with offices in San Francisco, Washington DC, Berlin, London, and Beijing
- Mission: improve the environmental performance and energy efficiency of all modes of motorized transportation – passenger cars, heavy-duty trucks and buses, ocean-going ships, and commercial aviation – and the fuels they burn to address air pollution and climate change

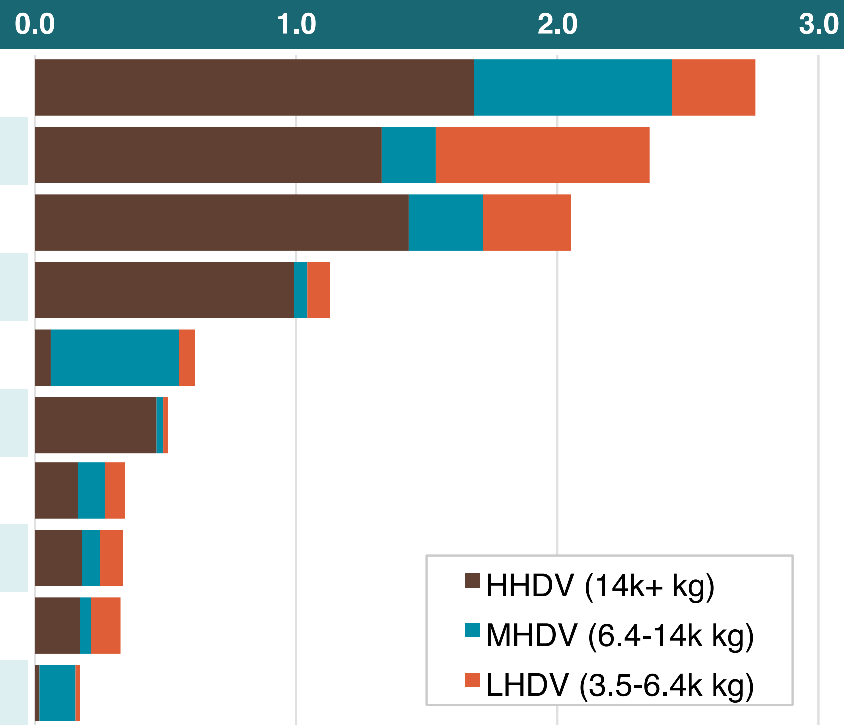
Industry survey project

- Primary objectives
  - Interview a diverse cross-section of stakeholders in the trucking industry in India to build a deeper understanding on a number of topics related to fuel-saving technologies and practices
  - Gain insights into the key factors in decision-making processes for manufacturers and fleets
- Targeted stakeholder groups
  - Truck and bus original equipment manufacturers
  - Tier 1 suppliers (e.g., engines, transmissions, tires/wheels)
  - Truck and bus fleets
  - Testing facilities
  - Industry associations
- **All responses will be kept anonymous!**
- Key contacts
  - Ben Sharpe, ICCT – ben@theicct.org
  - Jai Malik, TERI – jai.kishanmalik@teri.res.in

Efficiency regulations in major markets

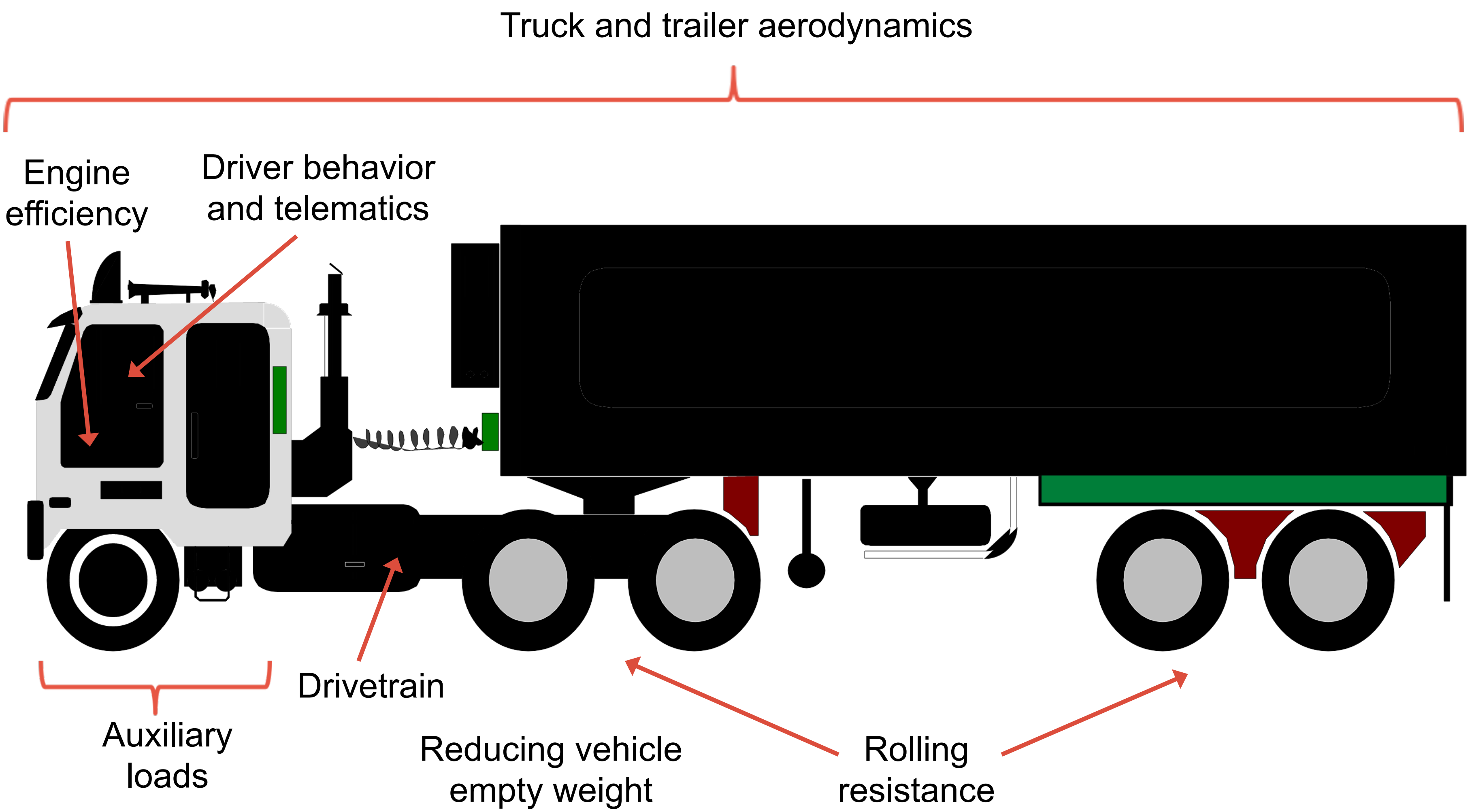
- Efficiency regulations under consideration in major freight markets
  - Markets include over 75% of HDV freight ton-km, HDV freight energy use

	HDV efficiency regulation in place	Regulations under consideration	Heavy-duty freight vehicle fuel use (million BOE/day)
U.S.	✓	✓	
China	✓	✓	
EU-27		✓	
India		✓	
Japan	✓	✓	
Brazil		✓	
Russia			
Canada	✓	✓	
Mexico		✓	
S Korea		✓	



Source: ICCT Roadmap, 2013; BOE = barrel of oil equivalent energy

Areas for on-vehicle efficiency improvements



Example energy balance: tractor truck and trailer

Tractor-trailer, HHDDT65 drive cycle (80 kph average), half loaded, level road

Major loss areas

Aerodynamic losses: 17%

Engine losses: 60%

Drivetrain: 1.5%

Auxiliary loads: 1.5%

Rolling resistance: 15%

Braking: 5%

Source: ICCT simulation analysis

Example energy balance: urban delivery truck

Urban delivery, HTUF Class 6 drive cycle (15 kph average), half loaded, level road

Major loss areas

Aerodynamic losses: 3%

Engine losses: 70%

Braking: 15%

Rolling resistance: 6%

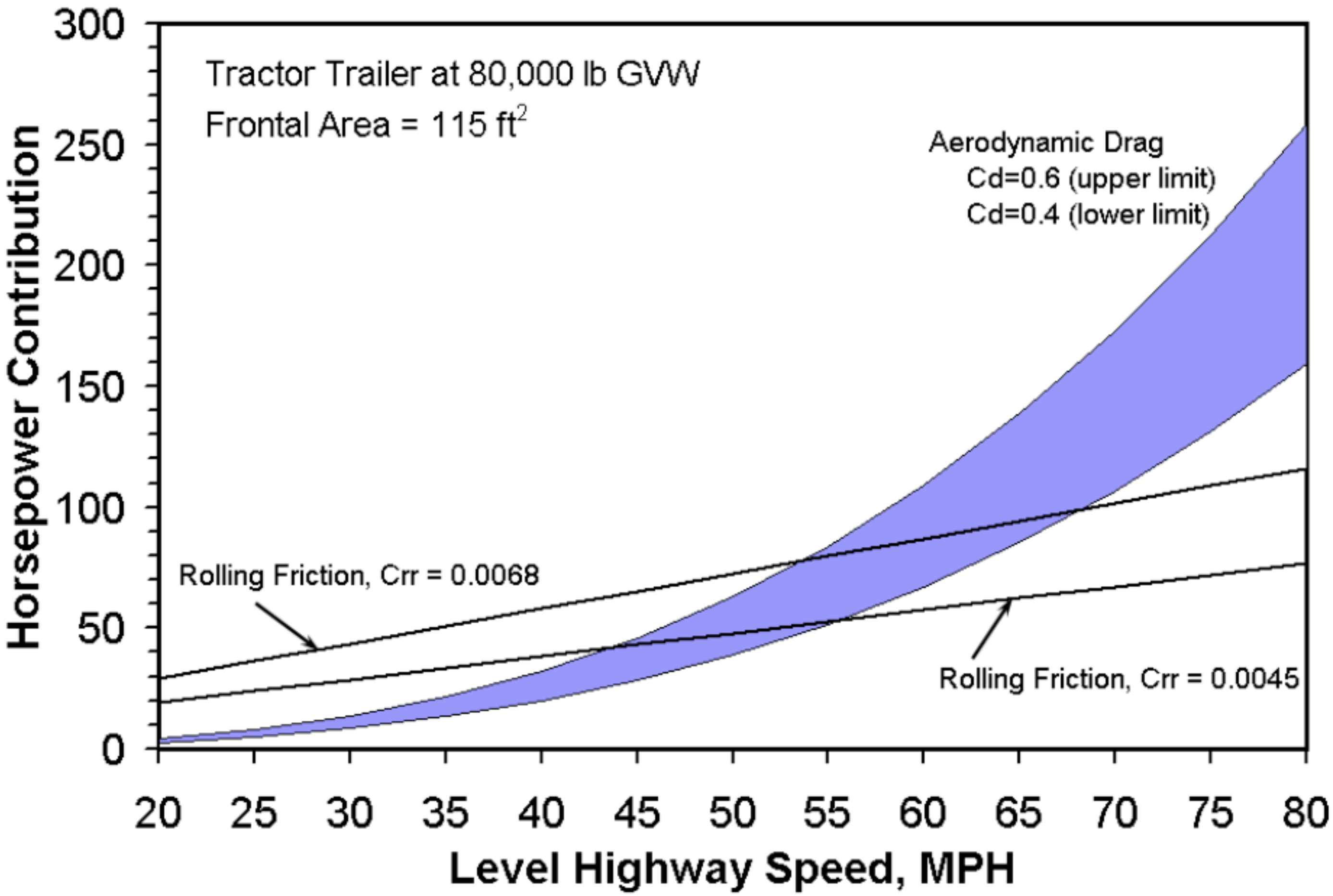
Drivetrain: 5%

Auxiliary loads: 1.5%

Source: ICCT simulation analysis

Impact of aerodynamics and rolling resistance as a function of speed

Aerodynamic drag contributes to an increasing portion of overall resistance as vehicle speed increases

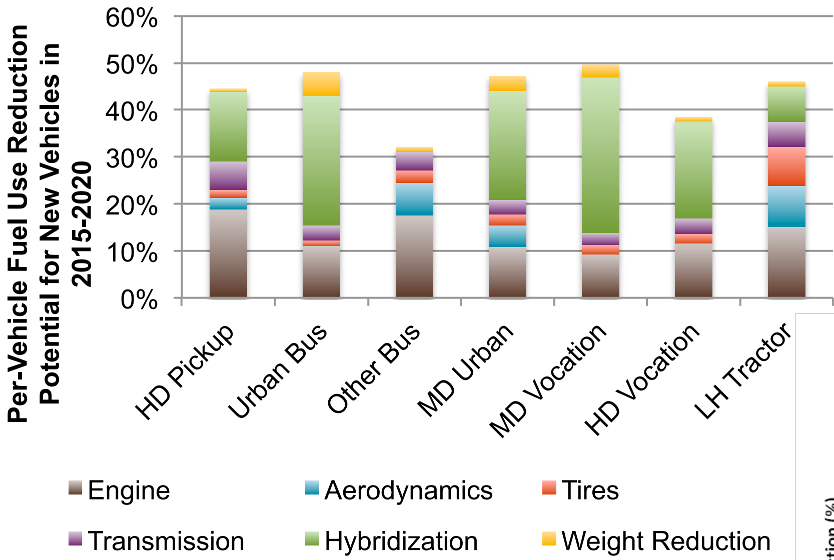


Source: TIAX (2009) Assessment of Fuel Economy Technologies for Medium- and Heavy-Duty Vehicles.

Studies on HDV technology potential

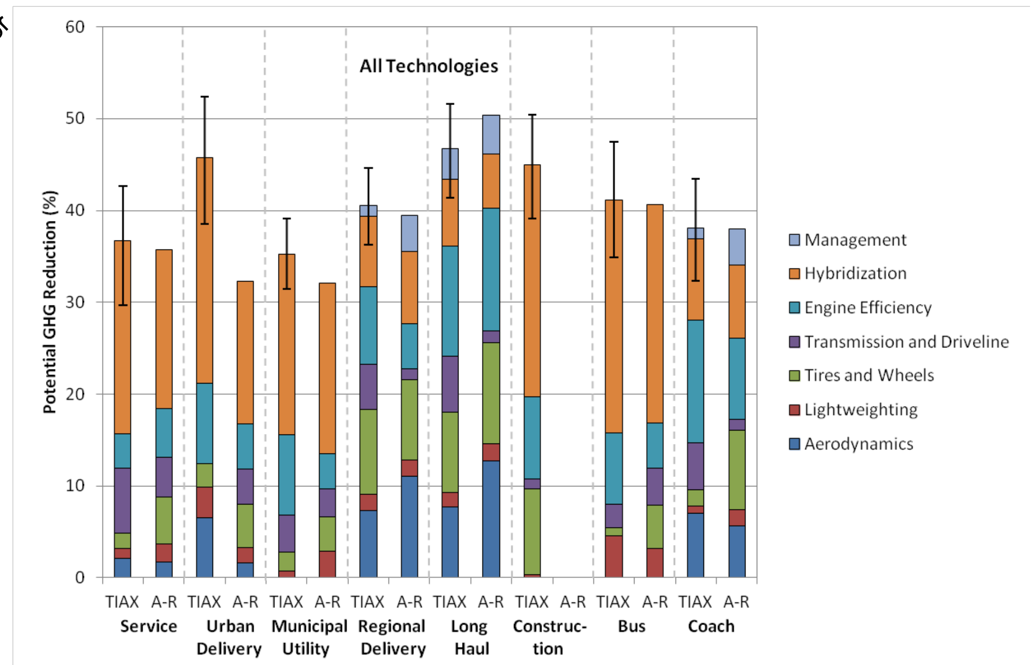
- North American studies
  - NESCAUM Tractor-trailer study (Oct 2009)
    - http://www.nescaum.org/documents/heavy-duty-truck-ghg_report_final-200910.pdf
  - National Research Council report (March 2010)
    - *http://www.nap.edu/catalog/12845/technologies-and-approaches-to-reducing-the-fuel-consumption-of-medium--and-heavy-duty-vehicles*
  - National Research Council report (April 2014)
    - *http://www.nap.edu/catalog/18736/reducing-the-fuel-consumption-and-greenhouse-gas-emissions-of-medium--and-heavy-duty-vehicles-phase-two*
  - Analysis of SuperTruck technologies (June 2014)
    - *http://www.theicct.org/us-supertruck-program-expediting-development-advanced-hdv-efficiency-technologies*
  - Tractor-trailer simulation modeling of technology potential (April 2015)
    - *http://www.theicct.org/us-tractor-trailer-efficiency-technology*
  - Tractor-trailer technology cost and payback period assessment (April 2015)
    - *http://www.theicct.org/us-tractor-trailer-tech-cost-effectiveness*
- European studies
  - LOT 1 report (Feb 2011)
    - http://ec.europa.eu/clima/policies/transport/vehicles/docs/ec_hdv_ghg_strategy_en.pdf
  - TIAX report (Jan 2012)
    - http://www.theicct.org/ghg-reduction-potential-heavy-duty-vehicles-eu

Substantial opportunity for HDV efficiency improvements



Source: National Research Council (2010). http://www.nap.edu/catalog/12845/technologies-and-approaches-to-reducing-the-fuel-consumption-of-medium--and-heavy-duty-vehicles

Studies from N. America and Europe show per-vehicle fuel consumption reduction potential of ~ 30-50% in the 2015 to 2020 timeframe compared to a 2010 baseline

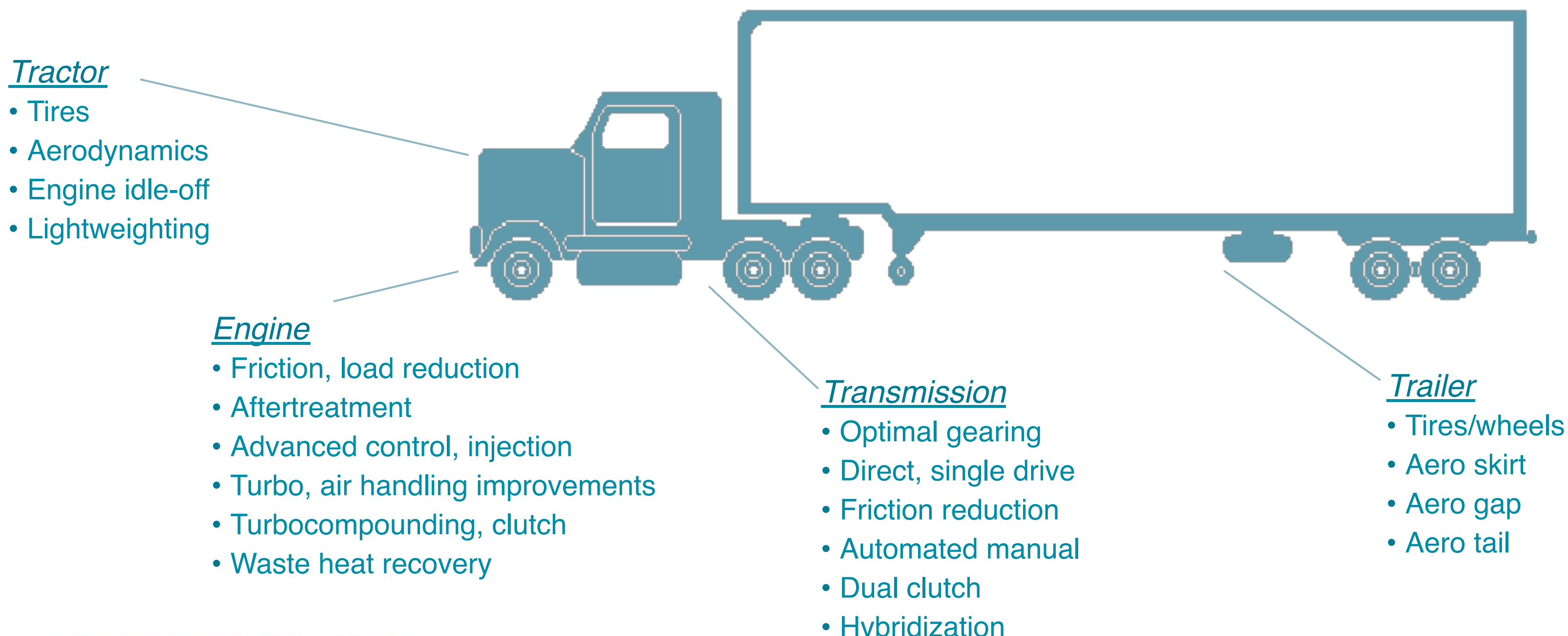


Source: TIAX (2012). http://www.theicct.org/ghg-reduction-potential-heavy-duty-vehicles-eu

icct THE INTERNATIONAL COUNCIL ON Clean Transportation

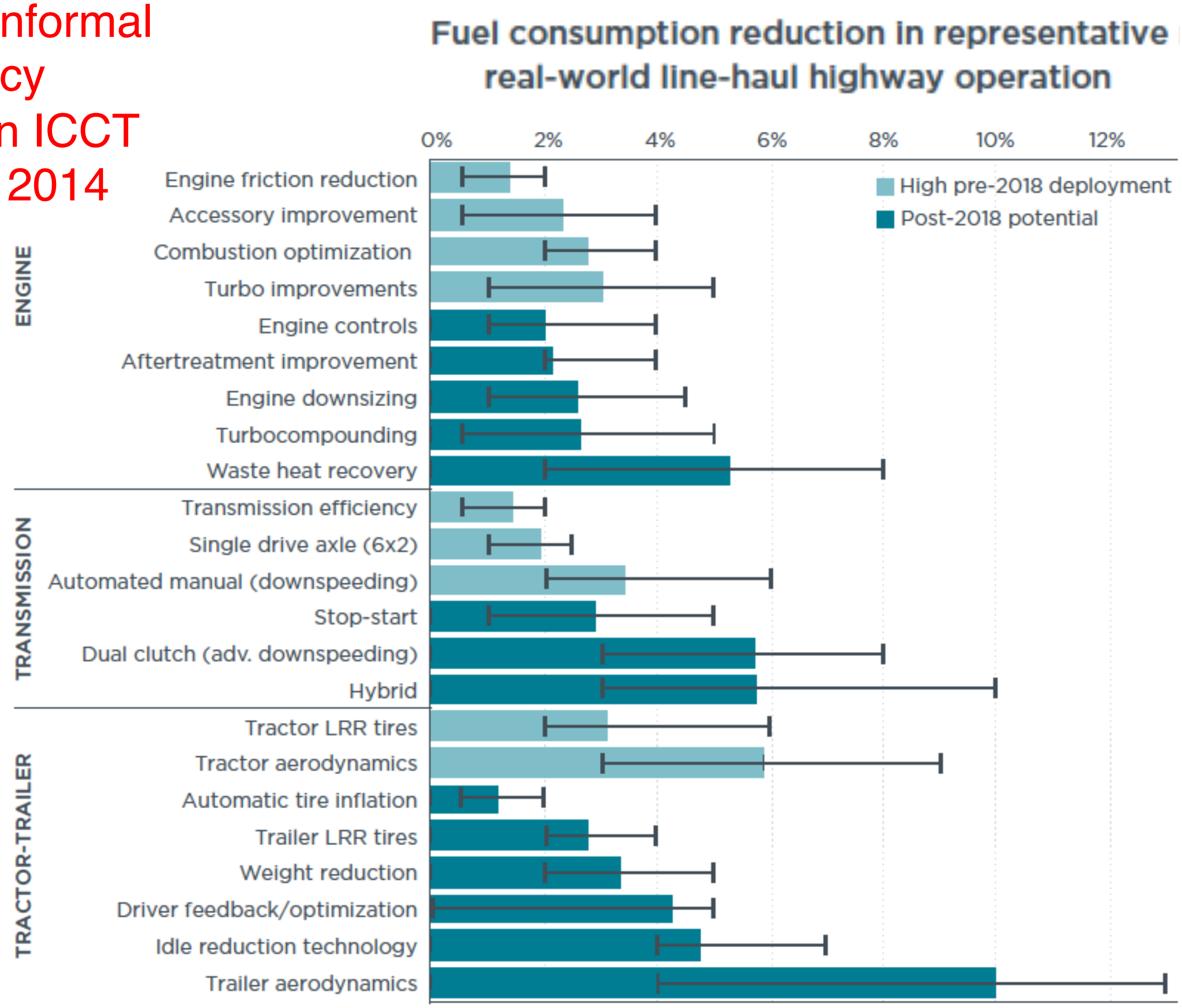
Tractor-trailer efficiency

- Combinations tractor-trailers are largest fuel consumer in most regions
  - For example, in the U.S., tractor-trailers are ~2% of all on-road vehicles, but consume 20% of vehicles' energy use and greenhouse gas emissions
  - According to the ICCT Roadmap model, tractor-trailers represent nearly 80% of total heavy-duty vehicle fuel use and carbon emissions in India
  - There are many available and emerging efficiency technologies



Fuel consumption reduction potential for tractor-trailers

Results from an informal technology efficacy survey done at an ICCT workshop in July 2014



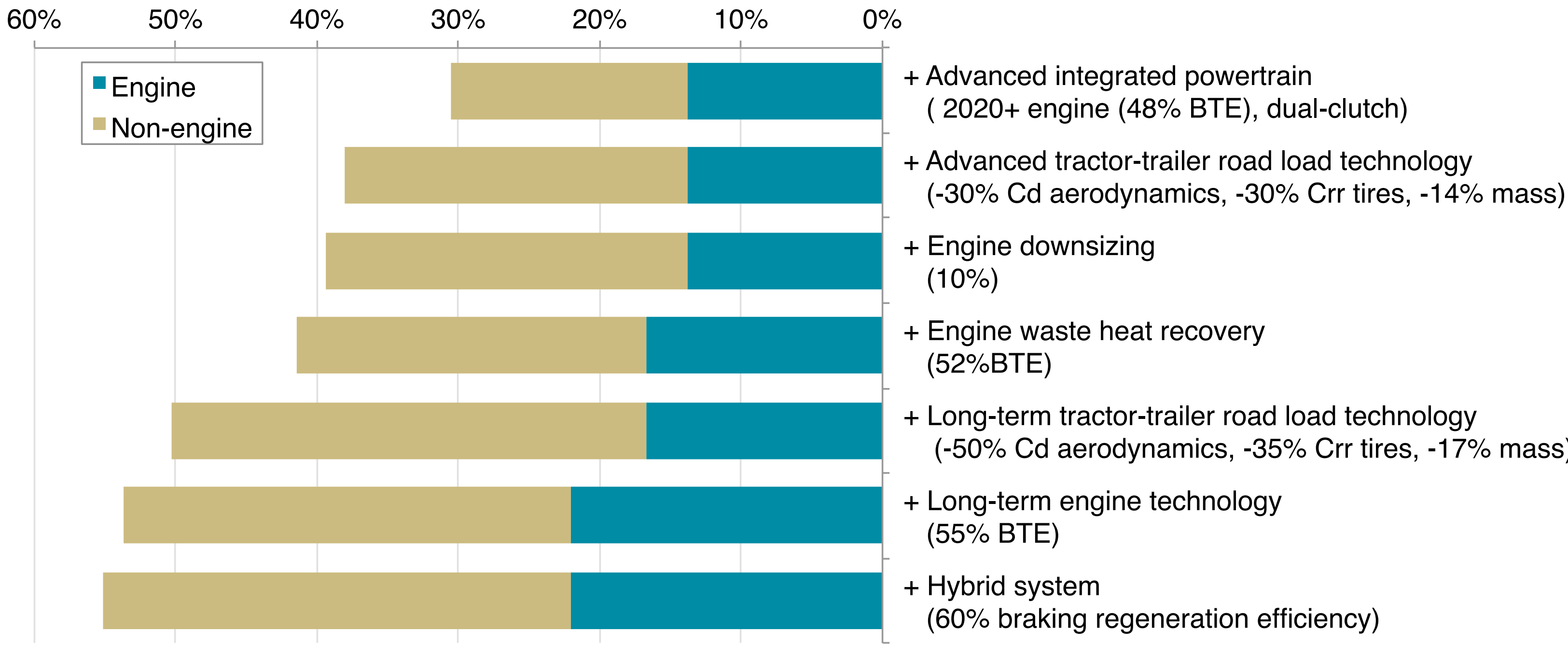
icct THE INTERNATIONAL COUNCIL ON Clean Transportation

From July 22, 2014 HDV stakeholder workshop with OEMs, suppliers, research groups, NGOs, government agencies. Lutsey et al (2014). http://www.theicct.org/stakeholder-workshop-report-tractor-trailer-efficiency-technology-2015-2030

Engine contribution to advanced efficiency packages

- ICCT's latest technology potential report for tractor-trailers in North America: engine efficiency amounts to about 1/3 to almost 1/2 of all potential fuel consumption benefits from 2020-2030 technology packages

Fuel consumption reduction from 2010 baseline

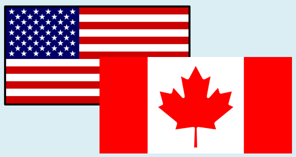
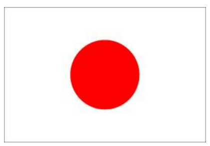


Delgado and Lutsey (2015). Advanced tractor-trailer efficiency technology potential in the 2020 to 2030 timeframe.
http://www.theicct.org/us-tractor-trailer-efficiency-technology

Preliminary technology potential observations for India

- Typical characteristics of HDVs in India
  - Freight hauling: lower speeds than trucks in Europe or North America; likely comparable to speeds in China
  - Overloading quite common
  - Trucks have lower power-to-weight ratios compared to other major markets
- Impacts for fuel efficiency
  - Lower speeds, high percentage of heavily-loaded trucks → engine and rolling resistance improvements much more important than aerodynamics

Relative contribution to overall technology potential for tractor-trailers

Country/region	Powertrain	Aerodynamics	Rolling resistance	Idle reduction	Hybridization	Weight reduction
	Moderate	Large	Moderate	Large	Moderate	Small
	Large	Small	Moderate	Small	Large	Small
	Large	Small	Large	Small	Moderate	Moderate
	Large	Moderate	Moderate	Small	Moderate	Small
	Large	Small	Large	Small	Moderate	Moderate

Large | Moderate | Small

Conclusions

- Development of HDV fuel efficiency and GHG regulations is happening in a number of countries and regions around the world
- Assessing the technology potential across the various categories of HDVs is an essential step in the regulatory development process
- Numerous studies evidence significant opportunities for the development and deployment of fuel-saving technologies
- Technology efficacy varies from region to region based on drive cycles, payloads, geography, and infrastructure conditions
- For India, engine and tire rolling resistance improvements are the technology areas that likely present the biggest opportunities for fuel savings in the near-term

Thank you!

Ben Sharpe *ben@theicct.org*
Anup Bandivadekar *anup@theicct.org*

Overview of heavy-duty vehicle regulations globally

Anup Bandivadekar

IEA-PCRA workshop on heavy-duty vehicle fuel efficiency regulations
New Delhi, India
April 29, 2015

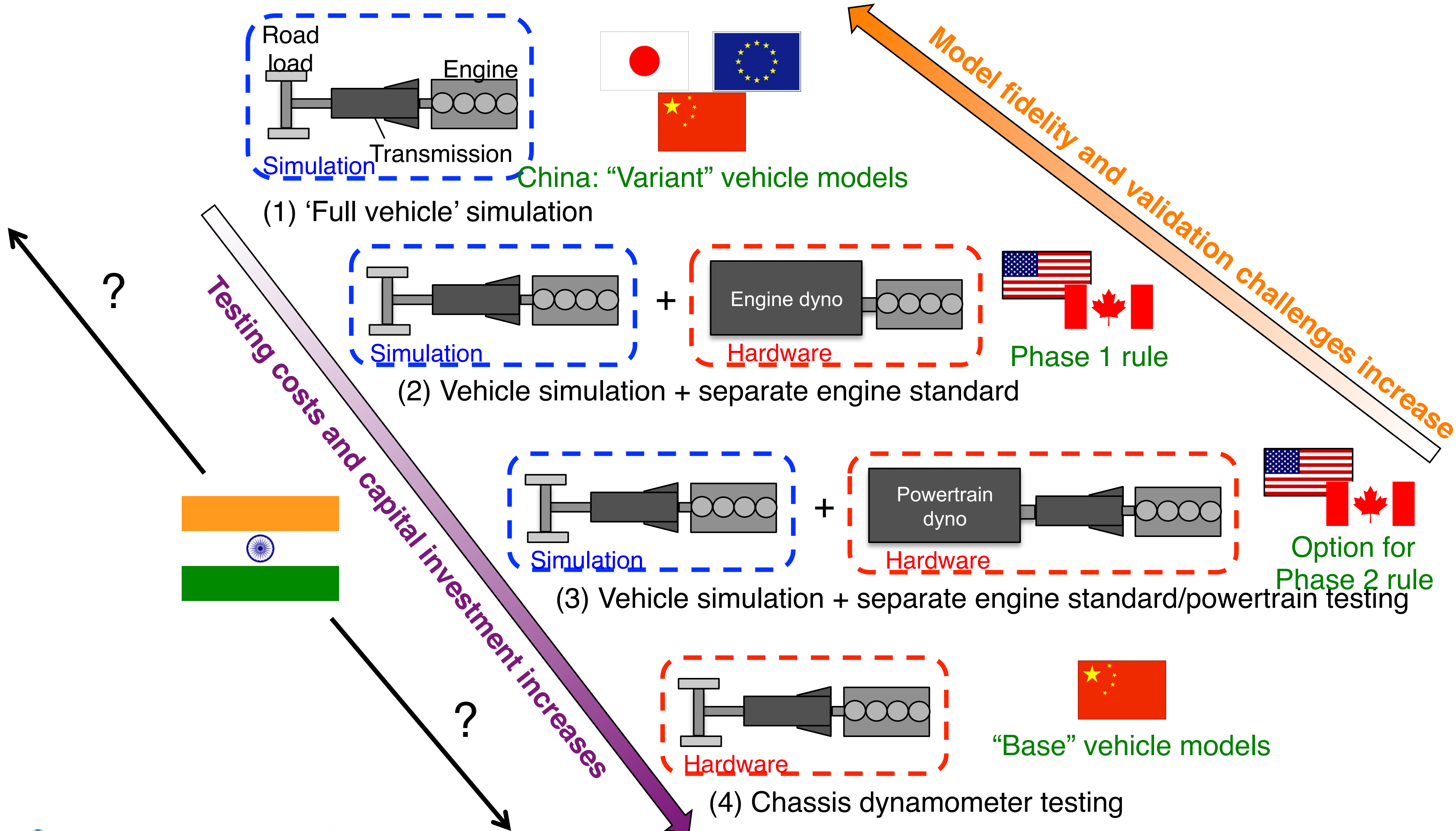
THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

Regulatory development timelines

Country/ Region	Regulation Type	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Japan	Fuel economy						Phase 1 regulation implemented starting MY 2015						
							Phase 2 under consideration					Phase 2 implementation	
United States	GHG/Fuel efficiency	Standard proposal	Final rule				Regulation implemented starting MY 2014 (mandatory DOT program starts MY 2016)						
					Phase 2 regulatory development		Phase 2 proposal	Phase 2 final rule				Phase 2 implementation	
Canada	GHG			Standard proposal	Final rule		Regulation implemented starting MY 2014 (optional until MY 2016)						
						Phase 2 regulatory development		Phase 2 proposal	Phase 2 final rule			Phase 2 implementation	
China	Fuel consumption	Test procedure finalized	Industry standard proposal	Industry standard implemented	National standard adopted	Final regulation of National standard effective on July 1, 2014 for newly certified vehicles and July 1, 2015 for existing vehicles						Next phase implementation	
European Union	CO_2 test procedure	Technical studies			Impact assessment	Test protocol and simulation model finalization						Policy implementation	
Korea	Fuel efficiency	Technical studies			Impact assessment and test procedure development		Regulatory development and finalization						
California	End-user purchase requirements	Requirements for new tractors, trailers (2011+)			Additional requirements for existing tractors and trailers (< MY 2010)			Additional requirements for existing trailers and reefers (< MY 2010)					

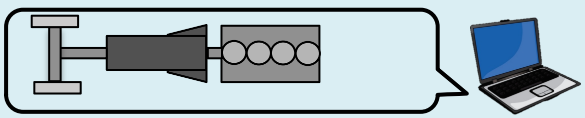
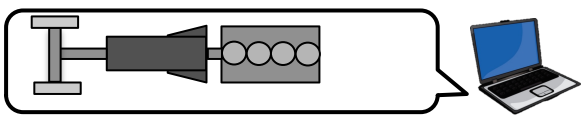
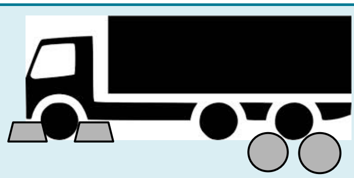
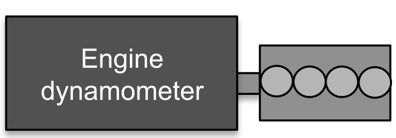
Items in blue are ICCT expectations (not public announcements)

Continuum of test procedure options



icct THE INTERNATIONAL COUNCIL ON Clean Transportation

Qualitative assessment of test procedure options for India

Certification option	Ability to leverage existing testing facilities	Complexity of certification process	Timeframe for regulatory implementation
 **Full vehicle simulation – adapted version of VECTO, GEM, Japan or China model**			5-7 years
 **Full vehicle simulation – new India model**		?	5-7 years
 **Chassis dynamometer**			5-7 years
 **Engine dynamometer**			3-5 years

Favorable

Moderate

Unfavorable