Policy Measures for Reducing Greenhouse Gas Emissions from Heavy-Duty Vehicles: California, the US, and the World

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Sustainable Transportation Seminar
The Precourt Energy Efficiency Center
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Topics

- Background and overview of policy measures in increase heavy-duty vehicle (HDV) efficiency
- Regulatory timelines across countries/regions
- Voluntary ‘green freight’ programs
- Regulatory design summaries and considerations for next phases of fuel efficiency and GHG regulations
  - California
  - US and Canada
  - Japan
  - China
  - European Union
- Summary remarks

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The International Council on Clean Transportation

- The mission of the ICCT is to dramatically improve the environmental performance and efficiency of onroad vehicles, aircraft, and marine vessels in order to protect public health, the environment, and quality of life
- Full-time staff of roughly 40
- Staff are natives of 10 countries and speak more than a dozen languages
- Offices in San Francisco, Washington DC, Berlin

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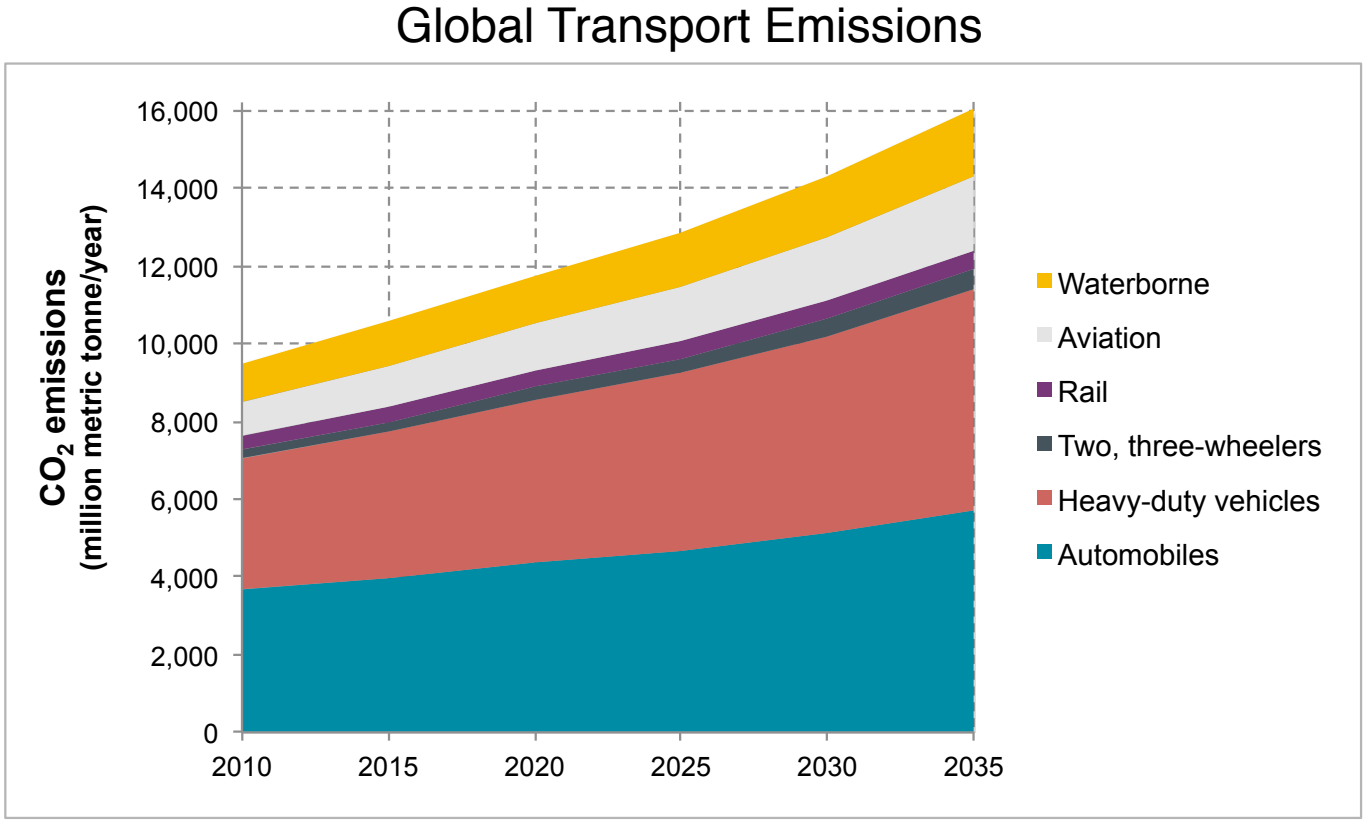
Background: HDV CO_2 Emissions

- Heavy-duty vehicles are a major, growing energy demand and CO_2 source
- Policies for light-duty are well underway, but policies for HDVs are in early phases



Source: ICCT Roadmap Model, 2013

Integrated Vehicle Efficiency Policy Portfolio

Today's presentation

VEHICLE FUEL EFFICIENCY STANDARDS	• Introduce and regularly strengthen mandatory standards • Establish and harmonize testing procedures for fuel efficiency measurement.
FISCAL MEASURES	• Fuel taxes and vehicle taxes to encourage the purchase of more fuel-efficient vehicles. • Infrastructure support and incentive schemes for very fuel-efficient vehicles.
MARKET-BASED APPROACHES	• Voluntary programs such as U.S. SmartWay and other green freight programs
INFORMATION MEASURES	• Vehicle fuel economy labels • Improving vehicle operational efficiency through eco-driving and other measures.

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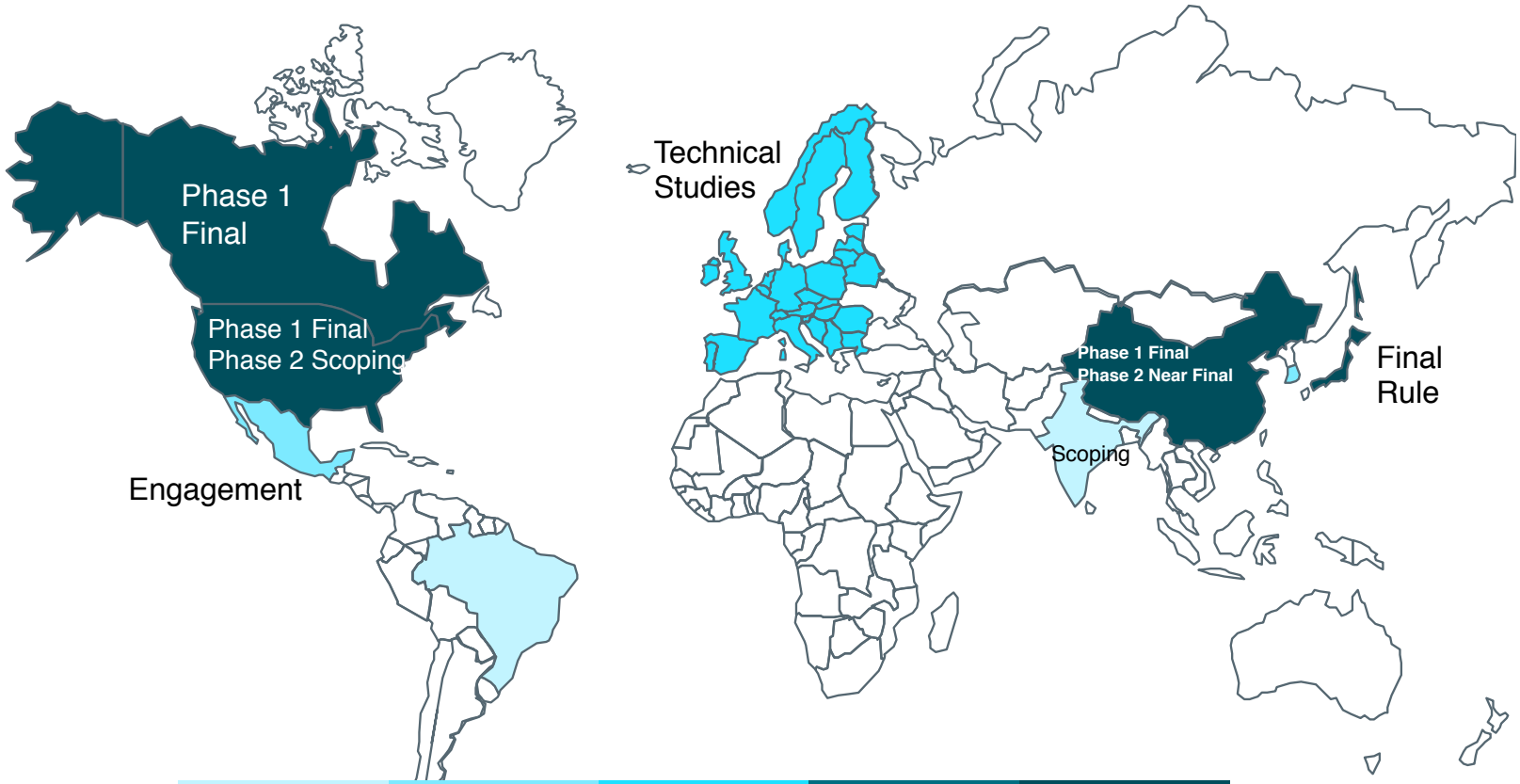
Heavy-Duty GHG Regulation Status

- HDV efficiency standards being considered at some minimal level – represents over 80% of global HDV population



Source: ACEEE[5]

HDV global regulatory landscape

Country/ Region	Regulation Type	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	
Japan	Fuel economy	Phase 1 regulation implemented starting MY 2015											
United States	GHG/Fuel efficiency	Standard proposal	Final rule				Regulation implemented starting MY 2014 (mandatory DOT program starts MY 2016)						
						Phase 2						Phase 2 implementation	
China	Fuel consumption	Test procedure finalized	Industry standard proposal	Industry standard implemented	National standard adopted	Regulation implemented starting MY 2015							
European Union	CO_2 test procedure	Technical studies			Impact assessment/ Test procedure finalized		Policy implementation						
Canada	GHG/Fuel efficiency			Standard proposal	Final rule		Regulation implemented starting MY 2014					Phase 2	
Korea	Fuel efficiency	Technical studies			Impact assessment	Test procedure finalized	Policy implementation (second half of 2015)						
Mexico	Fuel efficiency				Proposal			Regulation implemented starting MY 2016				Phase 2 implementation	
California	End-user purchase requirements	Requirements for new tractors, trailers (2011+)			Additional reqs. for existing tractors and trailers (<MY 2010)			Additional reqts. for existing trailers and reefers (<MY 2010)					

Items in blue are ICCT expectations (not public announcements)

Voluntary, Public-Private Partnership Programs

- Over the past decade a number of voluntary programs have been implemented to improve the environmental performance and efficiency of the goods movement sector
- First program: US EPA's SmartWay Transport Partnership began in 2004 (http://www.epa.gov/smartway/)
- SmartWay has grown from roughly a dozen charter companies to over 3,000 partner companies and affiliates
  - Roughly 1/3rd of all trucking miles in the US are done by SmartWay members
- SmartWay as a model for other countries/regions
  - SmartWay in Canada

    http://oee.nrcan.gc.ca/transportation/business/smartway/18053
  - China Green Freight Initiative

    http://www.greenfreightandlogistics.org/programs/green-freight-china-program-2/
  - Green Freight Europe

    http://www.greenfreighteurope.eu/
  - Transporte Limpio (Mexico)

    http://www.transportelimpio.gob.mx/

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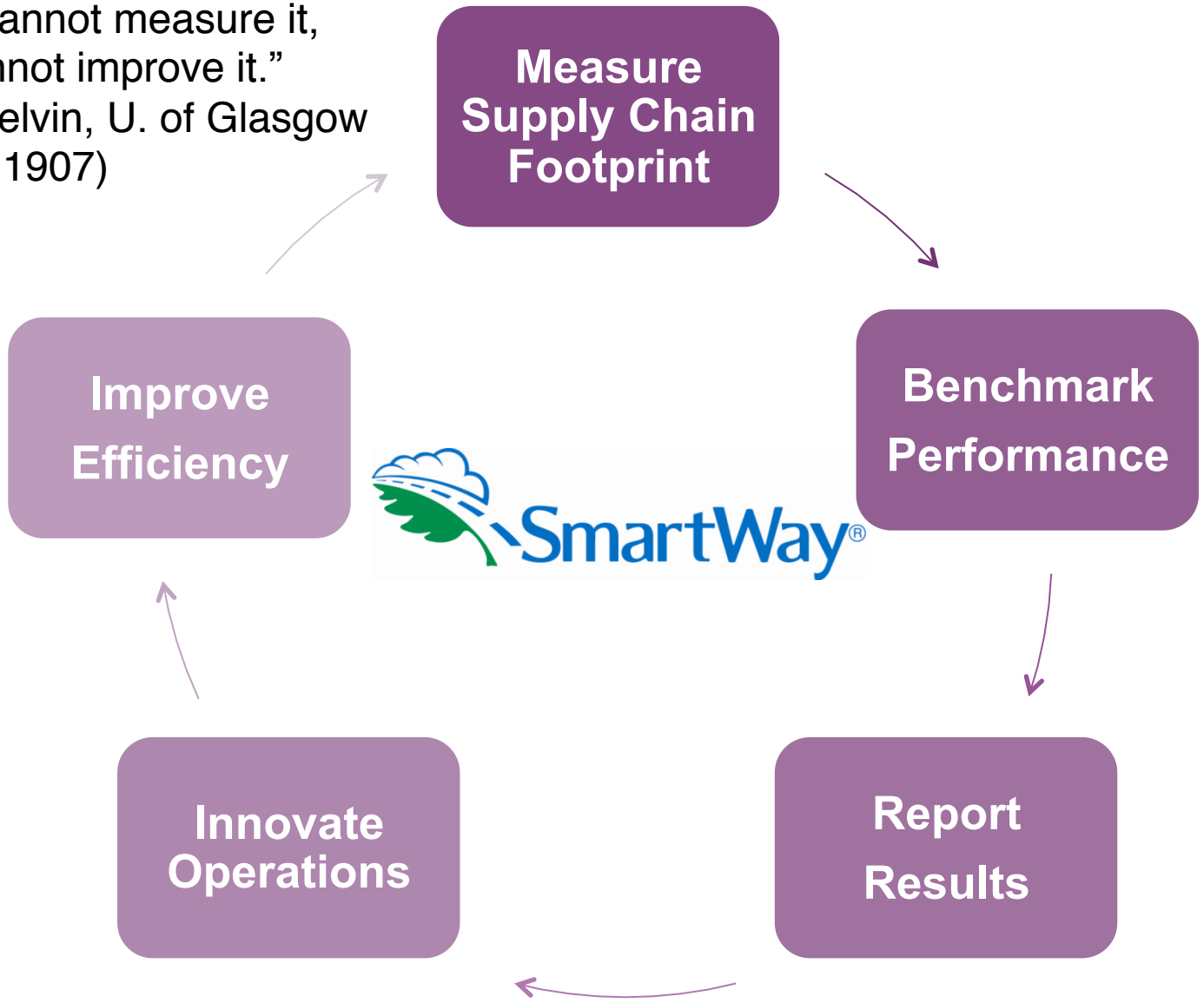
How SmartWay Works

"If you cannot measure it,
you cannot improve it."
- Lord Kelvin, U. of Glasgow
(1824 – 1907)



Source: US Environmental Protection Agency

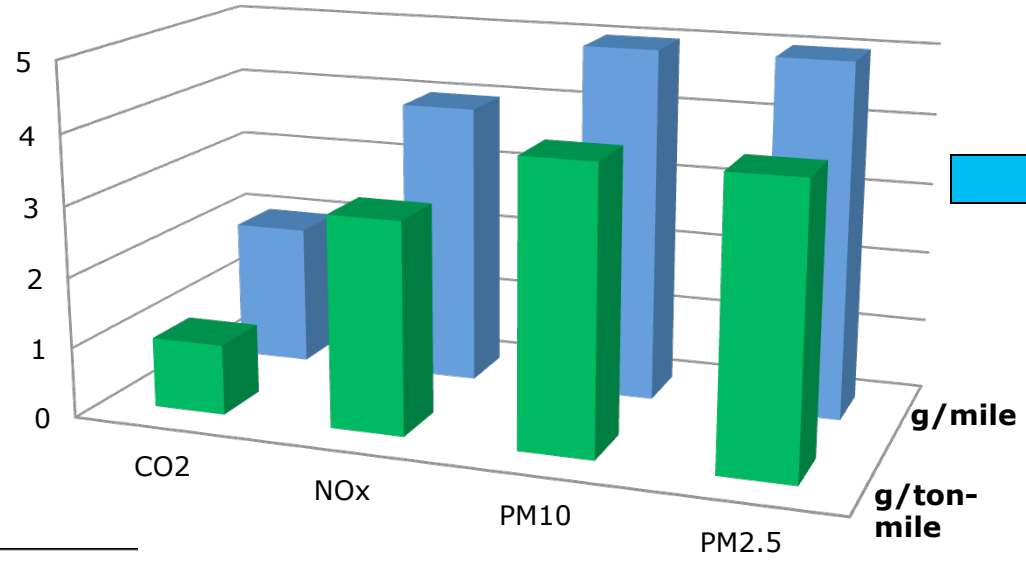
SmartWay Trucking Company Performance Data

Empowering shippers with information about trucking company performance

15 Carrier Categories
- (TL, LTL, Refrigerated, Tanker, etc.)

8 Emission Metrics

SmartWay Carrier Rating Pollutant Specific Performance Levels

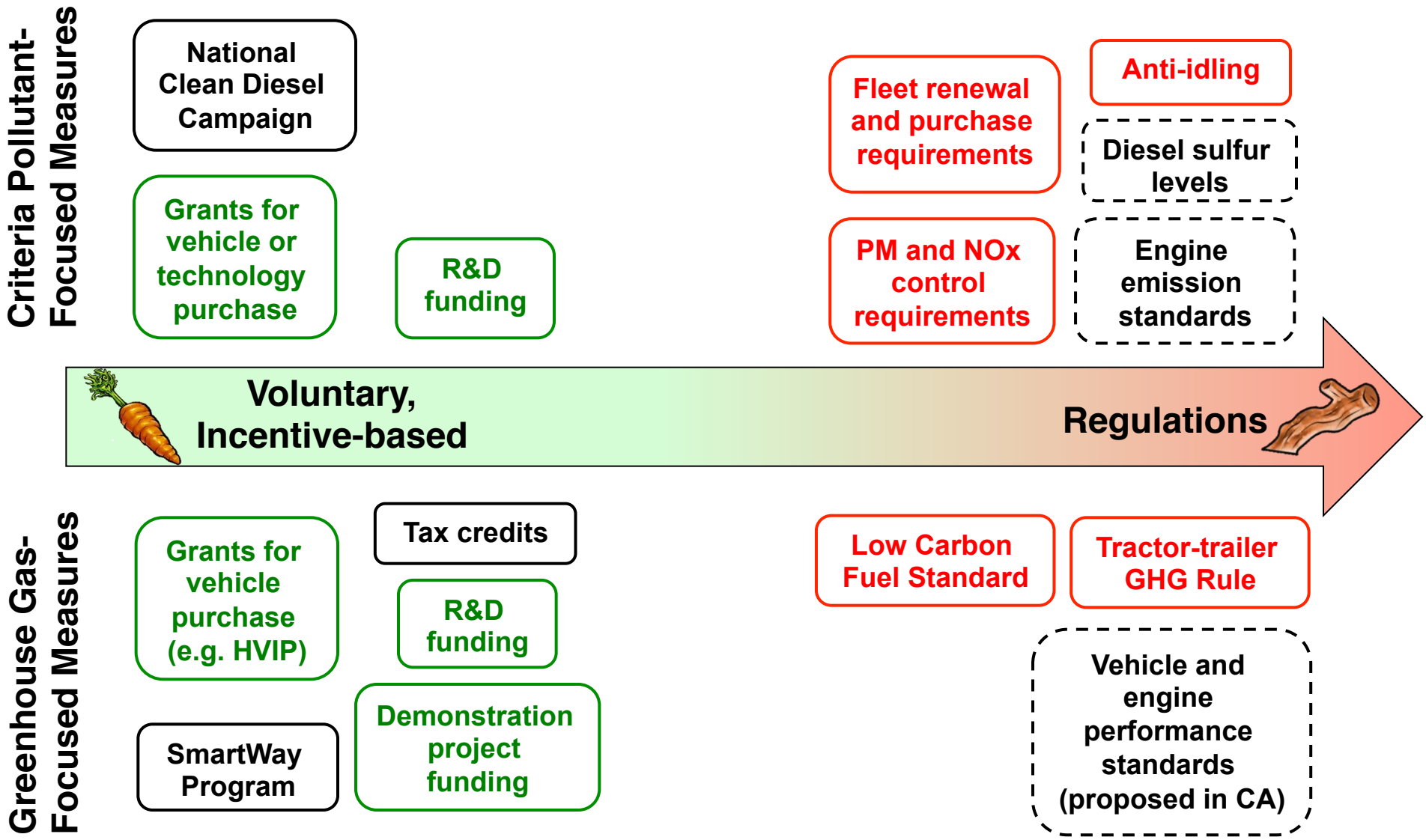


Quintile Rankings
(ex: Truckload CO_2 g/mile)

Top 20% TL Dry Vans	• 1550 g/mile
Second 20% TL Dry Vans	• 1650 g/mile
Middle 20% TL Dry Vans	• 1750 g/mile
Fourth 20% TL Dry Vans	• 1850 g/mile
Bottom 20% TL Dry Vans	• 1950 g/mile

Source: US Environmental Protection Agency

Policies Affecting Heavy-Duty Vehicles in California



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Incentive-based policy in California

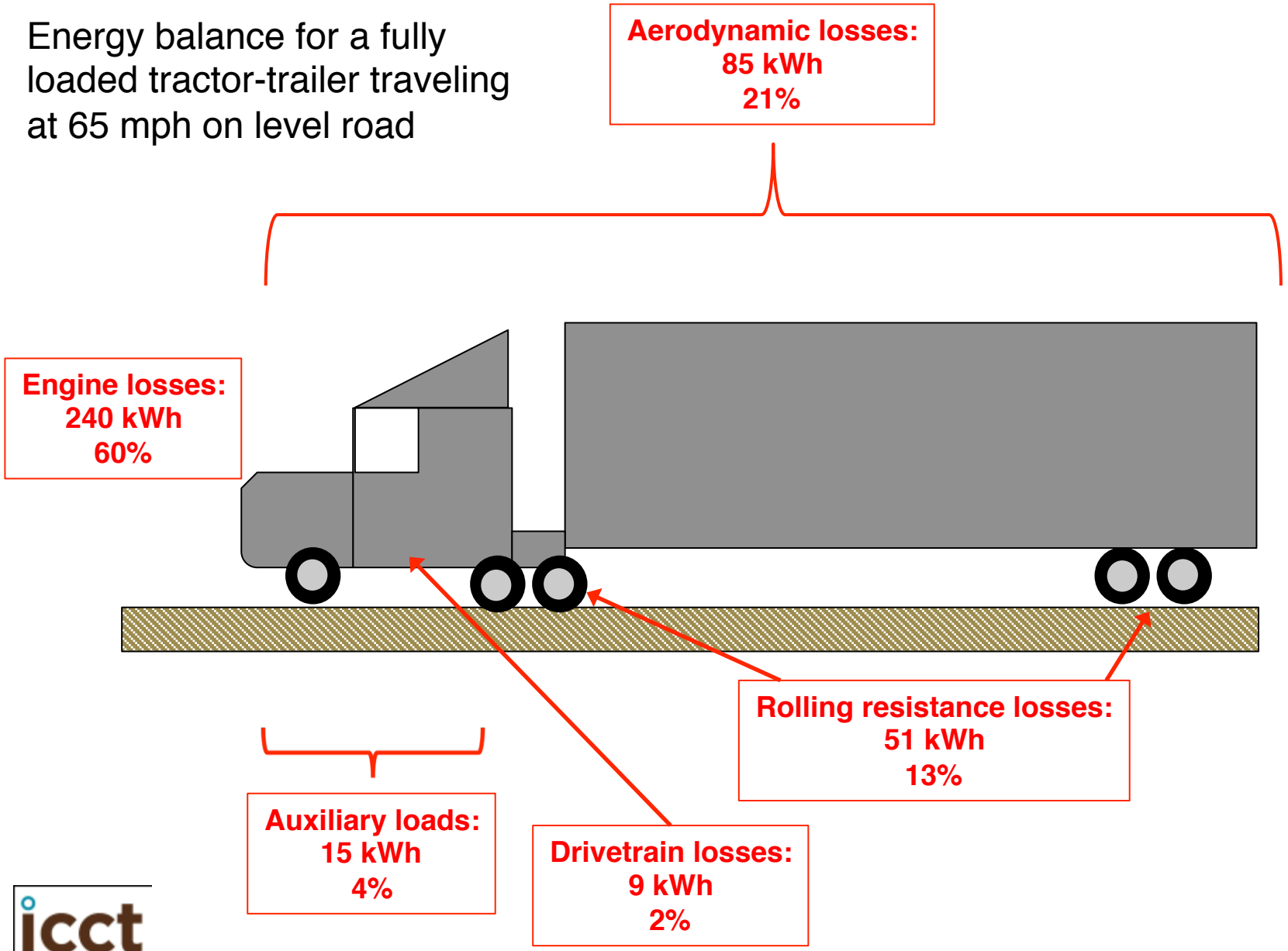
Regulatory program in California

Policy administered at the federal level

CA and US policy harmonized

California's Tractor-Trailer GHG Rule: Context

Energy balance for a fully loaded tractor-trailer traveling at 65 mph on level road



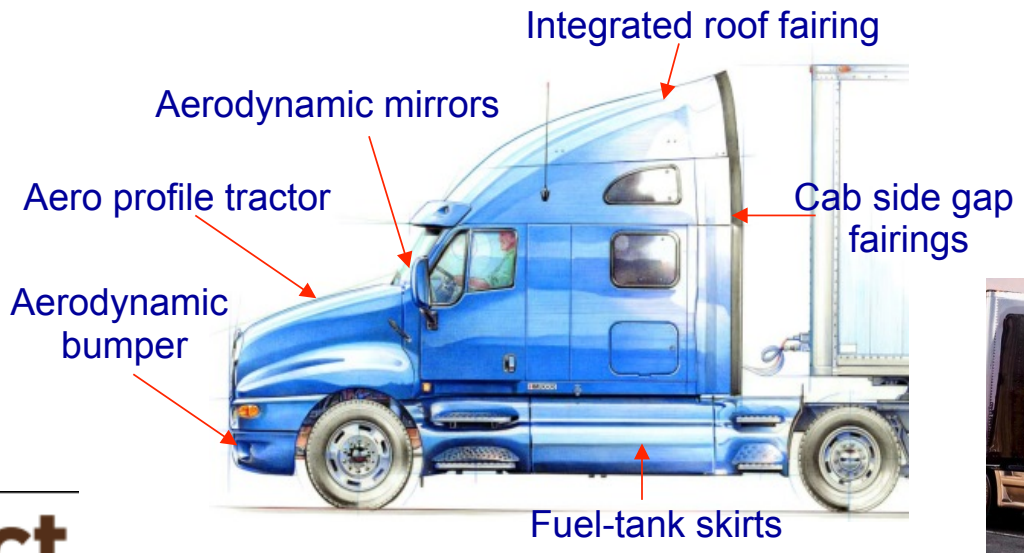
Source: 21st Century Truck Partnership

California's Tractor-Trailer GHG Rule: Overview

- Goal: Reduce Greenhouse Gas (GHG) emissions from long-haul tractors by improving tractor and trailer aerodynamics and tire rolling resistance
- Based on elements of US EPA SmartWay Program
- Applies to: 53-foot box-type trailers and heavy-duty (HD) tractors that pull them on California highways
- Implementation began 2010
- Responsible for compliance: owners, drivers, motor carriers, California-based brokers, California-based shippers

Tractor-Trailer GHG Rule: Tractor Requirements

- 2011+ model year sleeper cabs:
  - *SmartWay* certified beginning January 1, 2010
- 2011+ model year day cabs:
  - *SmartWay* verified low rolling resistance (LRR) tires (1.5% fuel efficiency improvement) certified beginning January 1, 2010
- Pre-2011 model year sleeper & day cabs:
  - *SmartWay* verified LRR tires beginning January 1, 2013



Tractor-Trailer GHG Rule: Trailer Requirements

- 53-foot box type trailers → *SmartWay* certified or retrofitted with *SmartWay* verified technologies, including:
  - LRR tires (1.5% fuel efficiency improvement), *and*
  - Aerodynamic technologies that provide,
    - 5% fuel efficiency improvement for dry vans
    - 4% fuel efficiency improvement for refrigerated vans
- Compliance deadlines:
  - 2011+ model year (new) trailers: January 1, 2010 for aero and tires
  - Pre-2011 model year trailers
    - Aerodynamic technologies by January 1, 2013 or choose a delayed compliance option 2012-2016
    - LRR tires by January 1, 2017

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Tractor-Trailer GHG Rule: Fleets Going Beyond!

Some fleets seeing fuel savings > 10%

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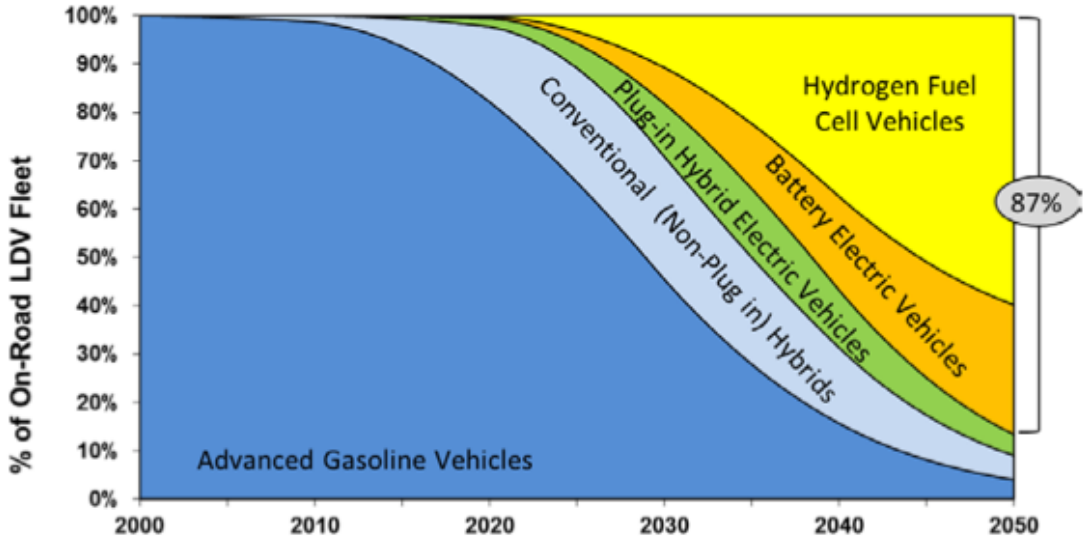
California's Long-Term Vision for GHG Reductions

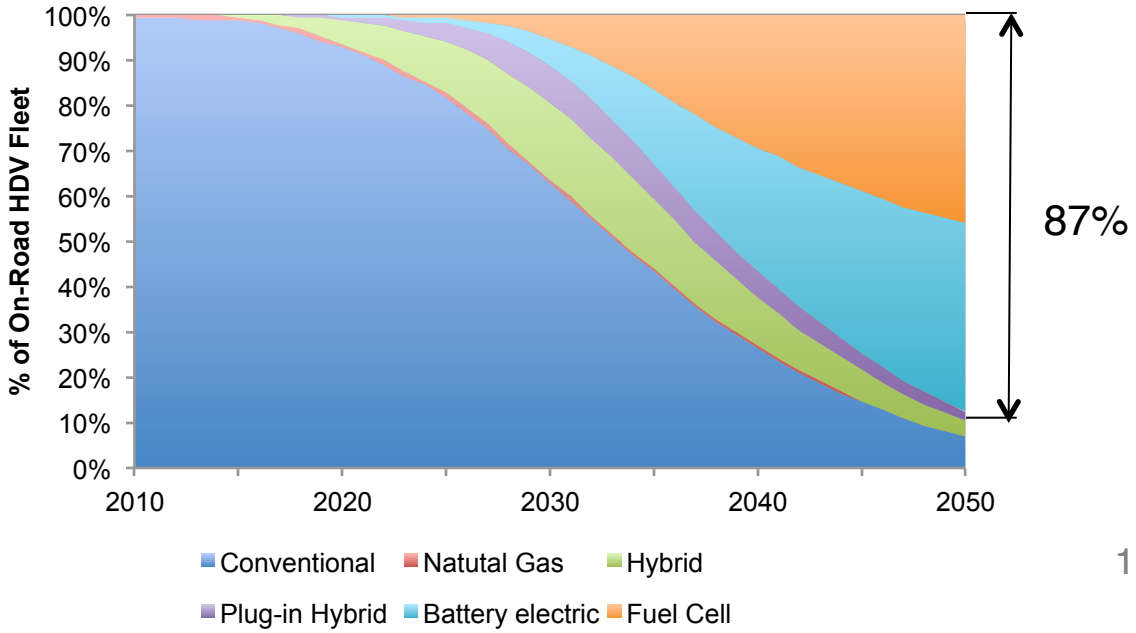
Source: California Air Resources Board



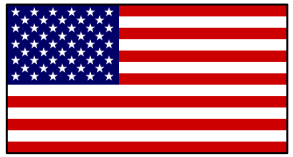
Achieving 80% reduction in GHGs from the on-road transportation sector by 2050 requires wide-scale adoption of zero-emission vehicles → **BOTH** in light- and heavy-duty vehicles

Zero emission solutions are in their infancy for HDVs. Significant technological progress and cost reductions are required!
→ **Especially for long-haul trucking**

Source: Ben Sharpe's Dissertation Research



US FE/GHG Phase 1 Program: Background



- Rule finalized in August 2011 → Implementation starts in model year 2014
- Two distinct but nearly identical programs:
  - EPA has authority to regulate GHGs under the Clean Air Act
  - National Highway Traffic Safety Admin. (NHTSA) has authority to regulate fuel efficiency under the Energy Independence and Security Act
- EPA program will regulate CO_2, CH_4, N_2O, and HFCs (refrigerant)
- EPA and NHTSA programs are identical in terms of fuel use/CO_2
  - Only real difference between the two programs is that the EPA's includes CH_4, N_2O, and HFCs
- EPA program starts in model year (MY) 2014, NHTSA: MY2016
  - In reality, manufacturers will only have to "worry" about meeting the EPA regulation

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US FE/GHG Phase 1 Program: Stringency

- Largely relies on promoting "off-the-shelf" technologies
- Regulation can be thought of as 3 distinct programs

12-17%

Class 2B/3 Pickup Trucks and Vans

Class 7/8 Tractors

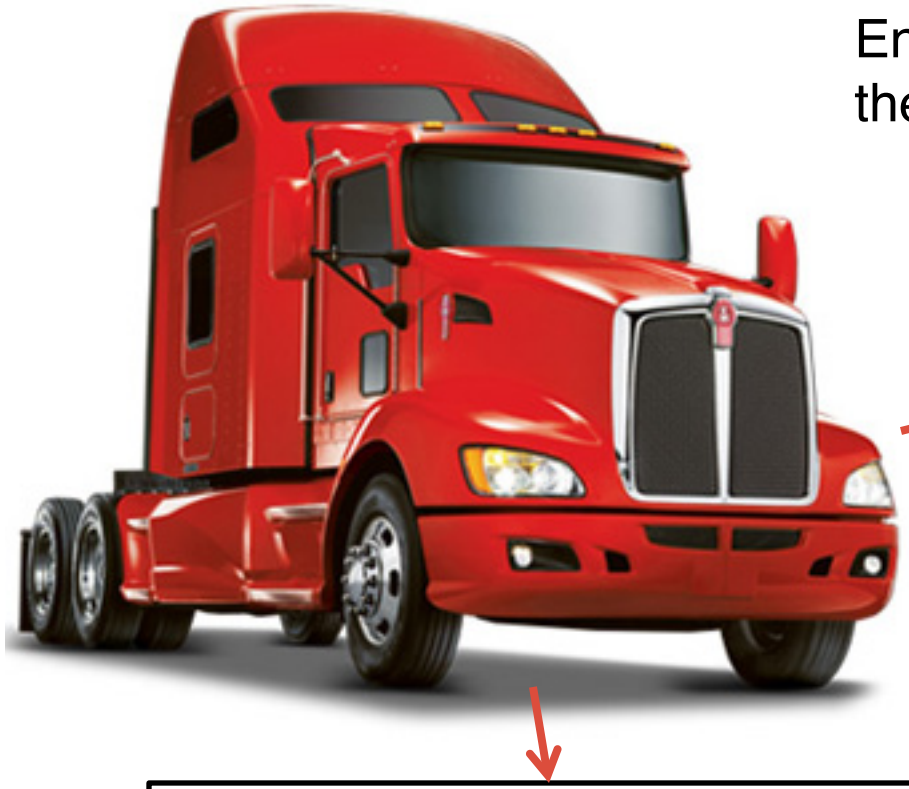
10-23%

Everything Else = "Vocational Vehicles"

6-9%

Required avg. reduction in fuel consumption in MY 2017 vs. MY 2010 baseline

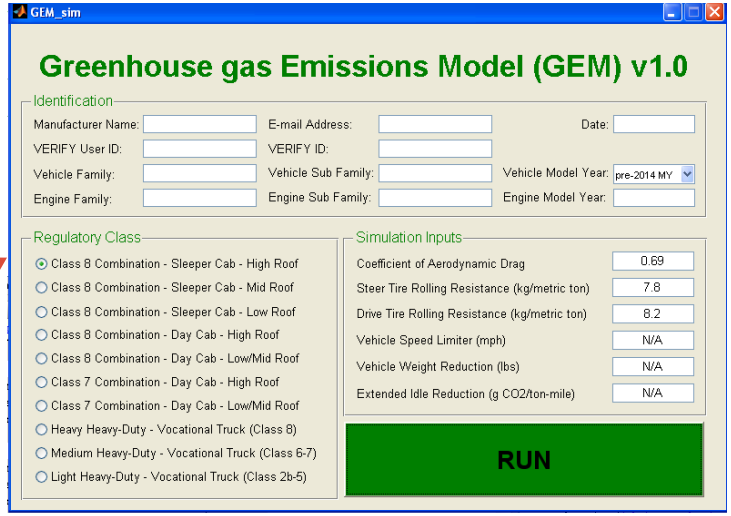
Class 7 and 8 Tractor Program



Engines subject to their own standard

Fuel
CO_2
CH_4
N_2O

Unique vehicle characteristics: aerodynamics, rolling resistance, weight reduction, idle reduction, speed limiter



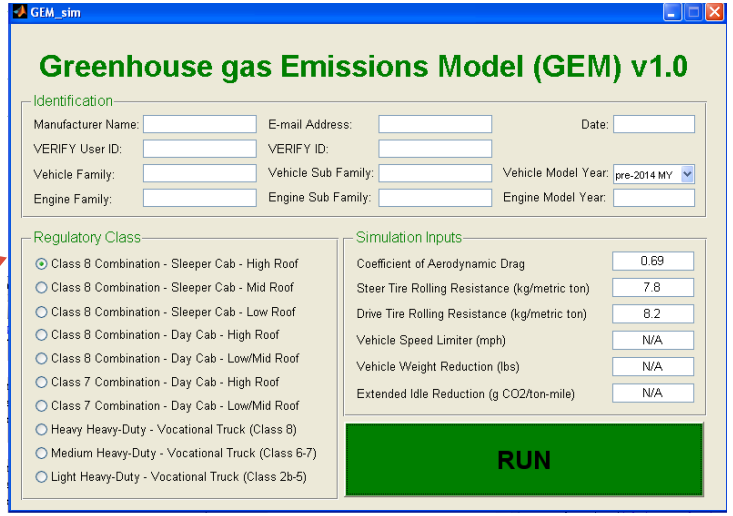
Full vehicle is certified using the GEM vehicle simulation tool

Class 2B – 8 “Vocational” Vehicle Program

Engines subject to their own standard

Fuel
CO_2
CH_4
N_2O

Unique chassis characteristic: rolling resistance



Full vehicle is certified using the GEM vehicle simulation tool

Class 2B and 3 Pickup Trucks and Vans Program

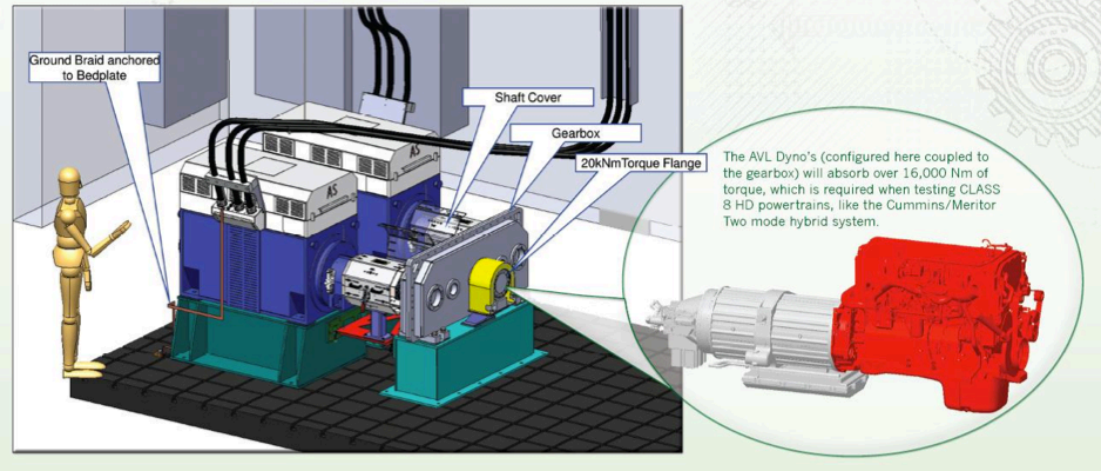
Chassis dynamometer testing

- Meant to mirror the light-duty testing program
- Main difference from LD program: vehicles are certified based on their "work factor" (WF)

WF = [0.75 x (Payload Capacity + xwd)] + [0.25 x Towing Capacity]
where
Payload Capacity = GVWR (lbs) – Curb Weight (lbs)
xwd = 500 if the vehicle is equipped with 4-wheel drive and 0 otherwise

Key Opportunities for Improvement in US Phase 2

Integrating transmissions into the testing protocols



Source: Oak Ridge National Lab

- Recognizing interactions btw engine and transmission
- Properly evaluating HD hybrid systems

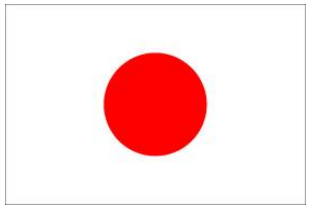
Including trailers

- 5-10% fuel savings available from trailer aero and RR improvements
- Opportunity to build on success of SmartWay program

Trailer Regulatory Challenges

- Trailer market diversity
- Approximately 2 or 2.5 trailers for every tractors
- Split incentive: owner of trailer often does not operate trailer, thus has little incentive to invest in fuel-saving technologies
- Large number of small businesses in trailer manufacturing

Japan: Fuel Economy Program Summary

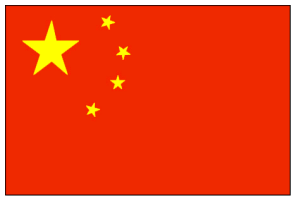


2006: Japan introduced the world's first fuel economy standard for HDVs

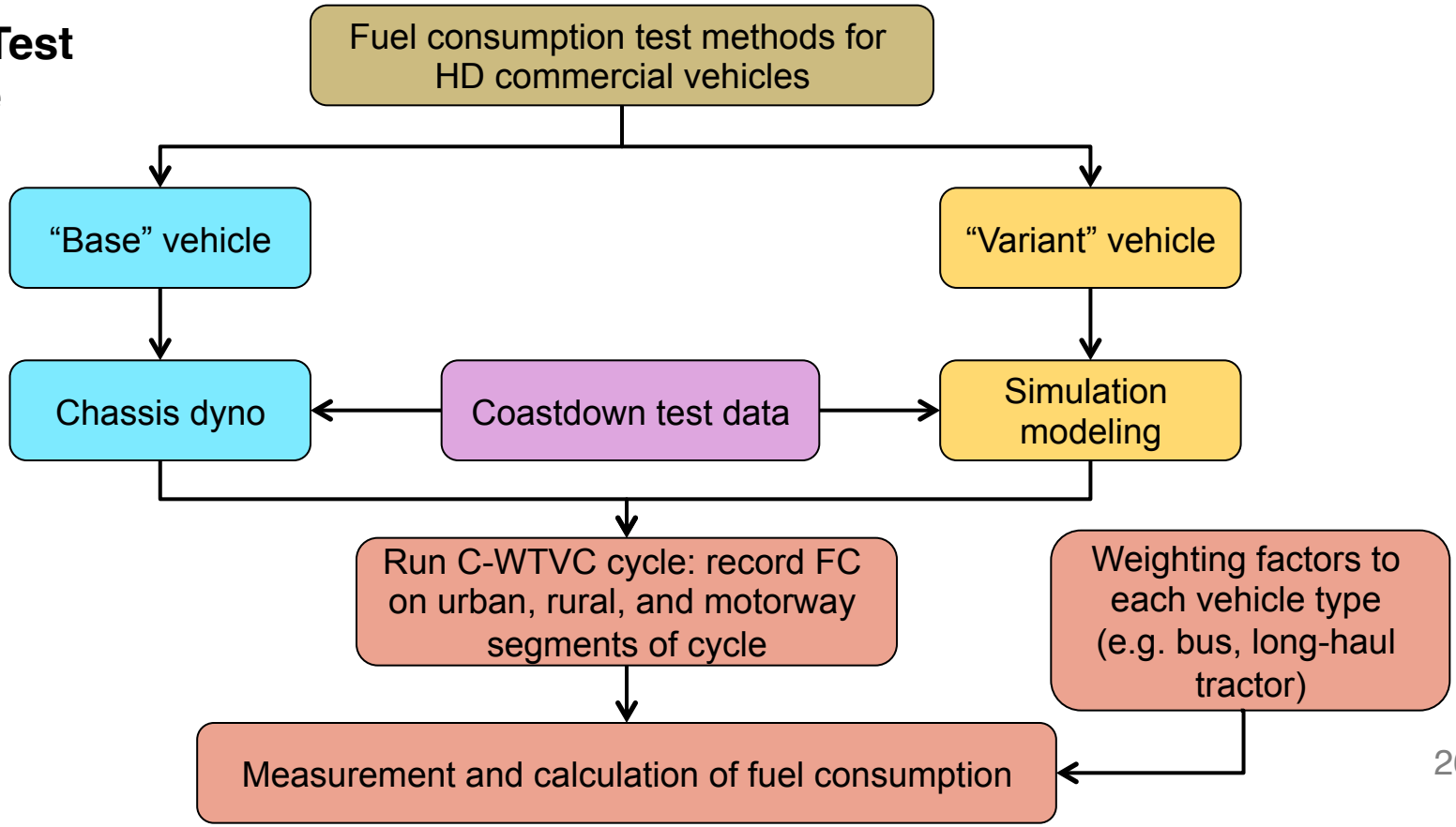
- Vehicles included
  - Commercial vehicles with gross vehicle weight rating (GVWR) > 3.5 metric tons, buses with carrying capacity > 11 people
- Targets (km/l) disaggregated by vehicle type, class, and weight
- Most efficient vehicle ("top runner") in MY 2002 set as baseline
  - Hybrid vehicles were excluded when determining the top runner
- Manufacturers must meet targets starting in MY 2015
- Roughly 10-13% FE improvement required vs. 2002 Top Runner baseline → improvements primarily from engines

- Phase 2 developments currently under way → target year 2025
- Expected completion timeframe: 2014/2015

China: Fuel Consumption Program Summary



Finalized Test Procedure



China: Industry vs. National Standard

- Industry Standard (Stage 1)
  - Proposed in 2011 and adopted in Dec 31, 2011
  - New models must meet standard starting July 1, 2012; existing models July 1, 2014
  - Standard is set at the 90th percentile of the baseline
  - Goal: Phasing out most inefficient and chance to collect further data
  - Based on 300+ vehicles tested
- National Standard (Stage 2)
  - Proposed September 2012
  - New models must meet standards starting from July 1, 2014; existing models by July 1, 2015
  - Tightens Industry standard ~10-15%, almost 50% of vehicles tested did not meet limits. (based on further testing)

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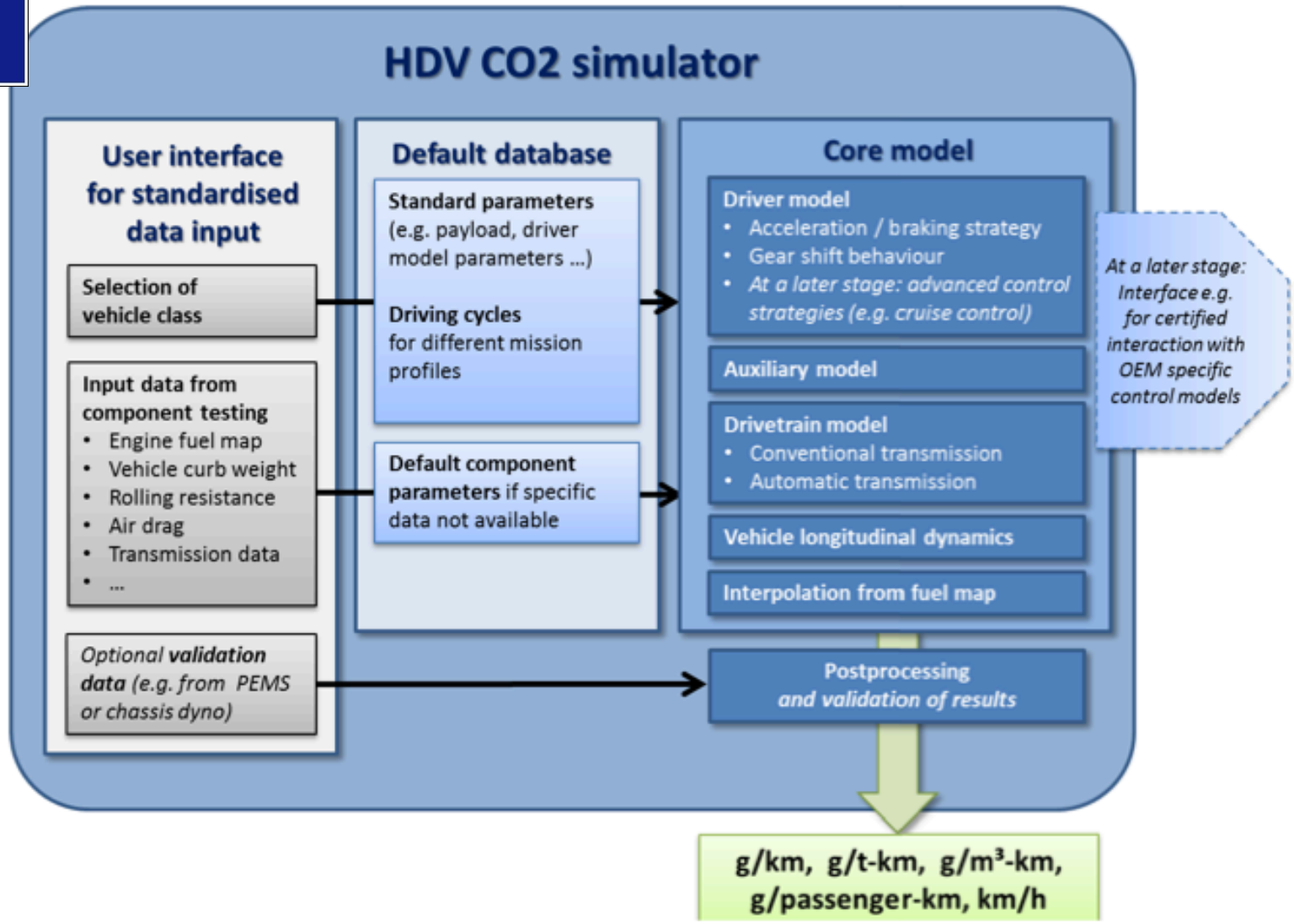
Developments in the European Union

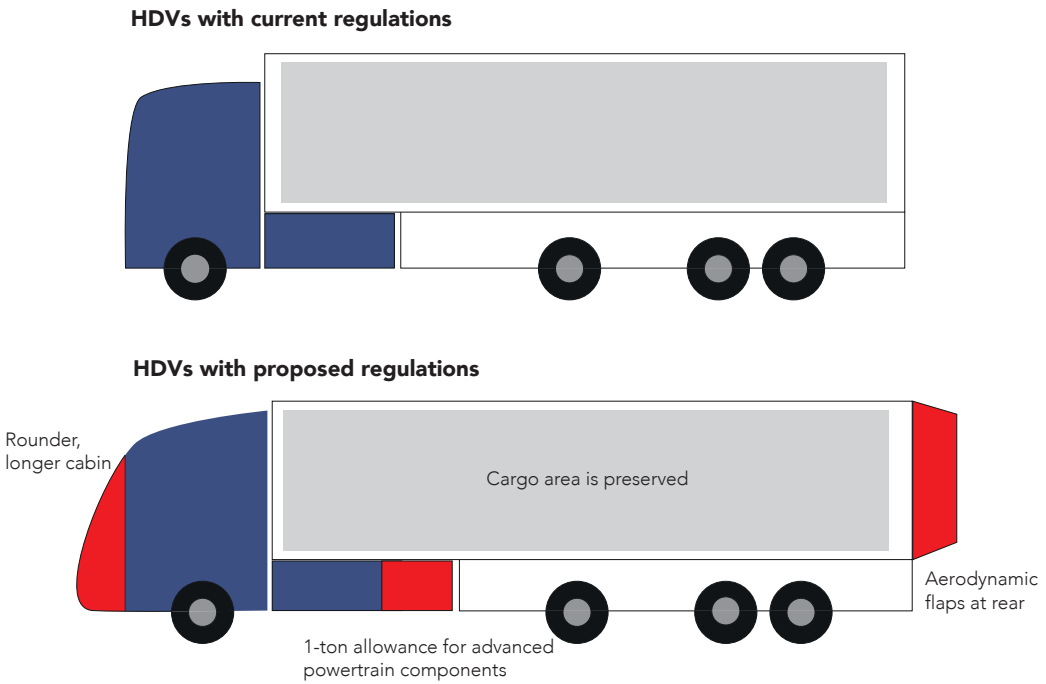


Source: University of Technology Graz (2012) Reduction and Testing of Greenhouse Gas Emissions from Heavy-Duty Vehicles – LOT 2

New Developments in the EU

- Truck shape – cab over engine
  - Due to length restrictions of total truck (not just trailer as in US)
  - New proposal to allow for more aerodynamic tractor/trailers

- For new trucks ~2018-2020
  - Previous weight/length limit – 40 metric tons/61.5 feet
  - New limits allow for increased weight to accommodate hybrid powertrain and increased length to accommodate aerodynamic design
  - Estimate 7-10% reduction in GHG emissions from long haul trucks



Conclusions

- It is an important period for heavy-duty vehicle GHG / fuel economy policy – worldwide
- Both voluntary and mandatory policy measures have an important role to play
- Incorporation of major technologies is important for standards
  - Transmission technologies
  - Hybrid technology
  - Tires, aerodynamics, lightweighting
  - Trailers
- More Information
  - www.theicct.org/heavy-duty-vehicles
  - www.transportpolicy.net

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Questions?

Thank you!

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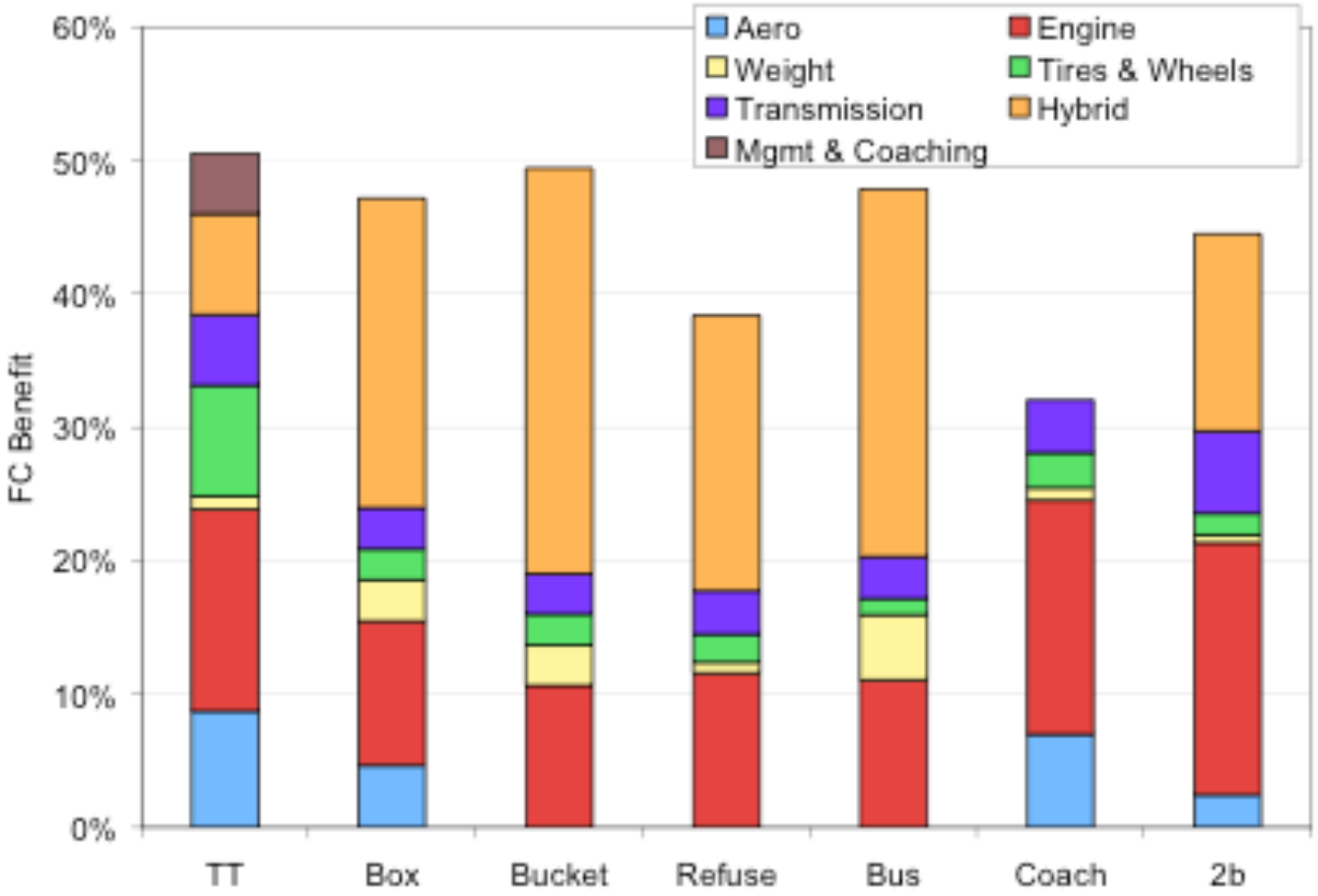
Extra Slides

US Technology Assessment

- National Academy of Sciences Report (March 2010) found 35 – 50% improvement could be achieved in the 2015 to 2020 timeframe



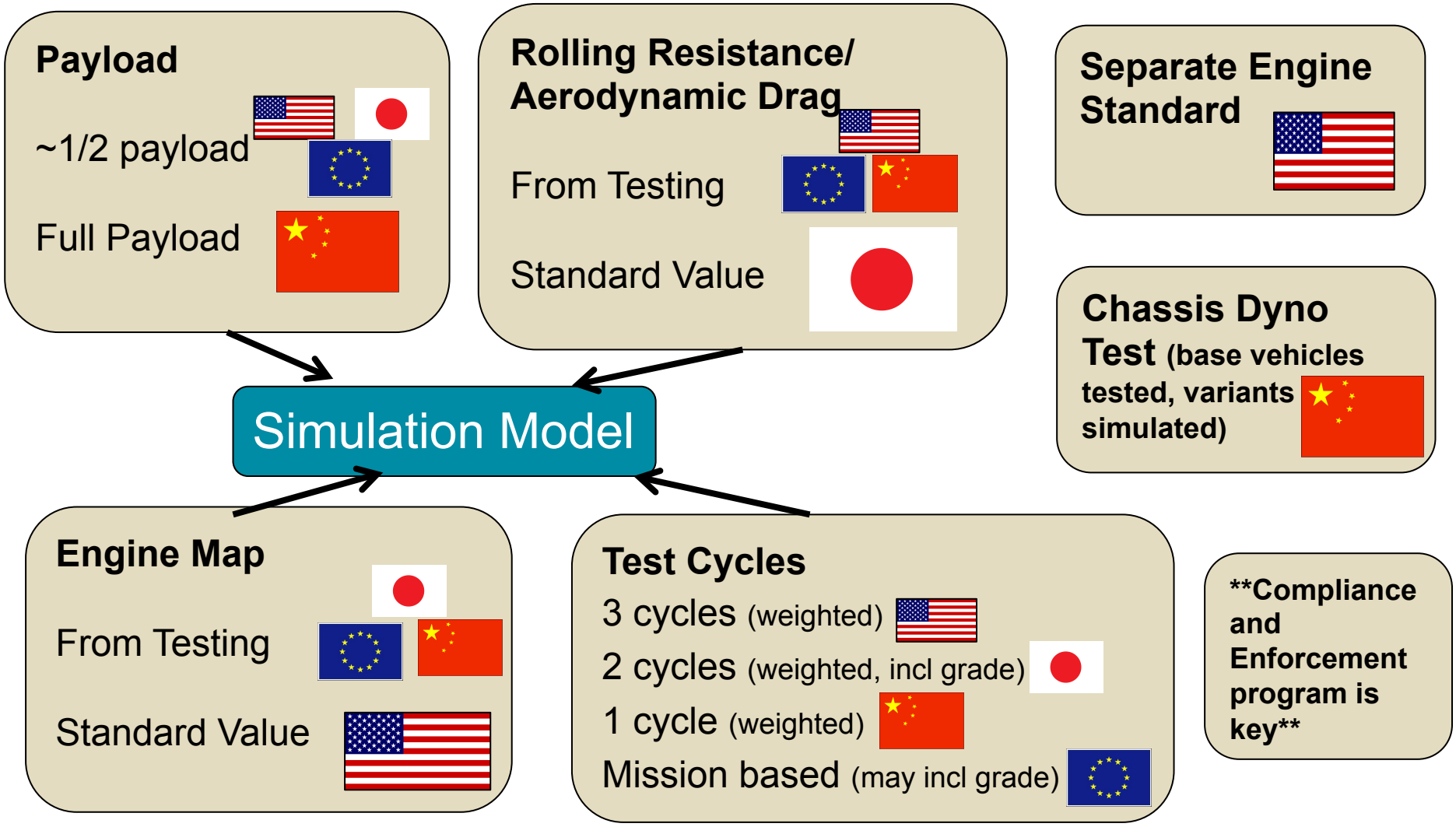
National Academy of Sciences (2010) FIGURE S-1 Comparison of 2015-2020 New Vehicle Potential Fuel Savings Technology for Seven Vehicle Types: Tractor Trailer (TT), Class 3-6 Box (Box), Class 3-6 Bucket (Bucket), Class 8 Refuse (Refuse), Transit Bus (Bus), Motor Coach (Coach), and Class 2b Pickups and 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.

Regulatory Design Summary

	Regulatory Categories	Certification Test Procedures	Metric		
Japan	Other Truck (11 subcategories) Tractor (2 subcategories) Route Bus (5 subcategories) Other Bus (8 subcategories)	Simulation modeling + engine dynamometer testing	Fuel economy (km/L)		
N. America	Tractors Vocational vehicles HD pickup trucks and vans Engines (tractors, voc. vehicles)	Vehicles → simulation model Engines → dynamometer testing	Tractors, Vocational	HD Pickups	Engines
			gal/1,000 ton-mi	gal/100 mi	gal/100 bhp-hr
			g/ton-mi	g/mi	g/kWh
China*	Tractors, dump trucks, rigid trucks, city buses, other buses	"Base" vehicles → chassis dynamometer "Variant" vehicles → simulation modeling	Fuel consumption (L/100 km)		
European Union*	Truck and bus categories based on GVWR, chassis configuration, and axle configuration	Simulation modeling	GHG (g/tonne-km)		

*Regulatory design is currently under development in China and the EU. This represents the ICCT's best estimate of the structure of these future programs. For the EU, this information represents an upcoming certification program, not necessarily a standard.

Test Procedure Comparison



Technical Potential Globally

- Different technologies have different value in different conditions
  - Approximate differences, compared to value in US context

Technology	US*	Basis for Reduction	Japan	China	EU
Engine	20%	Advanced 11-15L diesel with bottoming cycle		More	
Aerodynamics	11.5%	Improved SmartWay tractor + three aerodynamic trailers	Less	Less	Less
Tires and Wheels	11%	Improved WBS on tractor + three trailers		More	Less
Hybrid/Idle Reduction	10%	Mild parallel hybrid with idle reduction	More		Less
Transmission	7%	AMT, reduced driveline friction			
Management and Coaching/ Speed limits	6%	60 mph speed limit; predictive cruise control with telematics; driver training	Less	Less	Less
Weight	1.25%	Material substitution—2,500 lb.		More	

** These are based on NAS tractor-trailer Class 8 for US context; reductions are approximate, and are not additive*

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Efficiency Improvements Promoted by Regulation

	Japan	U.S. and Canada*	China	EU #
Engine	Yes	Through separate engine standards	Yes	Yes
Transmission	Somewhat	Optional; by demonstration outside of standard protocol	Yes	Yes
Hybridization	Unclear	By demonstration outside of standard protocol	Yes	Yes
Aerodynamic drag, rolling resistance	No	Yes	Yes**	Yes
Trailer	No	No	No	No

* *Potentially Mexico as well*
** *Option to use default values*
\# *Refers to ongoing government research and testing protocols; No standards in place*