U.S. HDV GHG and Fuel Efficiency Final Rule

Reducing Greenhouse Gas Emissions from Heavy-Duty Vehicles: Policy Options, Development, and Prospects Workshop Brussels

10 November 2011

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Highlights MY2014-2018

- ☑ First ever Medium- & Heavy-Duty Standards
- ☑ Will reduce oil imports, fuel consumption, CO_2 emissions, and operating costs for thousands of businesses
- ☑ Allows manufacturers to produce a single fleet of vehicles to meet requirement

- ☑ 530 million barrels less oil
- ☑ 270 MMT lower GHGs
- ☑ $50 billion in fuel savings
- ☑ $8 billion in new hardware
- ☑ $42 billion in net savings
- ☑ $49 billion in net benefits

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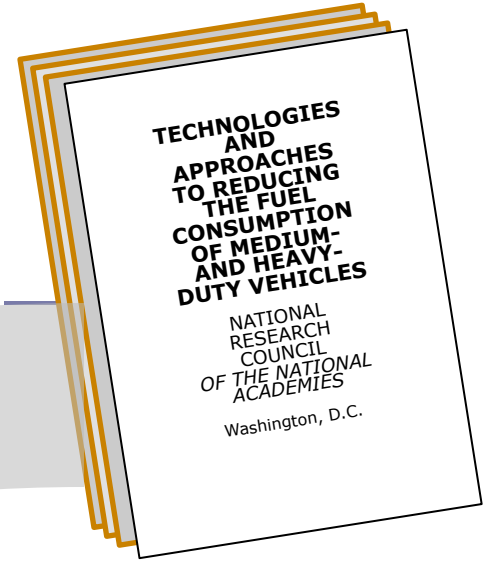
SmartWay Transport Partnership

- EPA program to improve freight transportation efficiency
- Encourages key technologies such as idle reduction, improved aerodynamics, & efficient tires

Reducing GHGs and Fuel Consumption in the U.S. Heavy-Duty Sector

March 2010
National Academy of Sciences issues its final report with recommendations for developing new standards



May 2010
President Obama directs EPA & NHTSA to develop a Joint National Program for medium- and heavy-duty vehicles

August 2011
EPA Administrator Jackson and Transportation Secretary LaHood sign final rule to reduce GHGs and fuel consumption

Presidential Memorandum

- As part of this rule development process, I request that the Administrators of the EPA and the NHTSA:
  - (a) Propose and take comment on strategies, including those designed to increase the use of existing technologies, to achieve substantial annual progress in reducing transportation sector emissions and fossil fuel consumption consistent with my Administration's overall energy and climate security goals. These strategies should consider whether particular segments of the diverse heavy-duty vehicle sector present special opportunities to reduce greenhouse gas emissions and increase fuel economy. For example, preliminary estimates indicate that large tractor trailers, representing half of all greenhouse gas emissions from this sector, can reduce greenhouse gas emissions by as much as 20 percent and increase their fuel efficiency by as much as 25 percent with the use of existing technologies;
  - (b) Include fuel efficiency and greenhouse gas emissions standards that take into account the market structure of the trucking industry and the unique demands of heavy-duty vehicle applications; seek harmonization with applicable State standards; consider the findings and recommendations published in the National Academy of Science report on medium- and heavy-duty truck regulation; strengthen the industry and enhance job creation in the United States; and
  - (c) Seek input from all stakeholders, while recognizing the continued leadership role of California and other States.

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Unique Aspects of the Rule

- More complex than light-duty and regulates many entities for the first time
  - Heavy-duty truck sector is incredibly diverse, serving a wide range of functions
  - Separate procedures for truck and engine performance, new metrics (g/ton-mile) to account for the work that trucks perform hauling freight
- Begins with Model Year 2014
  - 18 months from now for many products
  - typically heavy-duty rules give 4+ years lead time
- Gets existing technology off of the shelf and onto new trucks
  - As first-ever regulation of this sector, rule drives truck makers to apply fuel-saving technologies across all vehicles that will benefit
  - Flexible enough that fleets can get the right truck for their business
- Enjoys broad support from major stakeholders
  - Truck makers wanted a national program supported by California
  - American Trucking Association gets national fuel economy standards called for by ATA since 2008
  - Environmental stakeholders support early action on climate change

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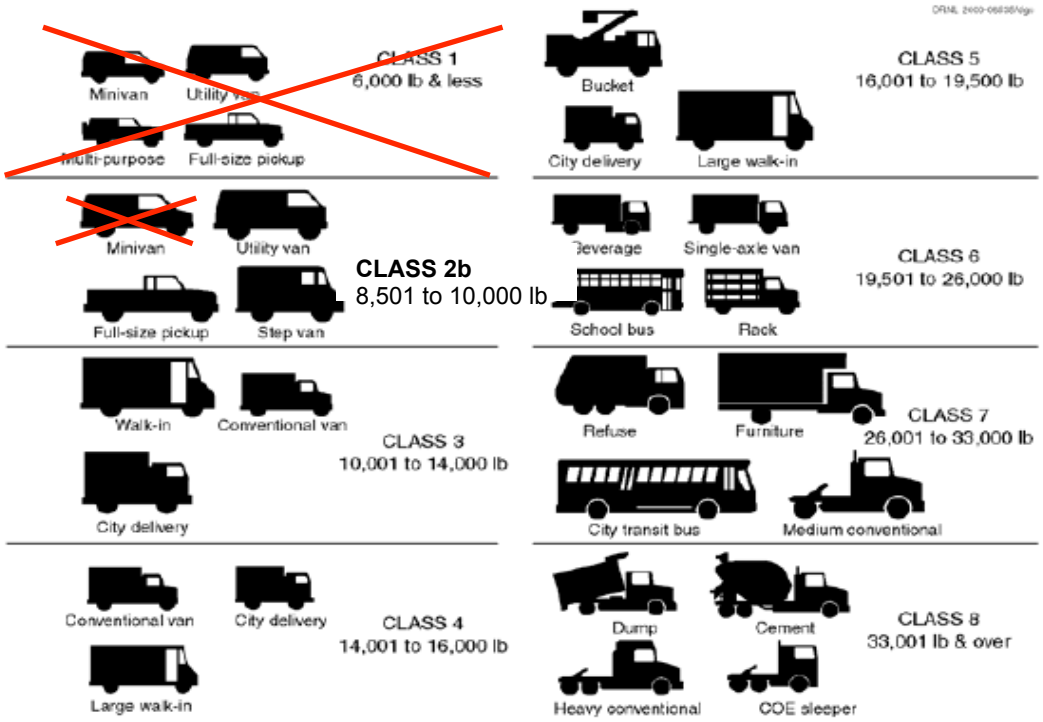
Vehicles Covered

- All on-highway vehicles that are not regulated by CAFE standards.
- Certain small businesses will not be covered in initial phase.



RVs ✗ ✓

Key Elements of the Final Rule

- Begins with 2014 model year and increases in stringency through 2018
- Breaks diverse truck sector into 3 distinct categories
  - Line haul tractors “semis” (largest heavy-duty tractors used to pull trailers, ie. 18 wheelers)
  - Heavy-duty pickups and vans (3/4 and 1 ton trucks and vans made primarily by Ford, GM and Chrysler)
  - Vocational trucks (everything else, buses, refuse trucks, concrete mixers, ambulances…)
- Sets separate standards for engines and vehicles, ensures improvements in both
- Sets separate standards for fuel consumption, CO2, N2O, CH4 and HFCs. Fuel consumption and CO2 standards are aligned.
- Provides incentives for advanced technologies (e.g. EVs and Hybrids)
- Manufacturer flexibilities, including averaging, banking and trading
- New compliance methods for heavy-duty hybrids and innovative technologies not contemplated in existing engine and vehicle test procedures

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Class 7/8 Line Haul Tractors

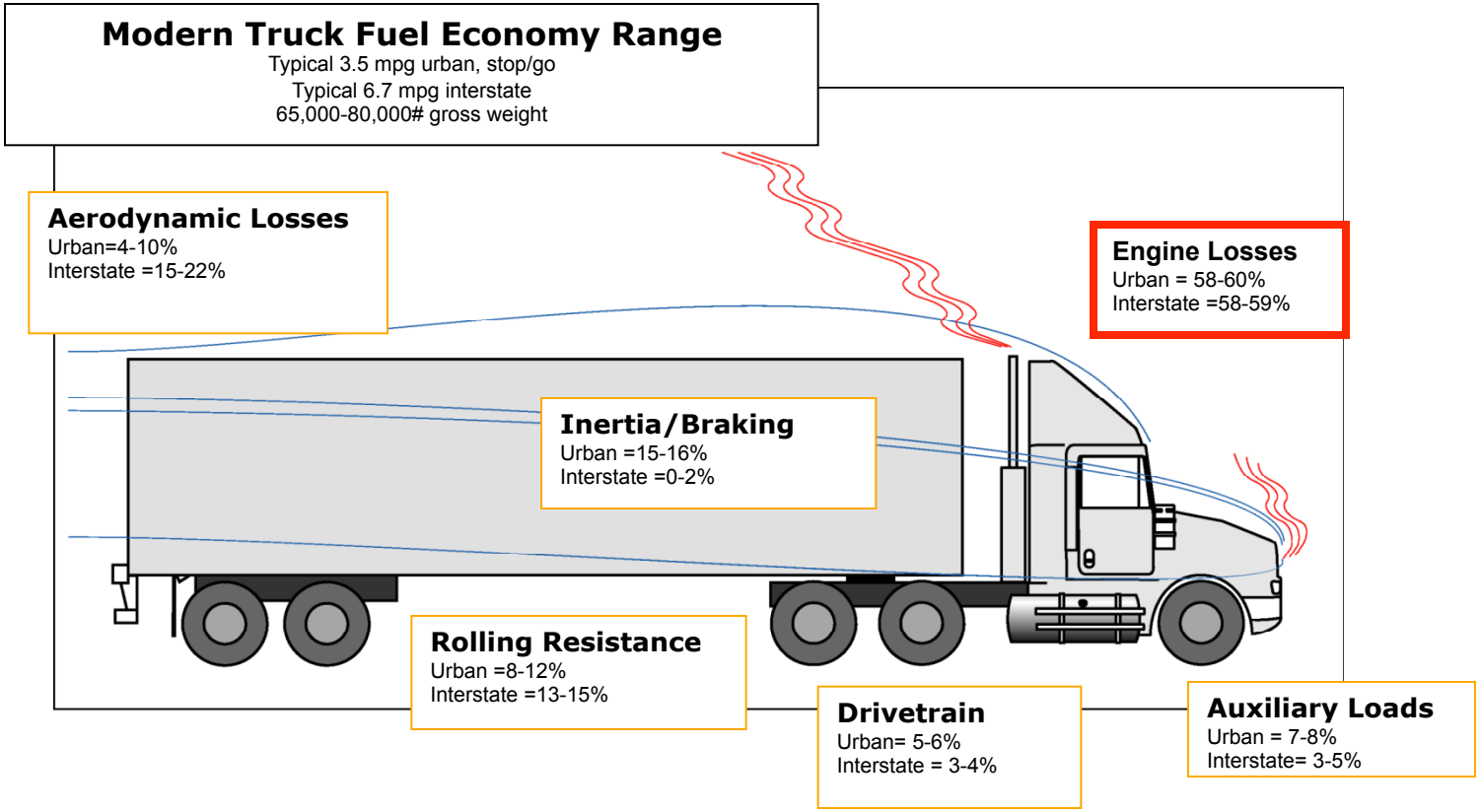
- Regulate engines and tractors separately
- Engine standards met through same procedures as for criteria pollutants
- Tractor standards met through a compliance model, Greenhouse gas Emissions Model (GEM)
- Only a limited number of technologies are reflected in the GEM model

	Day Cab		Sleeper Cab
	Class 7	Class 8	Class 8
Low Roof			
Mid Roof	--	--	
High Roof			

Final 2017 Standards (% reductions)

	Day Cab		Sleeper Cab
	Class 7	Class 8	Class 8
Low Roof	(10%)	(10%)	(17%)
Mid Roof	(10%)	(10%)	(17%)
High Roof	(13%)	(13%)	(23%)

US DOE 21st Century Truck Program (2008)



Class 8 truck energy audit from 21 CTP Roadmap, 2000
Updated Oct 2008

Which Technologies Enable Compliance? (technologies reflected in GEM)

Available today—

- Aerodynamic Profiles and Fairings
- Reduced rolling resistance tires
- Weight reduction
- Vehicle speed limiter
- Reduction in extended idle operation

Benefits—

- 10% to 23% reduction compared to 2010
- Tractors with sleeper cabs would achieve the greatest reductions by combining vehicle/engine improvements with reduced idling

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Which Technologies Are Not Available to Show Compliance?

Typical gearing and engine power curve selections made by fleets are not included

- Transmission gear ratios are not included
- Drive axle gear ratios are not included
- Tire size is not included
- Resulting final drive ratios are not included
- Engine power rating and torque curve profile are not included

These customer selections are not included because we want fleets to continue to make these decisions based on their actual operations not national average conditions

- Expected fleet payload (not national average payloads)
- Expected fleet average speeds (not national average drive cycle)
- Expected grade changes (not national average road grade)

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GHG Program Flexibilities

Vocational Tractors – 1037.630:

- Allows manufacturers to reclassify certain tractors, such as:
  - Low roof pickup and delivery
  - Off-road operation such as reinforced frames and increased ground clearance
  - GCWR>120,000 pounds
- Must conform to applicable vocational vehicle requirements instead of tractor requirements
- Provide explanation of why specific tractor qualifies as a vocational tractor in application
- Report VINs in end of the year report that fall under this provision
- Special Label required

Restrictions:

- Limited to 21,000 tractors in any three model year period per manufacturer

Off-Road Vehicles – 1037.631:

- Applies to vocational tractors intended for off-road use, such as vehicles that:
  - Tires rated at 55 mph or lower
  - Designed for low speed operation
  - GAWR>29,000 pounds
  - Speed attainable in 2 miles of not more than 33 mph
  - Speed attainable in 2 miles of 45 mph and an unloaded vehicle weight not less than 95% of its GVWR, and no capacity to carry occupants other than driver and crew
- Off-road vehicles do not have any vehicle requirements
- Provide explanation of why specific tractor qualifies as a off-road vehicle in application
- Report VINs in end of the year report that fall under this provision
- Special Label required
- 1037.150(h): In unusual circumstances, manufacturers may ask us to exempt vehicles under §1037.631 based on other criteria that are equivalent to those specified in §1037.631(a).

Tractor CO_2 Standards are Attribute-Based

1037.106

- Each tractor's standard is based on the GVWR and roof height of the tractor.
- The CO2 standards become more stringent in 2017 model year based on the required improvements in the HD engines. No additional tractor technologies are required.
- You may optionally certify a tractor to the standards and useful life applicable to a higher vehicle service class (such as heavy heavy-duty instead of medium heavy-duty), provided you do not generate credits with the vehicle. If you include smaller vehicles in a credit-generating subfamily (with an FEL below the standard), exclude its production volume from the credit calculation.

GVWR (pounds)	Sub-category	CO_2 Standard (g/ton-mile) for Model Years 2014-2016	CO_2 Standard (g/ton-mile) for Model Year 2017 and later
26,000 < GVWR ≤ 33,000	Low-Roof (all cab styles)	107	104
	Mid-Roof (all cab styles)	119	115
	High-Roof (all cab styles)	124	120
GVWR > 33,000	Low-Roof Day Cab	81	80
	Low-Roof Sleeper Cab	68	66
	Mid-Roof Day Cab	88	86
	Mid-Roof Sleeper Cab	76	73
	High-Roof Day Cab	92	89
	High-Roof Sleeper Cab	75	72

GEM Simulation Tool v2.0

- GEM is available at http://www.epa.gov/otaq/climate/gem.htm

- Download the executable version of GEM Setup.exe
  - Will create executable file on desktop
  - Creates GEM folder which contains:
    - GEM User Manual
    - Sample GEM input file
    - GEM Executable file

- Refer to User Guide for installation and use instructions

GEM Input File Example

For running one or more vehicle configurations

Manufacturer Name	XXX
Model Year	2014
Vehicle Family Name	XXX
Regulatory Subcategory	Class 8 Combination - Sleeper Cab - High Roof
Input File Name	GEM_Input

EPA Defined

User Entered

GEM Input

		Aerodynamics			Steer Tires	Drive Tires			
Configuration	**Brand/Model Name**	**Bin**	**CdA (Test)**	**Cd (Bin)**	**CRR**	**CRR**	**Idle Reduction**	**Weight Reduction**	**VSL**
1		II	6.8	0.68	7.8	8.2	0	0	65
2		III	6.5	0.60	7.8	8.2	0	0	65
3		IV	5.7	0.52	7.8	8.2	0	0	65
4		II	7	0.68	7.8	7.3	0	0	65
5		III	5.9	0.60	7.8	8.2	0	400	65
6		IV	5.6	0.52	7.8	7.3	0	400	65

GEM Input Requirements

- Aerodynamics – 1037.501, 1037.520, 1037.521
  - For high roof tractors:
    - Once per manufacturer:
      - Run coastdown test for one high roof sleeper cab configuration per 1037.521(b)
        - Use standard trailer, as defined in 1037.501
      - Test the same high roof sleeper cab configuration using an alternative aerodynamic method, for which prior approval has been granted per 1037.521(c)
      - Determine $F_{alt\text{-}aero}$ per 1037.521(a)(1)
    - For each tractor configuration:
      - Determine CdA using either a coastdown or alternative method – 1037.521(b), (d) or (e)
      - Correct the CdA test value from an alternative test method using $F_{alt\text{-}aero}$
      - Determine aerodynamic bin and Cd input per 1037.520(b)(2)
      - Use Cd input in GEM

High-Roof Sleeper Cabs		
Bin Level	If your measured C_DA (m^2) is . . .	Then your C_D input is . . .
Bin I	≥ 7.6	0.75
Bin II	6.7-7.5	0.68
Bin III	5.8-6.6	0.60
Bin IV	5.2-5.7	0.52
Bin V	≤ 5.1	0.47

GEM Input Requirements (continued)

- Aerodynamics – 1037.501, 1037.520, 1037.521
  - For low and mid roof tractors –
    - Determine drag area bin based on drag area bin of equivalent high roof tractor per 1037.520(b)(3).
      - If the high roof tractor is a Bin I or II, then assume the equivalent low and mid roof tractor is in Bin I
      - If the high roof tractor is a Bin III, IV or V, then assume the equivalent low and mid roof tractor is in Bin II
    - Determine Cd input for GEM per 1037.520(b)(2)
    - Use Cd input in GEM
    - If an equivalent high roof tractor does not exist, then conduct aerodynamic testing per the high roof tractor procedures

Low-Roof Day and Sleeper Cabs		
Bin Level	If your measured C_DA (m^2) is . . .	Then your C_D input is . . .
Bin I	≥ 5.1	0.77
Bin II	≤ 5.0	0.71
Mid-Roof Day and Sleeper Cabs		
Bin Level	If your measured C_DA (m^2) is . . .	Then your C_D input is . . .
Bin I	≥ 5.6	0.87
Bin II	≤ 5.5	0.82

GEM Input Requirements (continued)

- High Roof Tractor Aerodynamics Example
  - A coastdown of high roof sleeper cab #1 produced a CdA test result of 6.2 m^2
  - The same high roof sleeper cab #1 was tested in a wind tunnel and produced a CdA test result of 6.3 m^2
  - $F_{alt\text{-}aero}$ for this manufacturer's wind tunnel is equal to 6.2 / 6.3 = 0.984127
  - High roof sleeper cab #2 is tested in the same wind tunnel and produces a CdA of 5.8 m^2
  - The CdA value for #2 is equal to 5.8 * 0.984127 = 5.7
  - Tractor #2 falls into Bin IV
  - A Cd value of 0.52 is entered into GEM

High-Roof Sleeper Cabs		
Bin Level	If your measured C_DA (m^2) is . . .	Then your C_D input is . . .
Bin I	≥ 7.6	0.75
Bin II	6.7-7.5	0.68
Bin III	5.8-6.6	0.60
Bin IV	5.2-5.7	0.52
Bin V	≤ 5.1	0.47

GEM Input Requirements (continued)

- Tires 1037.520(c)
  - GEM input is equal to the average rolling resistance of 3 tires, measured once each using ISO 28580 test procedure
- Weight reduction 1037.520(e)
  - Determine the total weight reduction based on the components installed in the vehicle as indicated in Table 4 and Table 5 to §1037.520

Weight Reduction Technology		Weight Reduction (lb per tire or wheel)
Single-Wide Drive Tire with . . .	Steel Wheel	84
	Aluminum Wheel	139
	Light-Weight Aluminum Wheel	147
Steer Tire or Dual-wide Drive Tire with . . .	High-Strength Steel Wheel	8
	Aluminum Wheel	21
	Light-Weight Aluminum Wheel	30

Weight Reduction Technologies	Aluminum Weight Reduction (lb)	High-Strength Steel Weight Reduction (lb)
Door	20	6
Roof	60	18
Cab rear wall	49	16
Cab floor	56	18

GEM Input Requirements (continued)

- Vehicle Speed Limit 1037.520(d), 1037.640
  - Enter speed limit to nearest 0.1 mph
  - For systems which are equipped with either an expiring VSL or soft top, derive input per– 1037.640(d)

- Extended idle reduction 1037.520(f), 1037.660
  - If equipped with an automatic engine shutdown after 5 minutes of idling, use 5 g/ton-mile
  - Allowable delays and override conditions are listed in 1037.660(a) and (b)
  - For systems which are equipped with an expiring automatic engine shutdown, derive input per the following equation, and input the value rounded to one decimal place - 1037.660(c)
    - Input = 5 g CO_2/ton-mile × (miles at expiration / 1,259,000 miles)

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GEM Output File Example

Manufacturer Name	XXX
Model Year	2014
Vehicle Family Name	XXX
Regulatory Subcategory	Class 8 Combination - Sleeper Cab - High Roof
Date/Time of Run	19-Aug-2011/02:58:00pm
Input File Name	N/A

	Passed through from input matrix
	GEM Inputs (from input matrix)
	GEM Outputs
	User Input following GEM run

		Aerodynamics			*Steer Tires*	*Drive Tires*				*Results*		*FEL*		*Subfamily*		
Configuration	**Brand/Model Name**	**Bin**	**CdA (Test)**	**Cd (Bin)**	**CRR**	**CRR**	**Idle Reduction**	**Weight Reduction**	**VSL**	**g CO2/ ton-mile**	**gal/ 1000 ton-mile**	**g CO2/ ton-mile**	**gal/1000 ton-mile**	**Subfamily Name**	**Subfamily FEL**	**Subfamily Volume**
1	N/A	III	6.5	0.65	7.8	8.2	0	0	65	87.09933	8.55592	87	8.6			

Pickups & Vans

- Pickups & vans classified as a separate category of heavy-duty
- Largely derivatives of light-duty trucks
  - Light-duty = 1500 series pickups and vans
  - Heavy-duty = 2500 and 3500 series pickups and vans

Finalized as proposed

- HD Vehicles chassis certified since mid-1990s
- Same basic test procedure as for light-duty vehicles
- Same CO_2 gallons/mile metric
- Gallons/100 miles metric for fuel efficiency

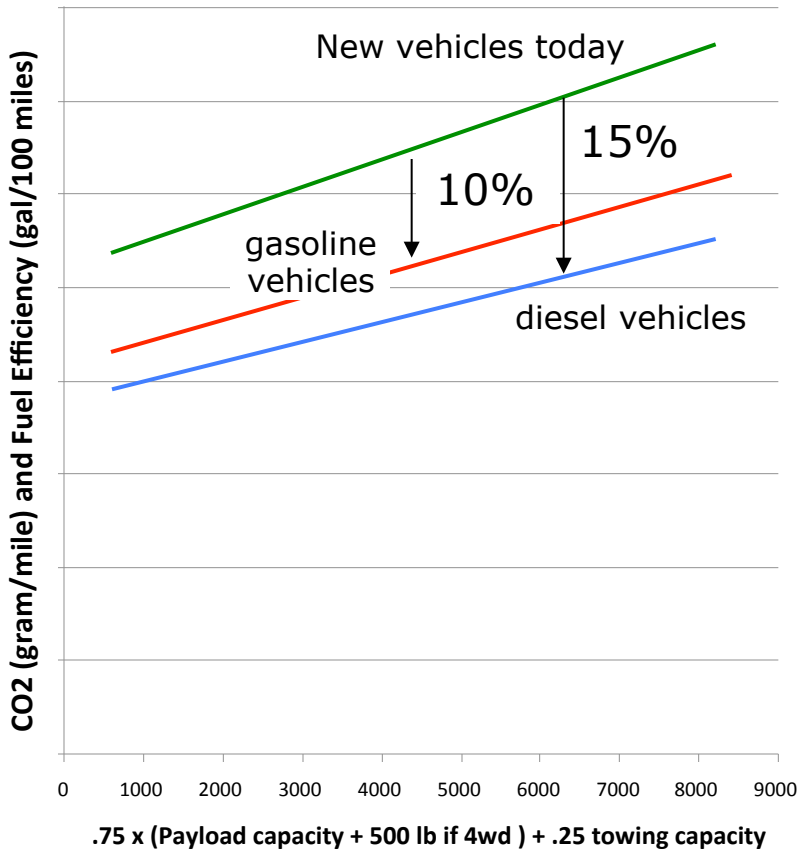
Key differences from Light Duty

- No footprint curve—Attribute = payload + towing
- A/C leakage not counted as a credit
- Not all light-duty vehicle technologies are equally effective for heavier duty vehicles operating

Heavy-Duty Pickups & Vans

	Reduction
Diesel	15%
Gasoline	10%
AC HFC leakage	2%

- Phased in consistent with manufacturers' redesign cycles
- Alternative flat standards
- Compliance assessed on "corporate average" basis



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What Technologies Do We Expect Manufacturers Would Use to Comply?

- Similar technologies to 2012-2016 light-duty program
  - But adapted for HD applications

- Four broad technology categories--
  - Engines: gasoline direct injection, internal friction reduction, diesel aftertreatment optimization, …
  - Transmissions: 8-speed transmissions, …
  - Vehicles: aerodynamic drag reduction, mass reduction, lower-rolling resistance tires, …
  - Accessories: electric power steering, high-efficiency accessories, improved air conditioning systems, …

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Vocational Trucks (Classes 2b – 8)

- The vocational vehicle category includes the wide range of remaining trucks and buses of all sizes and functions.
- Some of the primary applications for vocational vehicles:
  - Delivery, refuse, utility, dump, and cement trucks
  - Transit, shuttle, and school buses
  - Emergency vehicles, motor homes, tow trucks






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Vocational Vehicles (Classes 2b – 8)

Final standards apply to manufacturers of chassis & engines, not bodies

- **Chassis Manufacturers**: GM, Ford, Chrysler, Isuzu, Mitsubishi, Volvo, Daimler, International, PACCAR, Oshkosh, Nissan, Hino, Hyundai, Lodal, Unimog, Crane Carrier, American Lafrance, Advance Mixer, Collins Bus, North American Bus Industries, Forest River, Gillig, Motor Coach Industries, Plaxton Coach & Bus, Thor, Van Hool, New Flyer
- **Engine Manufacturer**: Cummins, GM, Ford, Navistar, Hino, Isuzu, Volvo, Caterpillar, Detroit Diesel, PACCAR, Mitsubishi FUSO
- **Hybrid Powertrain Companies:** Eaton, Arvin Meritor, Parker Hannafin, Bosch Rexroth, BAE, Odyne, Volvo, Azure Dynamics, Terex, Enova, Mitsubishi, ISE

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Incentivizing Technology

- Advanced Technology Credits
  - Final rule will provide 1.5x multiplier for credits generated on vehicles or engines using advanced technologies such as hybrids, plug-in hybrids, EVs, and Rankine waste heat recovery
- Certifying Innovative Technologies
  - Like the light-duty GHG rule, this rule will provide a compliance mechanism to certify innovative technologies that are not fully accounted for by the test procedures.
- Alternative Fuel Vehicles - Natural Gas & EVs
  - GHG and fuel consumption compliance are calculated based on a vehicle's CO_2 emissions.
  - Low carbon fuels like natural gas will perform 20-30% better than comparable gasoline or diesel engines under this approach.

Innovative Technology Credits

1037.610

- Credits for CO2-reducing technologies where CO2 reduction is not captured in the test procedures
- Subject to EPA approval, technology must:
  - not be in common use with HD vehicles prior to 2010 MY
  - not be reflected in GEM
  - be effective for full useful life and deterioration – if any – must be accounted for
- Ways to quantify reductions
  - Alternative demonstration (EPA approval required)
    - Use chassis testing, modeling, on-road testing/data collection, etc.
    - Be robust and verifiable
    - Demonstrate baseline and controlled emissions over a *wide range* of vehicles and driving conditions, minimizing uncertainty
    - May be subject to notice and comment through Federal Register notice

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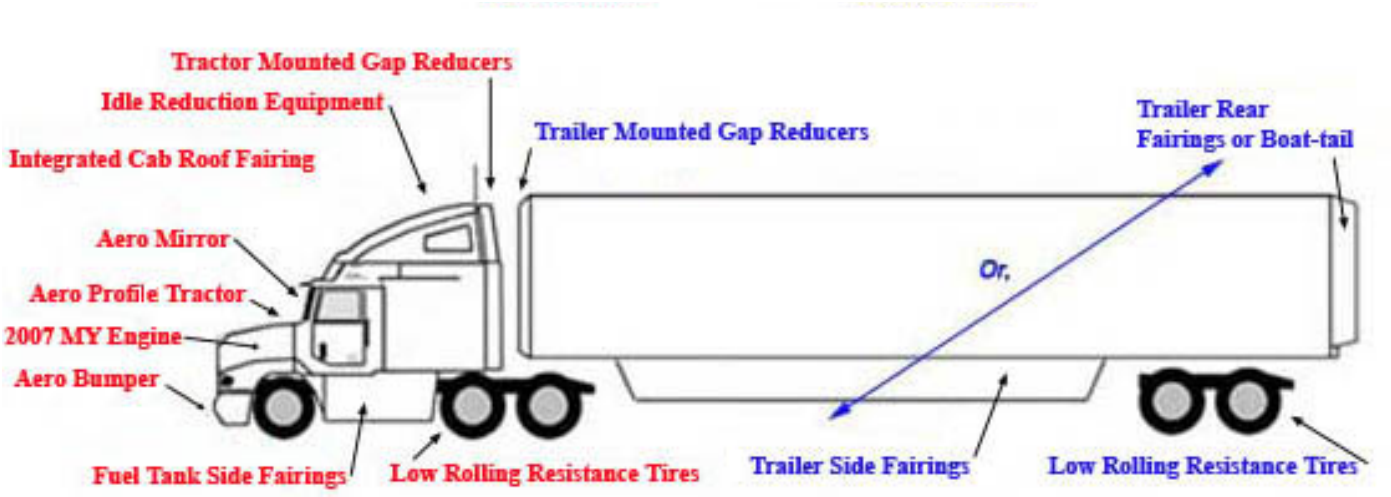
Defer Action on Trailers

- EPA's SmartWay demonstrated that trailer designs and low rolling resistance tires can substantially reduce fuel consumptions from tractor trailers
- The proposal provided broad notice of our intent to regulate trailers in the future
- We still need to develop a cost effective test procedure for trailers
- In the meantime, we will continue to rely on the SmartWay program to help drive trailer technology development and adoption



Costs, Savings, & Payback

Vehicle	Cost	Lifetime Fuel Savings	Lifetime Fuel Savings	Payback Period
¾ ton Pickup (e.g. F250)	$1,050	2,500 gallons	$7,200	2 years
Medium duty vocational	$380	2,000 gallons	$5,900	1 year
Class 8 Combination Tractor (interstate freight)	$6,220	26,150 gallons	$79,100	1 year

* Based on 2018 standards and net present value 3% discount rate

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Costs & Benefits

	Final Rule
Percent Reductions (2018)	Tractors: 10-23% Vocational Vehicles: 6-9% Pickup Trucks & Vans: 12-17%
Vehicle cost (2018)	Tractors: $6,220 Vocational Vehicles: $380 Pickup Trucks & Vans: $1,050
Fuel Savings (2014-2018 lifetime)	530 million barrels oil
CO2eq Reduction (2014-2018 lifetime, Upstream + Downstream)	270 MMT
Costs*	$8.1 billion
Benefits*	$57 billion
Net Benefits*	$49 billion

For More Information:

- See Fuel Efficiency and GHG rulemaking documents at www.epa.gov/otaq/climate/regulations.htm
- See Federal Register Vol. 76, No. 179 / Thursday, September 15, 2011 page 57106;
- Contact Angela Cullen US EPA
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