U.S. HDV GHG and Fuel Efficiency Final Rule

The Role for ICEs in Our Energy Future

17th Directions in Engine-Efficiency and Emissions Research (DEER) Conference

4 October 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

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.

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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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

- Final rule as proposed with improvements to test procedures raised through comments
- Regulate engines and tractors separately
- Engine standards met through same procedures as for criteria pollutants
- Tractor standards met through a compliance 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%)

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

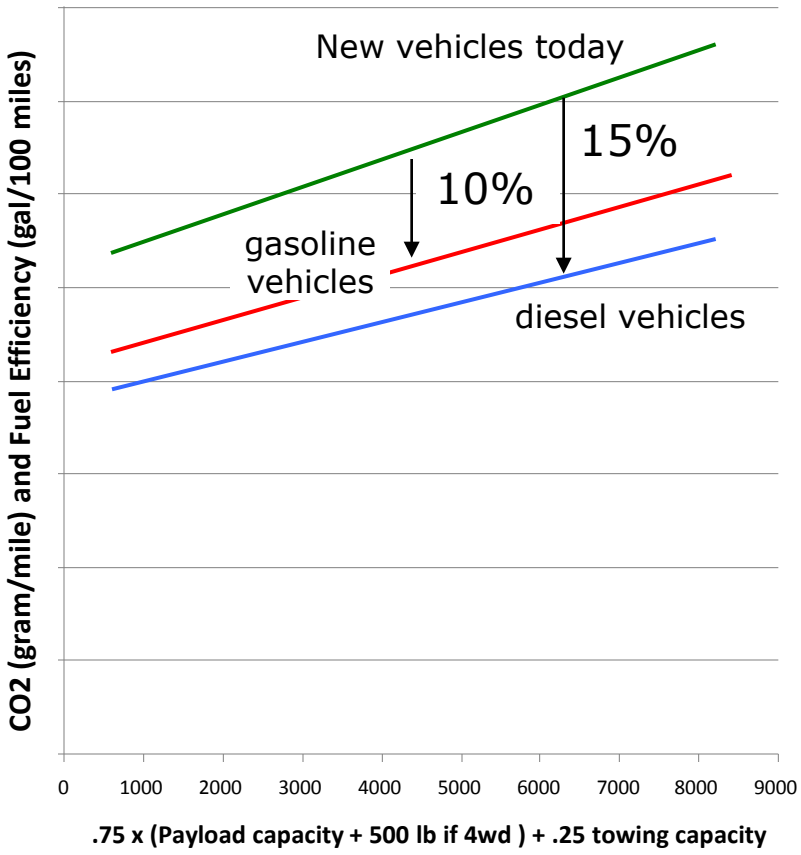
Key differences from Light Duty

- 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



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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Heavy-Duty Engine Cycle Classification
1036.150(c)

- The GHG standards depend on the engine cycle classification per the definitions in 1036.801
  - Spark-ignition means relating to a gasoline-fueled engine or any other type of engine with a spark plug (or other sparking device) and with operating characteristics significantly similar to the theoretical Otto combustion cycle. Spark-ignition engines usually use a throttle to regulate intake air flow to control power during normal operation.
  - Compression-ignition means relating to a type of reciprocating, internal-combustion engine that is not a spark-ignition engine.

- Engines which meet the definition of spark-ignition per 1036.801, but are regulated as diesel engines under 40 CFR part 86 (for criteria pollutants) then are treated as compression-ignition engines for GHG standards.

- Engines which meet the definition of compression-ignition per 1036.801, but are regulated as Otto-cycle engines under 40 CFR part 86 then are treated as spark-ignition engines for GHG standards.

Spark-Ignition Engine GHG Standards
1036.108

- The spark-ignition engine GHG emissions standards begin in 2016MY
- The GHG emissions for SI engines are evaluated over the Heavy-Duty Engine FTP cycle

Spark-Ignition Engines (g/hp-hr):

Model Year	CO2 Emissions	CH4 Emissions	N2O Emissions
2016 and Later	627	0.10	0.10

Primary CI Engine CO2 Standards

1036.108

- The compression-ignition engine CO2 emissions standards are based on:
  - GVWR of the vehicle for which the engine is primarily designed – 1036.140
  - Whether the engine is designed for installation in a vocational vehicle or combination tractor
- The CO2 emissions for vocational engines are measured over the Heavy-Duty Engine FTP cycle
- The CO2 emissions for tractor engines are measured over the Heavy-Duty Engine SET cycle

Compression-Ignition Engines (g/hp-hr):

Model Years	Light Heavy-Duty	Medium Heavy-Duty – Vocational	Heavy Heavy-Duty –Vocational	Medium Heavy-Duty –Tractor	Heavy Heavy-Duty – Tractor
2014-2016	600	600	567	502	475
2017 and later	576	576	555	487	460

Alternate Phase-In CI Engine CO2 Standards
1036.150(e)

- Must certify all 2013MY engines within a given primary intended service class to the alternate phase-in standards
- The alternate phase-in standards are applicable for 2013 through 2016 model years. If a manufacturer wants to select this pathway, then the engines must be certified in 2013 MY and continue through 2016 MY to the alternate phase-in standards. Once this path is selected, manufacturer cannot choose to opt out of these standards.
- No early credits can be earned on engines certified to this alternate phase-in

Alternate Phase-In CI Engine Standards (g/hp-hr):

Tractors	LHD Engines	MHD Engines	HHD Engines
Model Years 2013-2015	NA	512 g/hp-hr	485 g/hp-hr
Model Years 2016 and later[a]	NA	487 g/hp-hr	460 g/hp-hr
Vocational	LHD Engines	MHD Engines	HHD Engines
Model Years 2013-2015	618 g/hp-hr	618 g/hp-hr	577 g/hp-hr
Model Years 2016 and later[a]	576 g/hp-hr	576 g/hp-hr	555 g/hp-hr

Alternate CI Engine CO2 Standards

1036.620

- Available in 2014, 2015, and 2016 MYs only
- Available for averaging sets that do not have a balance of credits, which include the following:
  - Banked credits earned in the averaging set from previous model years
  - Early credits earned in the averaging set
  - Innovative credits earned in the averaging set
  - Advanced Technology credits earned in the averaging set
  - Advanced Technology credits earned outside the averaging set, up to 60,000 Mg per year
- The Alternate CI standards are:
  - LHD and MHD vocational engines = 0.975 * Adjusted CO2 Emissions from 2011 MY
  - HHD vocational engines = 0.970 * Adjusted CO2 Emissions from 2011 MY
  - MHD and HHD tractor engines = 0.970 * Adjusted CO2 Emissions from 2011 MY

CI Engine N2O and CH4 Standards
1036.108

- The N2O and CH4 emissions for all CI engines are measured over the Heavy-Duty Engine FTP cycle

Compression-Ignition Engines (g/hp-hr):

Model Years	CH4 Emissions	N2O Emissions
2014 and Later	0.10	0.10

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.

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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
- Trailer manufacturers are small businesses with limited technical expertise and resources
- The proposal provided broad notice of our intent to regulate trailers in the future
- Continue to rely on the SmartWay program to help drive trailer technology development and adoption

Key Differences

	Standard Metrics	Vehicles Covered	Other Pollutants	Lead Time
NHTSA www.nhtsa.gov	gallons/mile gal/ton-mile gal/bhp-hr	No recreational vehicles	Only fuel consumption	Voluntary in 2014 & 2015
EPA	gCO_2/mile gCO_2/ton-mile gCO_2/bhp-hr	All Heavy-Duty (non MDPVs)	A/C Leakage (HFC) N_20 & CH_4	Effective 2014

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

Conclusion

- New for first time MD/HD truck fuel efficiency & GHG emission standards
- Will reduce oil imports, fuel consumption, CO2 emissions and operating costs for thousands of businesses
- Builds on existing criteria pollutant regulations and fuel quality (ULSD)
- Constitutes a single coordinated national program that helps manufacturers to produce a single fleet of vehicles to meet related federal and state requirements
- Program design balances simplicity and flexibilities to reduce fuel consumption from an incredibly diverse segment of vehicles

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Future Engine Thoughts

- Robust to fuel quality variation
- Trade elastic power delivery for higher peak efficiency – let the machine change
- Need solutions that can be produced in high volume (to control costs) but tailored to individual duty cycles to optimize performance
- Sophisticated adaptive control schemes and new sensor technologies are the most likely path, but we should not discount novel engine designs

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;
- See Code of Federal Regulations, 40 CFR Part 1037
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