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EPA & DOT Issue Proposal for Phase 2 of Medium- and Heavy-duty Vehicle Fuel Efficiency & GHG Rules

In 2011, EPA and DOT finalized greenhouse gas (GHG) emissions and fuel efficiency standards for model year 2014 through 2019 medium- and heavy-duty trucks. These rules were the first GHG or fuel efficiency standards ever imposed on newly manufactured heavy vehicles.

On June 19, 2015, EPA and DOT published a Notice of Proposed Rulemaking detailing their proposed approach to "Phase 2" of the fuel efficiency and GHG standards for medium- and heavy-duty trucks, applicable to vehicles built starting in model year 2021. Generally, the structure and compliance mechanisms of the proposed Phase 2 rules are the same as the Phase 1 rules, but the proposed Phase 2 fuel use and GHG limits are significantly more stringent: up to 23 percent more efficient compared to model year 2019 vehicles when fully implemented in model year 2027. EPA and DOT are also proposing to regulate commercial trailers for the first time beginning in the 2018 model year, as trailers were not included in the Phase 1 rules. EPA and DOT have also proposed technical changes to the certification process to expand the suite of technologies that can be used by manufacturers to comply with the proposed Phase 2 standards and to better match the certification process to real world driving conditions.

While the proposed Phase 2 rules will increase purchase costs for future new trucks, EPA and NHTSA estimate that annual fuel savings will pay back these costs in two to six years for most vehicles. They estimate net cost savings for vehicle owners of more than $69 billion over the life of vehicles manufactured between 2018 and 2029, and total reductions in fuel use of over 73 billion gallons.

History of Vehicle Fuel Economy Standards

This brief summary of the history of U.S. light-duty fuel economy regulation provides context for the existing and proposed medium- and heavy-duty fuel efficiency regulations and highlights the similarities and differences between the two sets of rules.

Since 1975, the average fuel economy of new cars and light trucks sold in the U.S. has been regulated by DOT's National Highway Traffic Safety Administration (NHTSA) under the Corporate Average Fuel Economy Program (CAFE). Historically, CAFE rules only applied to vehicles less than 8,500 pound gross vehicle weight (GVW), thereby exempting medium- and heavy-duty trucks and buses. Under CAFE, not all models sold each year have needed to meet a specific fuel economy target. Rather, manufacturers have been required to meet a sales-weighted fleet average each year, and the rules include a number of other mechanisms to provide further flexibility to manufacturers.

Between 1978 and 1990, the CAFE-mandated fleet average fuel economy for new cars was raised incrementally from 18 miles per gallon (MPG) to 27.5 MPG, where it remained, unchanged, for the next 20 years. The CAFE program also includes a separate fleet average standard for light trucks at 22.5 MPG for model year 2008.

In 2006, NHTSA established new standards for light trucks manufactured from the 2008 to 2011 model years. These new standards extended CAFE requirements to larger vehicles up to 10,000 pounds GVW and applied different numerical standards to vehicles of different size, based on their "foot print" (foot print = width x wheelbase). Trucks with a larger foot print were allowed to have lower average fuel economy. The new fleet-average light truck fuel economy standard rose to 24.1 MPG for the 2011 model year.

In 2010, NHTSA and EPA issued a joint rulemaking that established a new program to regulate both the fuel economy and GHG emissions from cars and light trucks. This rulemaking was the first time that EPA asserted its obligation to regulate carbon dioxide (CO_2) emissions under the Clean Air Act. This new program applies to new cars and light trucks sold in the 2012 through 2016 model years, and assigns both a fleet average fuel economy target (MPG) and an equivalent fleet average CO2 emissions target (grams/mile) for various subsets of vehicles. This program also extended the foot print concept to cars, allowing larger vehicles to have lower fuel economy and higher CO_2 emissions. These rules increased the over-all fleet average fuel economy required of model year 2016 vehicles to 34.1 MPG.

In 2012, EPA and NHTSA finalized new CAFE fuel economy and CO_2 emissions targets for cars and light trucks to be sold from the 2017 through 2025 model years, which will raise the required fleet average fuel economy for cars and light trucks to 54.5 MPG in model year 2025.

Heavy-Duty GHG and Fuel Efficiency Standards

The Phase 1 GHG and fuel efficiency standards for medium- and heavy-duty vehicles issued by EPA and NHTSA in 2011 are in some ways similar to their 2010 joint CAFE program for light-duty vehicles, but in many ways they are markedly different. For Phase 2, EPA has proposed to maintain the same basic structure as the Phase 1 rules, with only minor modifications.

The heavy-duty rules are similar to the light-duty rules in terms of both fuel efficiency targets and equivalent CO_2 emission targets for different types of vehicles, but the heavy-duty metrics used for these targets are quite different than those used in the CAFE program for cars and light trucks.

The heavy-duty rules divide the entire world of heavy trucks into subsets and set different numerical standards for different types of trucks, in the same way that CAFE treats light trucks differently than cars. The three main regulatory categories for both Phase 1 and Phase 2 are: 1) "heavy-duty pickups and vans", 2) "combination trucks" (truck tractors used to pull trailers), and 3) all other trucks, labeled as "vocational trucks".

The heavy-duty pick-up and van and combination truck categories are each fairly homogenous, but the vocational truck category is very diverse. Vocational trucks include everything from buses, to dump trucks to refuse trucks ranging in size from 10,000 to more than 60,000 pounds GVW. For Phase 2, EPA and NHTSA have proposed to further subdivide vocational trucks into: 1) those primarily used in urban (low speed) applications, 2) those used in regional (higher speed) applications, and 3) multi-purpose vehicles that could be used in a variety of applications.

The assignment of a particular vocational truck to one of these regulatory categories would be based primarily on the ratio of engine speed over the highway test cycle (based on the vehicle's transmission gearing and final drive ratio) to rated maximum engine speed. Manufacturers could request exemptions to this rule based on stated intended use or other physical vehicle characteristics. EPA's presumption is that vehicles will be certified as multi-purpose vehicles unless there is strong objective evidence to support their inclusion in one of the other regulatory categories. EPA is also proposing that all trucks with hybrid drive trains would be certified as urban vehicles and that all inter-city coach buses and recreational vehicles would be certified as regional vehicles.

Similar to light-duty CAFE, the heavy-duty regulations contain significant flexibility mechanisms such that not every vehicle of the same type is required to have the same fuel economy. For heavy-duty pick-ups and vans, EPA and NHTSA mandated in Phase 1 that manufacturers must meet a sales-weighted fleet average each year, just as they do for cars and light-trucks under CAFE. However, EPA and NHTSA did not adopt fleet average standards for Phase I for combination trucks and vocational trucks. For these vehicle types, flexibility is provided by an averaging, banking, and trading program (ABT) and by various types of credit programs similar to the way EPA provides flexibility when certifying heavy-duty engines to criteria pollutant emission standards. EPA has proposed this same structure for Phase 2: heavy-duty pick-ups and vans will be required to meet a sales-weighted fleet average each year, while flexibility for the other types of heavy-duty vehicles will continue to be provided via ABT and credit programs.

CAFE sets "full vehicle" standards for cars and light trucks, expressed as a mile per gallon fuel economy target and an equivalent gram per mile CO_2 emissions target. Certification that a vehicle does or does not meet the standard is based on vehicle testing – with vehicles mounted on a chassis dynamometer and exercised over specific test cycles (speed versus time). This approach is how the Phase 1 medium- and heavy-duty pick-ups and vans were treated. For Phase 2, EPA and NHTSA are proposing to stay with mile per gallon and gram per mile targets and to keep certification based on full-vehicle testing for these vehicles.

However, combination trucks and vocational trucks are treated very differently in both Phase 1 and the proposed Phase 2 rules. For these types of trucks, EPA and NHTSA mandated in Phase 1 both engine and separate vehicle standards. The engine standards are expressed as allowable fuel use and CO_2 emissions per unit of engine work – gallons per 100 brake horsepower-hour (gal/100 bhp-hr) and grams per bhp-hr. This approach is analogous to how EPA regulates criteria pollutants (NO_X, PM, VOC, and CO) from medium- and heavy-duty trucks, using engine rather than vehicle standards.

For Phase 1, certification to the engine fuel efficiency and CO_2 emission standards is based on the same test cycles and engine test procedures used to certify engines to the criteria pollutant standards. For Phase 2, EPA and NHTSA are again proposing to set both engine and separate vehicle standards and to keep the form of these standards the same as in Phase 1. Certification to the Phase 2 engine standards is proposed to still be based on the procedures and test cycles used for criteria pollutants, except that EPA and NHTSA have proposed to modify the engine test cycle to be used for combination truck engines, to better reflect real-world driving conditions.

The separate Phase 1 vehicle standards applied to combination and vocational trucks were not expressed as MPG and g/mi standards as they are for light duty vehicles and heavy-duty pick-ups and vans. Rather, they were expressed as allowable fuel use and CO_2 emissions per ton of payload driven one mile (gallons/1,000 ton-mi and grams/ ton-mi) in recognition that most heavy-duty vehicles are used to haul freight. Certification to these Phase 1 vehicle standards is not based on actual vehicle testing but is instead based on modeling, using a computer simulation program called Greenhouse Gas

Emissions Model (GEM), which was developed by EPA for the Phase 1 regulations. Combination trucks are modeled in GEM assuming that they are pulling a "standard trailer," which represents a typical 53-ft dry van trailer in use today.

For Phase 2, EPA and NHTSA are proposing to keep the form of the vehicle standards the same as in Phase 1, and to continue the use of the GEM model for certification. However, for Phase 2, EPA has proposed technical changes to GEM, which will provide manufacturers greater flexibility and allow them to claim credit in the certification process for a wider range of fuel efficiency technologies, including improved transmissions and drivelines. EPA is also proposing to slightly modify the drive cycles used in GEM for Phase 2 compared to Phase 1, including different drive cycles for different types of vocational trucks (urban, regional, multi-purpose). Finally, for Phase 2, EPA is proposing to change the definition of the "standard trailer" used to certify combination trucks, to reflect greater adoption of aerodynamic side skirts in the trailer fleet since adoption of the Phase 1 rules.

How will New Vehicles be Different than Older Vehicles?

Table 1 summarizes EPA and NHTSA's assessment of how fuel use from medium- and heavy-duty trucks, compliant with both the Phase 1 and proposed Phase 2 standards, will compare to trucks built before the standards were implemented (model year 2010). The Phase 1 standards were implemented in two steps, and EPA an NHTSA are proposing to implement the Phase 2 standards in three steps beginning with less string interim standards in model year 2021, with the most stringent standards applying as of model year 2027.

Table 1: EPA Phase 1 Fuel Efficiency Standards – Reduction in Fuel use Compared to MY2010

Vehicle Type		Phase 1 by model year		Proposed Phase 2 by model year		
		2014 - 2016	2017- 2020	2021 - 2023	2024 - 2026	2027+
Heavy-duty Pick-Ups and Vans [1]	Gas	Up to 4%	Up to 10%	Up to 12%	Up to 20%	Up to 26%
	Diesel	Up to 7%	Up to 10%	Up to 12%	Up to 20%	Up to 26%
Vocational Trucks [2]	*Engines*	*Up to 5%*	*Up to 9%*	*Up to 11%*	*Up to 12%*	*Up to 13%*
	Vehicles	Up to 6%	Up to 9%	Up to 16%	Up to 20%	Up to 25%
Combination Trucks [3]	*Engines*	*3%*	*6%*	*8%*	*9%*	*10%*
	Vehicles	Up to 21%	Up to 23%	Up to 36%	Up to 43%	Up to 47%
Commercial Trailers		NA	Up to 2%[4]	Up to 4%	Up to 6%	Up to 8%

[1] Standards vary depending on size (footprint) and towing capability.

[2] Engine standards vary depending on engine size: light-medium, medium-heavy, or heavy-heavy duty. In Phase 2 vehicle standards also vary depending on intended vehicle use: urban, regional, or multi-purpose.

[3] Standards vary depending on GVWR (Class 7 or 8) and cab type (sleeper cab or day cab, and cab height – low, mid, high). The highest reductions will be from high-roof sleeper cab trucks. Lower reductions are required from low-roof sleeper cab and from day cab equipped trucks.

[4] Trailer standards start in MY2018 under the proposed Phase 2 rules. Trailers were not regulated in Phase 1

As shown, the final proposed Phase 2 standards are significantly more stringent than the Phase 1 standards, more than doubling the reductions in fuel use required in Phase 1 for most heavy vehicles. However, both the Phase 1 and proposed Phase 2 standards are more stringent for combination trucks than for pickups and vocational trucks. When Phase 2 is fully implemented, a new model year 2027 high roof sleeper cab tractor pulling a new model year 2027 van trailer that both meet the proposed

Phase 2 standards will use less than 50 percent of the fuel per ton-mile used by a similar model year 2010 tractor and trailer combination. By contrast, fuel use for compliant model year 2027 pickups and vocational trucks will be only about 25 percent lower than fuel use by similar model year 2010 trucks.

In both Phase 1 and proposed Phase 2, combination truck standards vary by weight class (Class 7 or Class 8) and by cab type, with the most stringent standards applied to high-roof sleeper cab trucks and less stringent standards applied to low-roof sleeper cab and day cab trucks.

In Phase 1, the same numerical standards were applied to all vocational trucks. In Phase 2, EPA and NHTSA are proposing to apply separate numerical limits for both fuel use and GHG emissions to urban, regional, and multi-purpose vocational trucks.

The separate engine standards for combination trucks and vocational trucks in both Phase 1 and Phase 2 will ensure that engines in virtually all of these vehicles will become more efficient over time. EPA projects that improved engine efficiency will come mostly from changes to internal engine parts that will improve combustion, and reduce friction and other internal engine losses. However, they do project that by model year 2027, about 25 percent of combination truck engines will employ some type of exhaust waste heat recovery, such as turbo-compounding or rankine-cycle systems. These systems will add components and complexity to these engines. EPA does not believe that waste heat recovery systems will be required for vocational truck engines to meet the proposed Phase 2 limits.

The only other required change expected for vocational trucks to meet Phase 1 vehicle standards is that many will need to be delivered with low rolling resistance tires. More extensive changes will be required for vocational trucks to meet the proposed Phase 2 vehicle limits, including improvements in the transmission and driveline, use of workday idle reduction technologies, weight reduction, and the application of hybrid technology for some trucks.

The changes to combination trucks in order to meet Phase 1 and proposed Phase 2 vehicle standards will be more significant, including, most importantly, improvements to vehicle aerodynamics, as well as limited vehicle weight reduction, and implementation of auxiliary power units to reduce overnight idling for many sleeper cab-equipped trucks. Meeting the most stringent Phase 2 limits will also require improvements to the transmission and driveline, as well as reduction in vehicle accessory loads.

EPA expects that in order to meet the proposed Phase 2 limits, heavy-duty pickups will need to have more efficient engines, improved transmissions, improved aerodynamics, low rolling resistance tires, reduced weight, and improved vehicle accessories. To meet the most stringent Phase 2 limits in model year 2027, some heavy-duty pickups may also need to employ engine stop-start, and powertrain hybridization.

Commercial Trailers

Other than increased stringency, the most significant difference between the Phase 1 and the proposed Phase 2 heavy-duty fuel efficiency and GHG rules is that EPA and NHTSA are proposing to start regulating commercial trailers in Phase 2, beginning with trailers built in model year 2018.

Combination trucks currently burn approximately two thirds of all fuel used by medium- and heavy-duty trucks. Commercial trailers do not have engines, and therefore, they do not technically use any fuel. However, the physical characteristics of a trailer can have as great or greater effect on total fuel use from a combination truck-trailer as the physical characteristics of the truck. The aerodynamics and rolling resistance of the trailer affect how much work the truck's engine must do, and therefore how

much fuel it burns, which is why EPA and NHTSA have proposed to regulate commercial trailers for the first time in the proposed Phase 2 fuel efficiency and GHG rules. Improvements to commercial trailers can reduce the total amount of fuel used by the heavy truck sector to a greater extent than improvement to trucks alone.

Under the proposed Phase 2 rules, EPA and NHTSA have set different numerical targets for fuel use (gallon per 1,000 ton-miles) and CO_2 emissions (grams per ton-mile) for four types of commercial trailers: long and short dry van trailers, and long and short refrigerated van trailers. These trailers represent about 70 percent of the current fleet. Compliance with these rules will be evaluated using the GEM simulation model by modeling the trailer being pulled by a Phase 2 compliant "standard tractor."

When fully implemented in model year 2027, EPA estimates that compliant trailers will reduce fuel use by the trucks pulling them by an additional 8 percent compared to current trailers.

Changes that will be required to meet the proposed Phase 2 van trailer standards include improved aerodynamics using side and rear fairings and gap closers, reduced weight, use of low rolling resistance tires, and use of automatic tire inflation systems.

For other types of commercial trailers such as flat beds and tank trailers, EPA and NHTSA are not setting numerical fuel efficiency and GHG targets, but are proposing design standards that mandate adoption of certain tire technologies that will reduce rolling resistance.

Costs and Benefits

Technologies required to meet the proposed Phase 2 standards are in varying stages of commercial availability ranging from already available but with limited adoption, to still in research and development stages. All of these technologies will add cost to the price of new vehicles, but will reduce annual fuel costs for vehicle owners, while reducing GHG emissions from the heavy-duty fleet.

EPA and NHTSA estimate that meeting the proposed model year 2027 standards will, on average, add about $12,000 to the purchase price of a combination truck tractor, $3,400 to the price of a vocational vehicle, $1,400 to the price of a heavy-duty pickup, and $1,200 to the price of a commercial van trailer. These costs are in addition to any costs associated with meeting the Phase 1 standards and are expressed in 2012 dollars.

EPA and NHTSA estimate that the payback period for these additional purchase costs will be two years for combination trucks, three years for heavy-duty pickups, and six years for the average vocational truck, based on additional annual fuel cost savings.

EPA and NHTSA estimate that the proposed Phase 2 rules will result in reduced fuel use of 73 to 77 billion gallons over the life of vehicles built in model years 2018 to 2029, equating to a reduction in GHG emissions of 932 to 990 million metric tons of CO_2.

They estimate that over-all compliance costs for the proposed Phase 2 rules will total $20 to 31 billion, but that over-all benefits will total $156 to 276 billion. In addition to estimated total fuel cost savings of $89 to 175 billion, the estimated benefits include the monetized value of GHG and other emission reductions, as well as increased energy security.

Key Takeaways

- EPA and NHTSA's proposed Phase 2 heavy-duty fuel efficiency and GHG rules are intended to be technology forcing. They will incentivize further adoption of already commercially available technologies, but they will also require the use of new technologies that are still being developed. EPA has provided manufacturers more than 10 years lead time to develop the most advanced technologies, which will not be required on new trucks until the 2027 model year.
- In order to meet the most stringent proposed Phase 2 limits in model year 2027, virtually all truck engines will need to be more efficient than current engines. It is expected that efficiency gains will derive primarily from internal engine changes that improve combustion and reduce engine friction and other internal losses. In addition to improved engines, virtually all trucks will also require improved transmissions and drivelines, technologies to reduce engine idling, and low rolling resistance tires. Combination truck tractors and heavy-duty pickups will also require improved aerodynamics and reduced weight. The proposed Phase 2 limits are also expected to drive limited adoption of waste heat recovery systems on combination truck engines and drivetrain hybridization for some heavy-duty pickups and urban vocational trucks.
- Compliance with the proposed Phase 2 fuel efficiency and GHG limits will increase truck purchase costs by as much as 10 percent in the 2027 model year, compared to continuation of the less stringent Phase 1 limits currently in place. However, these incremental costs will be recovered by additional annual fuel cost savings in 2 to 6 years for most trucks. Increased costs will be greatest for combination truck tractors; however, these vehicles will also have the greatest annual fuel costs savings and the shortest pay-back period because they typically drive many more miles, and burn significantly more fuel, than vocational trucks or heavy pickups each year.
- In the last five years, there has been increased adoption of new-build and retrofit aerodynamic aids on the commercial trailers pulled by combination trucks, particularly side and rear fairings on van trailers. This change has likely been driven primarily by rules issued by the California Air Resources Board, which mandates them on all trailers used in California. The inclusion of commercial trailers in the proposed Phase 2 heavy-duty fuel efficiency and GHG rules is expected to accelerate the adoption of these technologies, as well as the adoption of low rolling resistance trailer tires and automatic trailer tire inflation systems resulting in significantly greater reductions in total fuel use by the heavy truck sector than could be achieved by improvements to trucks alone.

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