MECA **Executive Bulletin**

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For MECA Members Only

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SPECIAL REPORT:
Summary of the U.S. EPA/NHTSA Phase 2 Heavy-Duty GHG Proposal

The U.S. EPA and NHTSA have proposed new, more stringent standards for the same classes of heavy-duty vehicles currently regulated through model year 2018 and beyond under their Phase 1 program. They are also proposing the first ever carbon dioxide and fuel efficiency standards for certain trailers used with heavy-duty combination tractors. Specifically, EPA's proposed CO_2 emissions standards and NHTSA's proposed fuel consumption standards are tailored to each of four regulatory categories of heavy-duty vehicles: 1) combination tractors; 2) trailers pulled by combination tractors; 3) heavy-duty pickup trucks and vans; and 4) vocational vehicles, which include all other heavy-duty vehicles such as buses, refuse trucks, and concrete mixers. The proposal also includes separate standards for the engines that power combination tractors and vocational vehicles.

In addition to the proposed standards, EPA and NHTSA are seeking comment on alternative standards that would accelerate the program by 2-3 years (e.g., full phase-in by 2024 instead of 2027), as well as several other alternative sets of standards, including less stringent and more stringent options.

The proposed Phase 2 heavy-duty GHG requirements are summarized below.

Combination Tractors

Class 7 and 8 combination tractors and their engines account for roughly two-thirds of total GHG emissions and fuel consumption from the heavy-duty sector. This is due to their large payloads and high number of vehicle miles traveled. The proposed CO_2 and fuel consumption standards for combination tractors and engines would start in model year (MY) 2021, increase incrementally in MY 2024, and phase in completely by MY 2027. The proposed standards differ by vehicle weight class, roof height, and cab type (sleeper or day). The fully phased-in standards would achieve up to 24% lower CO_2 emissions and fuel consumption compared to the Phase 1 standards. The proposed tractor standards could be met through improvements in the engine, transmission, driveline, aerodynamic design, lower rolling resistance tires, extended idle reduction technologies, and other accessories of the tractor.

The table below provides EPA projections for technology penetration in future combination tractors to meet EPA's proposed standards in 2021, 2024, and 2027.

Table 1. Projected Tractor Engine Technologies and Reduction

Supplemental Emissions Test (SET) Mode	SET Weighted Reduction (%) (2020-2027)	Market Penetration (2021)	Market Penetration (2024)	Market Penetration (2027)
Turbo compound with clutch	1.8%	5%	10%	10%
WHR (Rankine cycle)	3.6%	1%	5%	15%
Parasitic/Friction (Cyl kits, pumps, FIE), lubrication	1.4%	45%	95%	100%
Aftertreatment (lower dP)	0.6%	45%	95%	100%
EGR/Intake & exhaust manifolds/Turbo/VVT/ Ports	1.1%	45%	95%	100%
Combustion/FI/Control	1.1%	45%	95%	100%
Downsizing	0.3%	10%	20%	30%
Weighted reduction (%)		1.5%	3.7%	4.2%

Trailers

Recognizing the trailer as an integral part of the tractor-trailer vehicle that significantly contributes to the emissions and fuel consumption of the tractor, the Phase 2 program includes proposed standards for trailers used with heavy-duty combination tractors. The proposed standards would apply to certain trailer types beginning in MY 2018 for EPA's standards, and would be voluntary for NHTSA from 2018 to 2020, with mandatory standards beginning in 2021. The proposed standards would extend to more trailer types in MY 2021.

The fully-phased standards would apply to the following five categories of trailers:

- Long (longer than 50 feet) highway box trailers-dry vans;
- Long highway box trailers-refrigerated vans;
- Short (50 feet and shorter) highway box trailers-dry vans;
- Short highway box trailers-refrigerated vans; and
- Non-box highway trailers

The standards increase in stringency in MYs 2021 and 2024, with final standards in MY 2027. Some types of trailers would have reduced requirements or would be excluded from the trailer standards altogether, including those designed for logging and mining, as well as mobile homes. The fully phased-in trailer standards would achieve up to 8% lower CO_2 emissions and fuel consumption compared to an average MY 2017 trailer. Technologies that could be used to meet the proposed standards include: aerodynamic devices, lower rolling resistance tires, automatic tire inflation systems, and weight reduction. Trailer manufacturers would certify their trailers using a simple equation developed from EPA's enhanced GEM modeling tool that

recognizes and quantifies the impacts of the expected trailer technology packages on CO_2 emissions.

Vocational Vehicles

Vocational vehicles consist of a wide variety of truck and bus types, including delivery trucks, refuse haulers, public utility trucks, transit, shuttle, and school buses. This segment also includes very specialized vehicles, such as emergency vehicles and cement and dump trucks. Vocational vehicles represent about one-fifth of the total medium- and heavy-duty fuel consumption. The agencies are proposing new CO_2 and fuel consumption standards for vocational vehicles starting in MY 2021, with increased stringency in MY 2024 and a fully phased-in stringency level in MY 2027. The proposed vocational vehicle standards are differentiated using three vehicle weights and three driving cycles (ARB transient cycle for stop-and-go city driving, 55 mph urban driving, and 65 mph rural interstate highway driving). The three vocational driving cycles have been adjusted in the Phase 2 proposal to distance-based rather than time-based cycles, with road grade adjustments included in both the 55 mph and 65 mph driving cycles. Reductions in work-day idling is also recognized in the Phase 2 proposal for vocational vehicles. The agencies are also proposing separate standards for emergency vehicles.

The fully phased-in standards would achieve up to a 16% reduction in CO_2 emissions and fuel consumption relative to Phase 1. The agencies project that the proposed vocational vehicle standards could be met through improvements in the engine, transmission, driveline, lower rolling resistance tires, work-day idle reduction technologies, and weight reduction.

The table below provides EPA projections for technology penetration in future vocational trucks to meet EPA's proposed standards in 2021, 2024, and 2027.

Table 2. Projected Vocational Engine Technologies and Reduction

Technology	GHG Emissions Reduction (2020-2027)	Market Penetration (2021)	Market Penetration (2024)	Market Penetration (2027)
Model based control	2.0%	25%	30%	40%
Parasitic/Friction	1.5%	60%	90%	100%
EGR/Air/VVT/Turbo	1.0%	50%	90%	100%
Improved AT	0.5%	50%	90%	100%
Combustion optimization	1.0%	50%	90%	100%
Weighted reduction (%)-L/M/HHD		2.0%	3.5%	4.0%

Heavy-Duty Pickup Trucks and Vans

Heavy- and medium-duty pickup trucks and vans represent about 15% of the fuel consumption and GHG emissions from the heavy- and medium-duty vehicle sector. The

agencies are proposing new CO_2 emission and fuel consumption standards for heavy-duty pickups and vans that would be applied in largely the same manner as the Phase 1 standards. Under this approach, all manufacturers face the same standards, but the average emission and fuel consumption rates applicable to each manufacturer depend on the manufacturer's sales mix, with higher capacity vehicles (payload and towing) having less stringent targets. The proposed standards for this segment take the form of a set of target standard curves, based on a "work factor" that, as in Phase 1, combines a vehicle's payload, towing capabilities, and whether or not it has 4-wheel drive. The proposed standards would become 2.5% more stringent every year from model years 2021 to 2027.

The proposed program would reduce CO_2 emissions and fuel consumption for these vehicles by about 16% beyond Phase 1 when fully phased in. EPA believes most manufacturers would choose to meet the performance standards through increased use of the same technologies already being used to meet the 2014-2018 standards. These technologies include improvements in engines, transmissions, and lower rolling resistance tire technologies. Under Phase 2, the agencies expect newer, advanced technologies, such as engine stop-start and powertrain hybridization, will also become available in this segment of the market.

Engine Standards

As with the Phase 1 program, the agencies are proposing separate standards and test cycles for tractor engines, vocational diesel engines, and vocational gasoline engines. For diesel engines, the proposed standards would begin in MY 2021 and phase in to MY 2027, with interim standards in MY 2024. EPA is also proposing a revised Supplemental Emissions Test (SET) test cycle weighting for tractor engines to better reflect actual in-use operation. This proposed revised weighting of the SET cycle for use in Phase 2 fuel consumption standards moves weighting primarily from the high-speed modes ("C" speed modes) to the low-speed modes ("A" speed modes) to better reflect real-world highway operation. The proposed diesel engine standards would reduce CO_2 emissions and fuel consumption by up to 4% compared to Phase 1. Technologies that could be used to meet the standards include: combustion optimization; improved air handling; reduced friction within the engine; improved emissions aftertreatment technologies; and waste heat recovery.

Table 3. Proposed Phase 2 Heavy-Duty Tractor Diesel Engine Standards over the SET Cycle

Model Year	Medium Heavy-Duty	Heavy Heavy-Duty
2017 Baseline CO_2	487 g/bhp-hr	460 g/bhp-hr
2021-2023 CO_2	479 g/bhp-hr (-1.6% vs. 2017)	453 g/bhp-hr (-1.5% vs. 2017)
2024-2026 CO_2	469 g/bhp-hr (-3.7% vs. 2017)	443 g/bhp-hr (-3.7% vs. 2017)
2027 and later CO_2	466 g/bhp-hr (-4.3% vs. 2017)	441 g/bhp-hr (-4.1% vs. 2017)

Table 4. Proposed Phase 2 Vocational Diesel Engine Standards over the FTP Cycle

Model Year	Light Heavy-Duty	Medium Heavy-Duty	Heavy Heavy-Duty
2017 Baseline CO_2	576 g/bhp-hr	576 g/bhp-hr	555 g/bhp-hr
2021-2023 CO_2	565 g/bhp-hr (-1.9% vs. 2017)	565 g/bhp-hr (-1.9% vs. 2017)	544 g/bhp-hr (-2.0% vs. 2017)
2024-2026 CO_2	556 g/bhp-hr (-3.5% vs. 2017)	556 g/bhp-hr (-3.5% vs. 2017)	536 g/bhp-hr (-3.4% vs. 2017)
2027 and later CO_2	553 g/bhp-hr (-4.0% vs. 2017)	553 g/bhp-hr (-4.0% vs. 2017)	533 g/bhp-hr (-4.0% vs. 2017)

EPA is not proposing any changes to the 2016 gasoline vocational engine standard, but expects some modest reductions to gasoline engine fuel consumption in vocational applications as a result of tighter vocational vehicle emission standards. EPA asks for comments on proposing a 1% reduction in the 2016 gasoline vocational engine standard.

Standards for Other Greenhouse Gases

Because certain refrigerants are also extremely potent GHGs, the program includes EPA proposed standards to control leakage of hydrofluorocarbons (HFCs) from air conditioning systems in vocational vehicles. Similar HFC standards already apply under the Phase 1 program for combination tractors, and for pickup trucks and vans.

EPA has proposed more stringent nitrous oxide (N_2O) standards for heavy-duty engines. These tighter N_2O standards only apply to diesel engines used in tractor and vocational applications. The proposal calls for a 50% reduction in the Phase 1 standard, from 100 mg/bhp-hr to 50 mg/bhp-hr starting with MY 2021. In addition to proposing a tighter N_2O standard, EPA has also proposed decreasing the default N_2O deterioration factor from 20 to 10 mg/bhp-hr. MY 2014 certification data included in the proposal shows that 18 of 24 heavy-duty diesel engines from a range of manufacturers exhibited N_2O emissions below 50 mg/bhp-hr. EPA is proposing to continue with their Phase 1 engine standards for methane with no changes for Phase 2 (CH_4 capped at 100 mg/bhp-hr).

As in Phase 1, excess N_2O and CH_4 emissions above the caps may be offset with available CO_2-equivalent credits or CO_2-equivalent over-compliance. EPA has asked for comment on whether they should update their global-warming potential values for both N_2O and CH_4 used in the CO_2 credit exchange process.

Natural Gas Vehicles

Starting with MY 2021, manufacturers would be required to divide all of their natural gas engines into primary intended service classes (as required by compression ignition engines). Any natural gas engine qualifying as a medium heavy-duty engine (19,500 to 33,000 lb GVWR) or a heavy heavy-duty engine (over 33,000 lb GVWR) would be subject to all of the emission standards (GHG and criteria pollutant emissions) and other requirements that apply to

compression ignition engines. The current natural gas engine assignments based on the source of the engine block (i.e., engines derived from a diesel engine block treated as compression ignition engines; engines derived from a spark-ignited engine block treated as spark-ignited engines) would continue through MY 2020.

EPA is also proposing to require that all new natural gas-fueled engines have closed crankcases starting with MY 2021, and require a five-day hold time for new LNG vehicles (based on SAE standard J2343) to limit boil-off emissions. EPA has requested comments on a number of other natural gas topics, including LNG boil-off warning systems, extending LNG hold time beyond five days, capturing/converting methane refueling or boil-off emissions, reducing refueling emissions, and separate standards for natural gas engines that reflect upstream methane emissions.

EPA includes in their proposal a review of various market projections for the use of natural gas in heavy-duty trucks. EPA believes that natural gas will continue to be a relatively small player in the heavy-duty market over the timeframe of the proposed Phase 2 regulations. EPA also notes that the agency is taking steps to reduce upstream methane emissions from the natural gas production and gas transmission industries.

PM Emissions from Auxiliary Power Units

EPA is seeking comment on the need and appropriateness to further reduce PM emissions from auxiliary power units (APUs) used primarily on heavy-duty tractors. APUs are used in lieu of operating the main engine during extended idle operations to provide climate control and power to the driver. EPA requests comments on the technical feasibility and costs of the ability of diesel particulate filters to reduce PM emissions by 85% from nonroad engines used to power APUs.

Since January 1, 2008, ARB has prohibited the idling of sleeper cab tractors during periods of sleep and rest. The regulations apply additional requirements to diesel-fueled APUs on tractors equipped with MY 2007 or newer engines. Truck owners in California must either: 1) fit the APU with an ARB-verified Level 3 particulate control device that achieves 85% reduction in PM, or 2) have the APU exhaust plumbed into the vehicle's exhaust system upstream of the PM filter device. Currently, ARB includes four retrofit filter technologies that have been verified to meet the Level 3 PM requirements.

Treatment of Glider Kits

EPA's proposed Phase 2 program would generally treat glider vehicles the same as other new vehicles. As a result, glider vehicles would have to be certified to the Phase 2 vehicle standards, which (among other things) would require a fuel map for the actual engine in order to run the GEM modeling tool. In other words, manufacturers producing glider kits would need to meet the applicable GHG vehicle standards and, as part of its compliance demonstration, would need to have a fuel map for each engine that would be used. EPA is also proposing to amend its rules to require that engines used in glider vehicles must be certified to the standards applicable to the calendar year in which assembly of the glider vehicle is completed. This requirement

would apply to all pollutants, and thus would encompass criteria pollutant standards as well as GHG standards. Used or rebuilt engines could be used, as long as they had been certified to the same standards as apply for the calendar year of glider vehicle assembly. For example, if assembly of a glider vehicle was completed in calendar year 2020, the engine standards applicable to MY 2020 engines would have to be satisfied. (If the engine standards for MY 2020 were the same as for MYs 2017 through 2019, then any MY 2017 or later engine could be used.) EPA is proposing that this requirement for gliders to meet engine and vehicle standards applicable to other new vehicles and engines take effect on January 1, 2018.

A limited number of glider kits produced by small businesses would not have to meet the GHG vehicle standards, and could use rebuilt or used engines provided that those engines were certified to the year of the engine's manufacture. For example, an existing small business that produced between 100 and 200 glider vehicles per year would be allowed to produce up to 200 glider vehicles per year without having to certify them to the GHG standards, or re-certifying the engines to the now-applicable EPA standards for criteria pollutants and GHGs (so long as the engine is certified to criteria pollutant standards for the year of its manufacture). To be eligible for this provision, EPA is also proposing that no small entity could produce more than 300 glider vehicles in any given model year without having to certify (or recertify) them to any EPA standards.

Certification and Testing Procedures

The basic vehicle certification process for Phase 2 remains generally the same as the Phase 1 process, but EPA is proposing the use of a more enhanced GEM model that will capture many more engine/vehicle attributes that impact vehicle GHG emissions. EPA believes that a combination of a robust powertrain family definition, a refined powertrain test procedure (engine + transmission in an engine dynamometer test cell), and a refined GEM could become an optimal certification path that leverages the accuracy of powertrain testing along with the versatility of GEM, which alleviates the need to test a large number of vehicle or powertrain variants. To balance the potential advantages of this approach with the fact that it has never been used for vehicle certification in the past, EPA is proposing to allow this approach as an optional certification path.

EPA is also proposing to require tractor and vocational vehicle manufacturers to annually chassis test five production vehicles over the GEM vehicle cycles to verify that relative reductions simulated in GEM are being achieved in actual production (limited to manufacturers with annual production in excess of 20,000 vehicles). For diesel engines utilizing urea SCR emission control systems for NOx reduction, EPA is proposing to allow correction of the final engine fuel map and powertrain duty-cycle CO_2 emission results to account for the contribution of CO_2 from the urea injected into the exhaust.

Projected Costs

The table below provides EPA compliance cost estimates for the proposed 2027 full phase-in of proposed Phase 2 standards and estimated compliance costs for an accelerated phase-

in that is completed by model year 2024 (three years earlier than the proposed compliance schedule).

Table 5. Per Vehicle Costs Relative to Baseline 1a (nominally flat baseline)

	Alternative 3 – 2027 (proposed standards)			Alternative 4 – 2024 (also under consideration)	
	MY 2021	**MY 2024**	**MY 2027**	**MY 2021**	**MY 2024**
Per Vehicle Cost ($)					
Tractors	$6,710	$9,940	$11,700	$10,200	$12,400
Trailers	$900	$1,010	$1,170	$1,080	$1,230
Vocational Vehicles	$1,150	$1,770	$3,380	$1,990	$3,590
Pickups/ Vans	$520	$950	$1,340	$1,050	$1,730

The proposal also includes estimated pay-back periods associated with both a final 2027 compliance date and an accelerated 2024 final compliance date. For combination tractors and trailers, EPA estimates pay-back would occur in the second year of ownership for both a MY 2027 and MY 2024 truck that meets the fully phased-in, proposed standards. The estimated pay-back for vocational vehicles would be in the sixth year of ownership for both a MY 2027 or MY 2024 truck that meets the fully phased-in, proposed standards. For pickups and vans, the estimated payback period would be in the third year of ownership for a MY 2027 truck that meets the fully phased-in, proposed standards. This payback would be delayed until the fourth year of ownership for a MY 2024 pickup or van that meets the fully phased-in, proposed standards.

ARB's Draft Heavy-Duty Efficiency Technology Assessment

In related news, ARB has published their draft technology assessment, "Engine/Powerplant and Drivetrain Optimization and Vehicle Efficiency," that evaluates a range of technologies to increase fuel efficiency and reduce CO_2 emissions from heavy-duty trucks. The release of the report coincides with the release of EPA's Phase 2 heavy-duty greenhouse gas proposed rulemaking.

Engine/powerplant and drivetrain optimization technologies evaluated in the report include:

- Advanced transmissions and engine downspeeding
- Waste heat recovery
- Engine downsizing
- Stop-start
- Automatic neutral idle
- Combustion and fuel injection optimization

- Higher-efficiency emission control systems
- Reduced friction
- Auxiliary load reduction
- Air handling improvements
- Cylinder deactivation
- Stoichiometric gasoline direct injection
- Lean-burn gasoline direct injection
- Camless engines
- Opposed piston engines
- Free piston engines
- Advanced combustion cycles

In addition, a number of vehicle efficiency technologies have been evaluated:

- Aerodynamics
- Lightweighting
- Low-rolling resistance tires
- Automatic tire inflation
- Vehicle speed limiters
- Axle efficiency improvements
- Idle reduction
- Improved air conditioning
- Connected vehicles

The assessment found that the evaluated technologies can produce significant reductions in fuel consumption. The table below summarizes the potential additional fuel consumption reduction (FCR) beyond Phase 1 GHG standard-compliant vehicles (i.e., post model year 2017) that incorporate all of the applicable technologies. In comparison, this table also includes the fuel consumption reduction estimates associated with EPA's proposed Phase 2 heavy-duty GHG standards.

Table 6. Potential Additional Fuel Consumption Reduction (FCR) Beyond Phase 1 GHG Standards

Vehicle Category	FCR Potential	EPA Phase 2 Proposal
Heavy-Duty Tractor-Trailer (Class 7-8) Long Haul	8-36%	up to 24%
Heavy-Duty Tractor-Trailer (Class 7-8) Short Haul	8-33%	up to 24%
Heavy-Duty Vocational (Class 3-8)	10-28%	up to 16%
Heavy-Duty Diesel Pickups and Vans (Class 2b/3)	3-23%	up to 16%
Heavy-Duty Gasoline Pickups and Vans (Class 2b/3)	10-27%	up to 16%

According to ARB, the percent FCRs shown in the table correspond directly to potential reductions in CO_2 emissions and can be used to help inform EPA's Phase 2 GHG standard. California air quality targets also require significant further reductions in emissions of criteria pollutants, particularly NOx emissions. In the past, many NOx-reduction technologies (such as exhaust gas recirculation and retarded ignition timing) have resulted in increased fuel consumption and reduced fuel efficiency. However, the introduction of urea SCR technology in 2010 allowed for increased fuel efficiency (and reduced GHG emissions) while achieving low tailpipe NOx emissions, noted the report.

ARB's draft heavy-duty efficiency technology assessment report is available at: www.arb.ca.gov/msprog/tech/techreport/epdo_ve_tech_report.pdf.

For More Information

The full package for EPA/NHTSA's Phase 2 heavy-duty GHG proposal, including EPA's draft Regulatory Impact Analysis, is available at: www.epa.gov/otaq/climate/regs-heavy-duty.htm. A 60-day comment period will open after the proposal is published in the *Federal Register*. EPA plans to hold public hearings in Chicago and Los Angeles during July (dates to be announced shortly). MECA intends to participate in the public hearings and submit written comments on the proposal.

(Note: The International Council on Clean Transportation [ICCT] has also put together a detailed summary of EPA/NHTSA's Phase 2 heavy-duty GHG proposal. The policy update is available at: www.theicct.org/us-phase2-hdv-efficiency-ghg-regulations-policy-update.)

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