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American Council for an Energy-Efficient Economy | Environmental Defense Fund
Natural Resources Defense Council | Sierra Club | Union of Concerned Scientists

RE: Docket ID Nos. EPA–HQ– OAR–2014–0827 and NHTSA–2014–0132
Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles - Phase 2 - Notice of Data Availability

Introduction

On behalf of our millions of members and supporters, the American Council for an Energy-Efficient Economy, Environmental Defense Fund, Natural Resources Defense Council, Sierra Club and Union of Concerned Scientists applaud the Environmental Protection Agency (EPA) and National Highway Traffic Safety Administration (NHTSA) for proposing Phase 2 standards that have the potential to significantly increase the efficiency of medium- and heavy-duty vehicles for years to come. Heavy-duty trucks are the fastest growing source of oil use in the transportation sector, and by 2030 global emissions from freight trucks are expected to exceed those of passenger vehicles.

Our organizations appreciate the opportunity to comment on new information made available by EPA and NHTSA. After reviewing the additional data and memoranda, it is clear that our original target of a 40 percent improvement in fuel consumption for new trucks in 2025 relative to new trucks in 2010 is achievable. These new data bolster our arguments that additional efficiency gains are possible throughout vehicles and across vehicle classes. It is critical that the agencies incorporate this new data and finalize more stringent standards than were proposed to ensure the greatest possible technically feasible and cost-effective reductions in carbon pollution and fuel consumption.

Below are analyses of key areas of the additional data and memoranda made available, along with recommendations for incorporating the new data into stronger final standards.

Tractor-trailers

Since the close of the public comment period, numerous new data on tractor-trailers have been submitted to the docket, including a revised report on fuel efficiency technologies[1] and additional information on tractor aerodynamics.[2,3] These data continue to show that the agencies have underestimated the technology potential of tractor-trailers and, particularly, tractor engines. Based on this new data, the agencies should tighten the fuel consumption and emissions targets for tractor-trailers and tractor engines. Furthermore, the agencies should improve the aerodynamic testing procedures for tractors to ensure that benefits of the rule are not eroded.

Tractor Engine Technology Effectiveness

The Southwest Research Institute (SwRI) completed a comprehensive analysis of fuel consumption reduction technologies applicable to commercial medium- and heavy-duty trucks.[1] Despite downward revisions in technology potential between the draft version of the report available in the proposal and the final report

[1] EPA-HQ-OAR-2014-0827-1623/NHTSA-2014-0132-0185.
[2] EPA-HQ-OAR-2014-0827-1624/NHTSA-2014-0132-0186
[3] EPA-HQ-OAR-2014-0827-1625/NHTSA-2014-0132-0188.

included in the NODA, this research indicates that tractor engines can improve their fuel consumption by at least 8 percent in 2027, nearly double the agencies' proposed target.

The revised benefit from friction reduction in the final SwRI report ranges from 1% to 2.9% for highway cruising, dependent upon vehicle loading and speed. The SET-weighted average of these friction reduction estimates is 2.1%, which is 50 percent higher than the agencies' estimate of friction reduction potential in the proposal (Appendix 1), indicating that friction reduction can contribute more efficiency benefit than the proposal indicates.

Furthermore, the final SwRI report[4] confirms the significant benefit of downspeeding on the engine side, even taking into account the accompanying loss in friction reduction potential. Downspeeding benefits are not reflected in the proposed engine standards, despite the fact that manufacturers have repeatedly acknowledged moving engine operation to even lower speeds.[5] The agencies also have noted the benefits of downspeeding when combined with downsizing, which they did refer to in setting the standard: "engine downsizing could be more effective if it is combined with downspeeding" (NPRM p. 40217). The SwRI report estimates savings ranging from 3% to 8% after lowering the engine speed from 1368 to 1051 rpm. This estimate includes the 50 percent discounting of friction reduction potential for the downsped engine. An SET-weighted average of downspeeding combined with friction reduction results in 3.3 percent improvement in 2027. As noted in other comments to the docket, the agencies should consider downspeeding improvements on the tractor engine test because of how it affects engine design.[6]

The agencies also should further consider their assessment of the penetration of advanced technologies like waste heat recovery (WHR). The SwRI report clearly illustrates the benefits of WHR, and a consultant report recently uploaded to the docket outlines how it is making its way into the fleet ahead of the rate of penetration that underlies the agencies' proposed targets.[7] The report also makes clear that current research into even more efficient engines indicates the potential for a durable, reliable 50-percent brake thermal efficiency engine in the timeframe of this rule. Further evidence of the significant penetration possible for WHR can be found in a recent white paper that illustrates that the agencies have significantly overestimated the costs of WHR and therefore underestimated its cost-effectiveness and potential rate of penetration in the market.[8]

The finalized report from the Southwest Research Institute indicates that tractor engines are capable of achieving an 8 to 10 percent reduction in fuel consumption from the 2018 baseline when considering the agencies' technology penetration rates; further analysis shows that a 15 percent reduction is possible (Appendix 1).

Impact on proposal

The tractor truck engine stringency should be significantly strengthened in the final rule to reflect the most up-to-date data, which indicates that tractor engines can easily exceed the proposed 2027 target of 4.2 percent improvement.

Tractor aerodynamic performance

Some comments on the proposed rule stated that tractor aerodynamic drag levels assumed in the agencies' 2027 compliance package were not achievable, at least without a more aerodynamic standard trailer for testing.[9] We are not aware of new information referenced in the NODA that relates directly to this matter; but given comments on the proposed rule, we note here that substantial, additional reductions in drag could be achieved by 2027 through co-optimization and integration of tractor and trailer. These additional drag reductions could be verified by using a more advanced trailer for testing and then correcting for the benefits of the trailer alone, as discussed in greater detail in Appendix 2.

[4] EPA-HQ-OAR-2014-0827-1471.
[5] E.g., EPA-HQ-OAR-2014-0827-1164, pp. 18-19; EPA-HQ-OAR-2014-0827-1298, p. 7; EPA-HQ-OAR-2014-0827-1254, p. 4.
[6] EPA-HQ-OAR-2014-0827-1237, p. 27; EPA-HQ-OAR-2014-0827-1298, p. 8; EPA-HQ-OAR-2014-0827-1329, pp. 7-8.
[7] EPA-HQ-OAR-2014-0827-1472.
[8] Wall, John C. "A perspective on waste heat recovery for consideration for the Phase 2 GHG Rule." February 11, 2016.
[9] EPA-HQ-OAR-2014-0827-1215.

Impact on proposal

There is no evidence provided in the NODA to support weakening of the 2027 aerodynamic targets for tractors. In fact, *increased* stringency could be achieved by redefining the standard trailer in later years to reflect future improvements to the average trailer and taking advantage of tractor/trailer co-optimization in the compliance package.

Tractor aerodynamic selective enforcement audit and confirmatory testing

In a memo referenced in the NODA, EPA clarified how a vehicle would be determined to pass or fail in selective enforcement audit (SEA) and confirmatory testing of its certified aerodynamic drag (CdA).[3] The EPA memo is responsive to comments of the manufacturers and others regarding the proposed elimination of the compliance margin in these testing processes in Phase 2. It proposes that multiple coastdown tests be performed in SEA or confirmatory testing, and that the vehicle would fail if and only if the testing showed with high statistical confidence that the vehicle lay in a lower-numbered (higher drag) aerodynamic bin than the one to which it had been certified.

The proposed approach represents a significant improvement over the one-bin compliance margin in Phase 1. However, it should be further improved by setting the threshold in the statistical test at the bin midpoint, rather than at the upper limit of the bin. Bin limits in the proposal appear to be based on the range of benefits from defined improvements in aerodynamic design or equipment, so a bin midpoint might best represent the result of a typical implementation of those aerodynamic improvements, making it a suitable threshold for the statistical test. Moreover, the bin midpoint is the GEM CdA input for a tractor certified to the given bin, so the midpoint is the proper value for purposes of SEA and confirmatory testing. Using the proposed procedure, by contrast, CdA values could be expected to accumulate around the upper limits of the bins. Tractor bins cover a range of drag values of about 0.5 m^2, or roughly 10 percent of CdA values; so the half bin between the bin midpoint and upper bin threshold is roughly 5 percent of a typical CdA value. Five percent increase in long-haul tractor-trailer drag increases fuel consumption by about 2 percent. Hence using the upper bin limit in SEA or confirmatory testing would overstate tractor emissions reductions under the standards by about 2 percent.

Impact on proposal

The proposed SEA and confirmatory testing procedure would improve upon the current procedure but would still overstate the emissions reductions resulting from the standards.
To ensure that the real world benefits of the rule are maintained, we recommend that the approach discussed in the EPA memo be revised to require that the average confirmatory or SEA test results be no higher (statistically) than the midpoint, rather than the upper limit, of the appropriate bin.

Updates to the Greenhouse Gas Emissions Model (GEM P2v2.1)

Significant changes have been made to the GEM model release that accompanies the NODA. These improvements enable more accurate modeling of the behavior of heavy-duty trucks and therefore can more readily capture technology improvements that were left on the table in the proposal. We support the changes to the GEM model and recommend that the standards be strengthened to reflect the additional fuel savings opportunities captured by the improved GEM.

New drive cycle weightings

As noted in the vocational vehicle section of these comments, the updated certification cycles both are more representative of vocational vehicle duty cycles and highlight further opportunities for fuel consumption reduction at high-speed (e.g., from aerodynamic improvements) and at low-speed through idle reduction (including automatic shut-down for parked idle).

Cycle-average map

Perhaps the biggest change to GEM is the replacement of the transient cycle modeling with the cycle-average mapping procedure to assess a vehicle's fuel consumption over the transient cycle. Most importantly, this replaces the "transient adjustment factor" of 1.05 with a value that more accurately captures the vehicle's transient behavior.

Impact on the proposal

The agencies used a transient adjustment factor of 1.05 so that leading engines with better transient response on a powertrain test would not receive undue advantage as a result of the test procedure. However, eliminating this factor would appropriately reward manufacturers who can prove better real world transient response. Replacing the transient adjustment factor may result in slightly higher baseline fuel consumption if the baseline reflects average performance, but it should allow the standards to drive leading-edge transient operation in the later years, creating a greater transient performance improvement from 2018 to 2027 than in the proposal.

Updates to modeled technologies

Changes to the representation of transmission, engine, and axle allow for more precise modeling of vehicle behavior in the GEM model. Additional vehicle technologies and greater acceptance of numeric parameters (instead of Y/N) for technology inputs allows manufacturers greater representation of the vehicles they are actually putting on the road.

Impact on the proposal

Modeling powertrain technology more accurately will help align GEM results with real world reductions. It will also allow for greater capture of incremental improvements. The proposal assumed fixed technology improvements—however, as is evident from sources like the Southwest Research Institute report,[10] there will be continuous development of many of these technologies throughout the course of this rule. Because GEM can now better capture these more subtle technology improvements related to transmission efficiencies, etc., it is critical that the agencies tighten their 2024 and 2027 targets accordingly to ensure that the targets represent the "maximum feasible" and "technology forcing" standards. Similarly, the inclusion of technologies that the agencies did not originally model within the GEM model (e.g., tractor neutral idling) means that those targets should be tightened to recognize that these technologies *can* reduce fuel use from heavy-duty trucks.

Improved functionality

In the MATLAB version of the model, it is possible to obtain detailed outputs for the 55-mph, 65-mph, and transient modes that include average engine speed and torque; crankshaft, transmission, and axle work; number of shifts; and grams fuel, grams CO_2, and grams CO_2 per ton-mile. This "detailed output" option is a change noted in the documentation for GEM P2v2.1,[11] and we expect this functionality to be available in the final, executable version of GEM. We support this addition to GEM output options. The ability to view these results for individual modes will allow end users to better understand the benefits of technologies for their own duty cycles, which may be better represented by weighting the three drive cycles differently than they are weighted for certification purposes.

Vocational vehicles

Recent information included in the docket provides additional research on the diversity of the vocational vehicle fleet and the real world behavior of these vehicles, many of which may be certified as incomplete. It is our assessment that this new information not only strengthens the case for increasing the stringency of the regulation of this class of vehicles but necessitates it in order to ensure the environmental benefits of a "maximum feasible" and "technology forcing" standard. Specifics related to the data itself are discussed below.

[10] EPA-HQ-OAR-2014-0827-1623/NHTSA-2014-0132-0185.
[11] EPA-HQ-OAR-2014-0827-1626/NHTSA-2014-0132-0181, "Summary_GEM_P2v2.1_Updates"

Duty cycles and segmentation

The National Renewable Energy Lab study utilizes its Fleet DNA database to show that vehicles largely fall into two classes of operation, high- and low-speed, with a much smaller fraction of vehicles bridging the two duty cycles.[12] The study finds that the high-speed vehicles spend a much higher fraction of time at cruise speeds above 55 mph than the weightings of the vocational regional category from the proposal, while all vehicles spend a much higher fraction of time at idle than the idle cycle weighting in the proposal.[13]

In addition to providing data on the characteristics of three overarching classes of vehicle, the Oak Ridge analysis provides a path for segmenting vocational vehicles in spite of the limited information that an incomplete chassis can provide.[14] The full prediction model leads to an appropriate categorization of high- or low-speed behavior with 89 percent accuracy, with prediction of low-speed behavior 94 percent accurate. Limiting the model to engine speed at 65 mph provides less accuracy (81 percent) but may allow for more flexibility to changes to the fleet over time (such as a decreasing use of manual transmissions in all classes, or a change in fuel use for applications that were previously predominantly gasoline or diesel).

<u>Impact on proposal</u>

The ability for a manufacturer to more accurately project a new vehicle's likely duty cycle allows better assessment of both the regulatory category of the vehicle and technologies that are most applicable. Correctly identifying high-speed vehicles, particularly ones which now show even greater operation at highway cruise speeds than first proposed, would allow for greater application of aerodynamic improvements, since there would be a clear need and payback. Similarly, the ability to more clearly define low-speed operation, which now should also include greater idle operation time, would incentivize greater application of idle reduction technologies.

Hybrid modeling

The agencies recently uploaded a physics-based simple hybrid model, which can be used to quickly estimate the potential fuel savings for different vocational hybrid designs.[15] It is clear from this model that there is a wide range of hybrids that can result in significant fuel savings, even those with relatively small batteries as would be found in a mild hybrid.

<u>Impact on proposal</u>
Mild hybrids were not discussed in the proposal as part of the compliance package; however, as is evident from this modeling, these cheaper hybrid variants could offer much of the same benefit in certain applications at reduced cost. We strongly encourage the agencies to include mild hybridization as part of its compliance package in addition to cost-effective full hybrid application, as already identified in the proposal.

Custom chassis certification

While not part of the NODA, an agency memorandum on alternative approaches to certifying specialty vocational vehicles, or custom chassis, has recently been added to the docket.[16] The two approaches are a simplified model of GEM similar to Phase 1 and a minimum applied technology package. The vehicles that these could be applied to are motor homes, intercity coaches, school buses, transit buses, refuse trucks, cement mixers, and emergency vehicles. These vehicles together represent around 20 percent of vocational vehicle sales, with motor homes being the largest contingent.

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[12] EPA-HQ-OAR-2014-0827-1621/NHTSA-2014-0132-0187, Figures 5 and 6.
[13] Ibid., Table 4.
[14] Ibid., Section 3.1.
[15] EPA-HQ-OAR-2014-0827-1725.
[16] EPA-HQ-OAR-2014-0827-1719.

Impact on proposal

The standard for these vehicles proposed in the memorandum is significantly weaker than the proposal for every single class of vehicle, by an average of between 5 and 7 percent.[17] This means that if manufacturers take advantage of this approach for the 20 percent of the fleet that is eligible, the vocational vehicle standard would need to be strengthened by more than 1 percent, on average, to offset the application of these standards and maintain the environmental benefits of the proposal.

If manufacturers are able to identify these specialized classes of vehicle as would be required to take advantage of this proposal, then they should also then be able to take advantage of the most appropriate fuel-saving technologies for that unique duty cycle (e.g., aerodynamic improvements for motorcoaches that spend extensive time at high speed cruise). The ability for manufacturers to identify these applications should therefore result in a *more* stringent vocational vehicle target for these custom chassis, not less.

Furthermore, the simplified compliance pathway eliminates incentives for technologies directly applicable to these vehicles, including transmission improvements and hybridization. This is especially concerning for intercity buses, school buses, and refuse trucks, all of which are ideal applications for powertrain improvements that would not be captured or incentivized under this approach. This could significantly undermine the vocational vehicle target and erode benefits of the rule.

Vocational engine certification

Since the public comment closed on the proposal, certification data for a number of new heavy-duty engines have been made public. Conventional diesel engines from Cummins,[18] Detroit Diesel,[19] Hino,[20] and PACCAR[21] in medium- and heavy-duty vocational applications could all be certified in 2016 to the proposed 2027 standard.

Impact on proposal

That an assortment of engine families certified for the 2016 model year from a breadth of manufacturers already achieve the 2027 fleet-average standard in their respective classes indicates that the agencies have set far too weak a standard for vocational engines. This, in turn, leads to weakened vocational vehicle standards, since these engines are incorporated into GEM for compliance. We expect based on careful examination of recent engine certification data that the agencies will adjust greenhouse gas emission and fuel consumption targets downward in 2027 to more appropriately account for where the technology is *today* and what it can achieve more than a decade hence.

Gasoline engines

Both boosted and naturally aspirated gasoline engines for vocational vehicles show considerable improvement potential in the revised SwRI report. Valve and EGR technologies were found to offer substantial benefit in gasoline engines, especially at high load.

[17] Simulating the technology packages identified in the memo with GEM P2v1.1 resulted in a shortfall for the vehicles ranging from 3 to 17 percent, which yielded an approximate sales-weighted average of 7 percent. Accounting for the reweighted drive cycles would reduce this average to 5 percent, with only motor homes having a standard that is as strong as the proposed vocational vehicle target for its class.

[18] Cummins 2016 8.9L MHDD diesel engine (GCEXH05040LAV): FCL = 553 g/bhp-hr, compared to a proposed 2027 MHDD standard of 553 g/bhp-hr. Certified to vocational applications (ISL9).

[19] Detroit Diesel 2016 14.8L HHDD diesel engine (GDDXH14.8EAD): FCL = 517 g/bhp-hr, compared to a 2027 HHDD standard of 533 g/bhp-hr. Certified to vocational and tractor applications (DD15).

[20] Hino 2016 7.7L MHDD diesel engine (GHMXH07.7JWU): FCL = 538 g/bhp-hr, compared to a proposed 2027 standard of 553 g/bhp-hr. Certified to vocational applications (J08E-WU).

[21] PACCAR 2016 10.8L HHDD diesel engine (GPCRH10.8M01): FCL = 509 g/bhp-hr, compared to a proposed 2027 standard of 533 g/bhp-hr. Certified to vocational and tractor applications (MX-11).

Impact on proposal

The Phase 2 proposal did not call for improvement of the gasoline engines used in vocational vehicles. The benefits of valve and EGR technologies for these engines, especially at higher loads, as found in the revised SwRI report[22], make a strong case for strengthening the standards for these engines.

Heavy-Duty Pickups and Vans

The SwRI report[23] updated the benefits of mild and full (parallel) hybrids for heavy-duty pickups and vans. The cycle weighted effectiveness of mild hybrids at ALVW (test weight) was 40% higher than the agency estimate, while full hybrids had a small increase in benefit. The aero and tire benefits for these vehicles were also higher than the agency estimate.

Impact on proposal

The agencies should strengthen the standards for heavy-duty gasoline pickups and vans to reflect a reasonable penetration of mild and full hybrids in 2027.

EPA's Clean Air Act Authority

Reducing Emissions through Trailer Improvements

We support EPA's interpretation of its authority to regulate trailer manufacturers, namely, that the trailer manufacturer is a motor vehicle manufacturer subject to compliance with emission standards under section 202 of the Clean Air Act. EPA's prior regulations affecting the manufacturers of major components of the motor vehicle demonstrate the agency's tradition of addressing mobile sources as systems of components that contribute to vehicle emissions. The trailer manufacturer is the entity with control over the design of the trailer - the load-carrying component of the heavy-duty vehicle, and thus a major contributor to that vehicle's emissions. As such, it is eminently reasonable for EPA to devise standards that harness the emissions-reducing opportunities inherent in trailer design.

Protecting Against Defeat Devices

Comments submitted in response to the Notice of Data Availability and raised in the media have expressed concern about EPA's authority to regulate aftermarket modification of vehicles. Our organizations strongly support EPA's long-standing authority to prevent tampering with emissions control systems, including the installation of defeat devices, on vehicles used on public roads. Many such technologies that alter or bypass emissions control systems are sold under the guise of competitive racing, but marketed for use on vehicles that are used on public roads. Such defeat devices lead to increased emissions of a range of pollutants which threaten public health. Going forward, EPA should continue to ensure that aftermarket defeat devices do not lead to increased emissions of health-threatening pollution from on-road vehicles. We note that EPA's record of enforcement has focused on technologies that are being sold to defeat emission control devices in vehicles that are being used on public roads, not competitive racecars used off public roads.

Conclusion

Our organizations appreciate the substantial work by EPA and NHTSA to propose the second phase of efficiency and emissions standards for medium and heavy-duty vehicles and the opportunity to comment on the Notice of Data Availability. We urge the agencies to incorporate new data and strengthen the final rule to ensure the greatest possible reductions in carbon pollution and fuel consumption.

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[22] Reinhart, T. E. (2016, February). *Commercial medium- and heavy-duty truck fuel efficiency technology study – Report #2.* (Report No. DOT HS 812 194). Washington, DC: National Highway Traffic Safety Administration

[23] Reinhart, T. E. (2016, February). *Commercial medium- and heavy-duty truck fuel efficiency technology study – Report #2.* (Report No. DOT HS 812 194). Washington, DC: National Highway Traffic Safety Administration

Appendix 1: Efficiency Improvement Potential for Tractor Truck Engines in 2027
Southwest Research Institute Report[24]

SET-weighted improvement

Improvements in efficiency measured on the drive cycles simulated in the SwRI report do not directly correspond to the improvements these technologies would achieve on the engine cycle. To estimate the improvements that would be achieved on the SET cycle, we have utilized specific drive cycles to represent the A, B, C, and idle points, weighting the improvements achieved on these cycles in accordance with the SET regulatory weighting (Table 1).

Table 1: Analogous weighting of drive cycles to represent SET engine cycle

SET cycle point	**Analog drive cycle**	**Weighting**
Idle	0% ARB Transient	12%
A, 100%	100% 55-mph	9%
B, 50%	50% 65-mph	10%
B, 75%	½ 50% 65-mph, ½ 100% 65-mph	10%
A, 50%	50% 55-mph	12%
A, 75%	½ 50% 55-mph, ½ 100% 55-mph	12%
A, 25%	½ 0% 55-mph, ½ 50% 55-mph	12%
B, 100%	100% 65-mph	9%
B, 25%	½ 0% 65-mph, ½ 50% 65-mph	9%
C, 100%	½ 100% 65-mph	2%
C, 25%	¼ 0% 65-mph, ¼ 50% 65-mph	1%
C, 75%	¼ 50% 65-mph, ¼ 100% 65-mph	1%
C, 50%	½ 50% 65-mph	1%

The A speed and B speed are most similar to 55 mph and 65 mph, respectively. This can be confirmed with the drive ratio assumed in the SwRI report. However, the C speed represents an engine speed that is not easily represented by any of the drive cycles measured. Because we are primarily concerned with friction reduction, which we know will show diminished improvement at high speed, we have chosen to halve the improvement of the 65 mph cycle to represent a stand-in. The idle cycle is represented by the unloaded ARB transient cycle. Because the engine test is run at 25, 50, 75, and 100 percent loading, we have averaged the 0 and 50 percent loaded cycles to represent 25 percent loading, and the 50 and 100 percent loading to represent 75.

Comparison of SwRI report and the NPRM: engine friction reduction

After assessing how to model the engine technologies in the SwRI report, we can compare these results to those of the NPRM (Table 2). Here, the fuel consumption reduction of each individual technology is shown as well as the agencies' assumed penetration of this technology in 2027, yielding a weighted reduction.

The revised effectiveness represents the SwRI SET-weighted value. In combining the technologies, the final value reflects some assumption about how the technologies interact, which we refer to as dis-synergy. Such interaction should be based on considerations specific to the technologies being combined—for example, the effectiveness of a waste heat recovery will be lower in combination with technologies that reduce the amount of waste heat available. However, we are unaware of other overlapping benefits among the particular technologies in the agency engine package. Therefore, while the agencies used a representative value of 15 percent for the dissynergy factor, we have reduced this value to 4 percent to reflect only the 25 percent of the fleet for which this the agencies applied this technology.

[24] EPA-HQ-OAR-2014-0827-1623/NHTSA-2014-0132-0185.

Table 2: Tractor truck engine fuel consumption reduction in 2027 (without downspeeding/downsizing benefit)

Technology	Phase 2 proposal (p. 40197)			Revised effective -ness	Weighted estimate	
	FC reduction	**Penetration in 2027**	**Weighted reduction**		**With agency penetration for MY 2027**	**With increased penetration for WHR in MY 2027**
Improved combustion	1.1%	100%	1.1%	2.0%	2.0%	2.0%
Engine controls	N/A			1.0%	1.0%	1.0%
Engine friction/parasitic reduction	1.4%	100%	1.4%	2.1%	2.1%	2.1%
Aftertreatment improvement	0.6%	100%	0.6%	0.6%	0.6%	0.6%
Engine downspeeding	N/A					
Engine downsizing	0.3%	30%	0.1%	N/A	N/A	N/A
EGR/airflow/turbo improvement	1.1%	100%	1.1%	1.7%	1.7%	1.7%
WHR (Turbocompounding)	1.8%	10%	0.2%	3.0%	0.3%	0.9%
WHR (Rankine cycle)	3.6%	15%	0.5%	4.4%	0.7%	1.4%
Discount for overlapping benefits (dis-synergy)			**15%**		**4.0%**	**9.3%**
Total reduction with dis-synergy			**4.2%**		**7.8%**	**8.5%**

Comparison of SwRI report and the NPRM: downspeeding

Downspeeding offers additional gains that are not included in Table 2. Higher brake mean effective pressure that results from downspeeding does interact with engine friction reduction; however, the SwRI report clearly showed that benefits from downspeeding were achieved beyond the levels outlined in Table 2. Table 3 outlines the additional benefits that are achievable when including downsizing on the engine standard, based upon the SwRI report.

Table 3: Tractor truck engine fuel consumption reduction in 2027 (with benefits from downsizing/downspeeding)

Technology	Revised effective-ness	Weighted estimate	
		With agency penetration for MY 2027	With increased penetration for WHR in MY 2027
Improved combustion	2.0%	2.0%	2.0%
Engine controls	1.0%	1.0%	1.0%
Engine friction/parasitic reduction and downspeeding	3.3%	3.3%	3.3%
Aftertreatment improvement	0.6%	0.6%	0.6%
Engine downsizing	0.3%	0.1%	0.1%
EGR/airflow/turbo improvement	1.7%	1.7%	1.7%
WHR (Turbocompounding)	3.0%	0.3%	0.9%
WHR (Rankine cycle)	4.4%	0.7%	1.4%
Discount for overlapping benefits (dis-synergy)		**4.0%**	**9.3%**
Total reduction with dis-synergy		**9.0%**	**9.6%**

Feasibility Assessment of Future Efficiency Improvement for Class 8 Diesel Tractor Engines[25]

In addition to the SwRI report, a presentation was uploaded to the docket from Dr. Stephen J. Charlton that outlines a path forward for the heavy-duty truck industry over the timeframe of the rule, taking into account ongoing research, product development cycles, and the breadth of technologies that could be available in the timeframe of this rule.

Table 4 summarizes the findings of this report, illustrating a path to an engine standard in 2027 that would achieve a 15 percent reduction from the current 2018 baseline engine on the SET test. Notable differences between the agencies' proposed targets are: 1) greater penetration of WHR; 2) recognition that downspeeding will lead to efficiency improvements on the SET cycle as well as on the vehicle; 3) greater potential improvements from model-based controls; and 4) increased stringency of the 2018 baseline itself to reflect the updated SET weighting.

[25] EPA-HQ-OAR-2014-0827-1472.

Table 4: Derivation of revised engine standards[26]

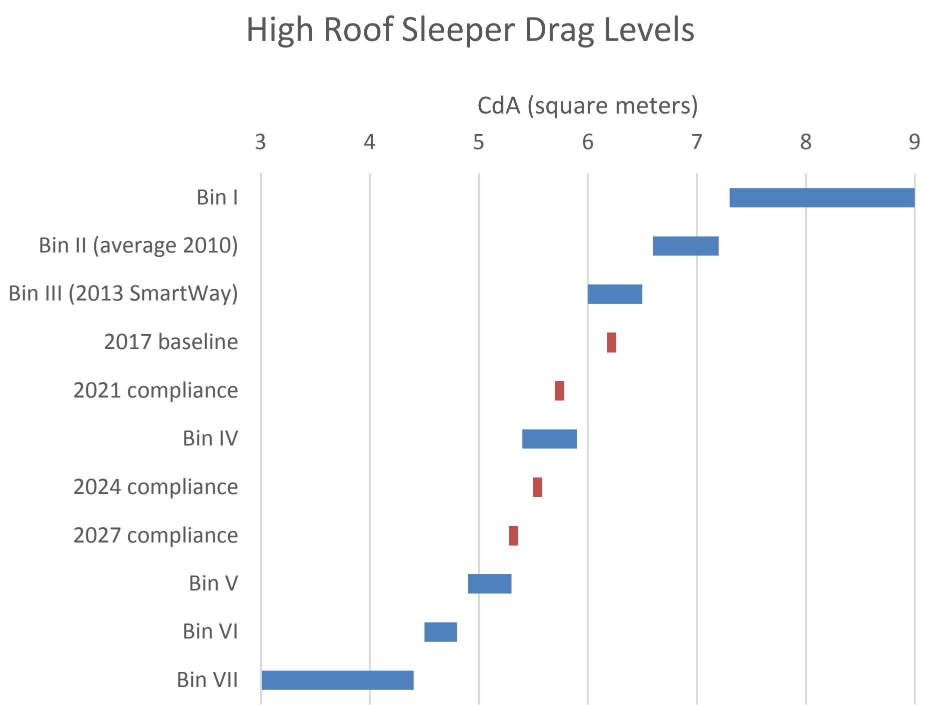
Technology	SET-Weighted Reduction 2020-2027	Market Penetration 2021	2024	2027
Turbocompounding	1.8%	5.0%	10.0%	10.0%
Waste Heat Recovery	5.5%	0.0%	20.0%	75.0%
Parasitic/friction—Cylinder kit, lube, etc.	1.4%	45.0%	95.0%	100.0%
Aftertreatment—efficiency, delta-P, and optimization of engine-out NOx	1.0%	45.0%	95.0%	100.0%
EGR, manifolds, ports, turbocharger	1.1%	45.0%	95.0%	100.0%
Combustion, fuel-injection optimization, model-based control	4.0%	45.0%	95.0%	100.0%
Engine downsizing	0.3%	5.0%	7.5%	10.0%
Engine downspeeding	3.5%	50.0%	75.0%	90.0%
Advanced combustion	0.5%	15.0%	75.0%	85.0%
SET reweighting	1.5%	100.0%	100.0%	100.0%
Dis-synergy multiplier		100.0%	95.0%	95.0%
Weighted reduction for engines without turbocompounding or WHR		6.54%	10.56%	11.39%
Weighted reduction for engines with turbocompounding		8.22%	12.08%	12.89%
Weighted reduction for engines with waste heat recovery		11.68%	15.21%	15.99%
Total weighted reduction (%)		**6.62%**	**11.6%**	**15.0%**
Brake-specific CO_2 (g/bhp-hr)	**460**	**430**	**406**	**391**

[26] Ibid., p. 32.

Appendix 2: Additional Savings from Tractor-Trailer Co-optimization and Integration

The agencies' compliance package for high roof sleeper cabs in the Phase 2 proposal includes aerodynamic improvements that reduce drag by 14% and fuel consumption by 6% in 2027. Manufacturers raised concerns about these levels of drag reductions in their comments, claiming that the expected tractor drag levels are not achievable using the prescribed "standard" trailer. We do not believe that this concern provides a basis for weakening the aerodynamic performance of high-roof sleeper cabs assumed in the agencies' compliance scenario. In fact, SuperTruck results indicate that greater aerodynamic improvements than those assumed in the Phase 2 proposal are achievable.

Aerodynamic drag (CdA) values and bin levels are shown below for reference.



Test trailer

The comments of Volvo Trucks (p.20) state: "Either the Agencies must reduce the aerodynamic targets for tractors or provide for a test trailer with advanced aerodynamics, including, at a minimum, an efficient boat-tail and side skirts." While we do not support the view that the proposed aerodynamic targets are too demanding when the prescribed test trailer is used, making the standard trailer for testing tractors more aerodynamic makes sense. As Volvo says (p.27), "The test trailer should represent an advanced aerodynamic design that meets the 2027 trailer targets so that future tractors are designed to operate efficiently with future trailers and the combinations can achieve the desired aerodynamic performance." Yet, by 2021, the average trailer will have better aerodynamics (delta CdA = 0.66) than the proposed standard trailer (delta CdA = 0.5). By 2027, the average trailer will achieve delta CdA = 1.1. This trailer would reduce the drag of the 2027-compliant tractor (high roof sleeper with standard trailer, CdA = 5.32) by more than 20%.

An insufficiently aerodynamic standard trailer forgoes an incentive for manufacturers to pursue certain improvements in the tractor and elsewhere in the vehicle. As one example, Daimler notes that lower vehicle drag allows greater benefits for its eCoast technology (http://energy.gov/sites/prod/files/2015/07/f24/arravt080_vss_rotz_2015_o.pdf slide 8). As another example, an aerodynamic trailer will reduce vehicle load, which may permit the use of a smaller engine. A more representative standard trailer will also yield better estimates of the benefits of various technologies.

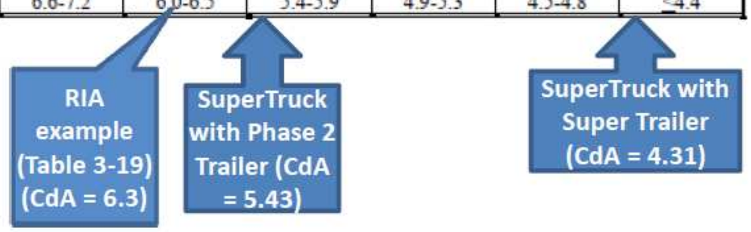
Updating the standard trailer to include an Advanced Combination (skirt and boat tail) gives delta CdA = 1.0 on average (RIA Table 2-70), which approaches the standard for box trailers in 2027. Alternatively, rather than specifying additional aerodynamic devices for the standard trailer, the agencies could simply increase the required delta CdA for the standard trailer to 1.0 and leave it to the manufacturers to select a test trailer.

When updating the standard trailer, the agencies will need to make a corresponding (downward) adjustment to the CdA of the tractor-trailer in the compliance package and hence increase the stringency of the tractor truck standard. Otherwise, the effect of updating the trailer would be to demand less improvement from the tractor, which is counterproductive and not the intent of our comment. If the test trailer had delta CdA = 1, for example, rather than the proposed standard trailer of delta CdA= 0.5, then the high-roof tractor compliance package for 2021 should achieve CdA = 5.24, rather than the CdA = 5.74 of the proposal. This adjustment offsets the aerodynamic benefit from the trailer alone, but recognizes any savings achieved through co-optimization of the tractor and trailer.

In addition to incentivizing co-optimization, this change to the standard trailer would make it feasible to achieve drag levels better than those in the compliance package. Volvo asserts (comments p.27; table replicated below) that its SuperTruck tractor would reach only bin IV (CdA = 5.43) with the proposed Phase 2 standard trailer, falling slightly short of the 2027 target (CdA = 5.32). However, the table shows that Volvo's SuperTruck tractor paired with its Super Trailer would achieve CdA = 4.31. A Volvo SuperTruck presentation (http://energy.gov/sites/prod/files/2014/07/f17/vss081_amar_2014_o.pdf, slide 10) suggests that this result is achieved through trailer add-on devices followed by co-optimization. The graphic (replicated below) suggests that co-optimization alone reduces CdA by about 0.27, which is more than sufficient to meet the 2027 target, even after the target has been adjusted to reflect the trailer add-on devices.

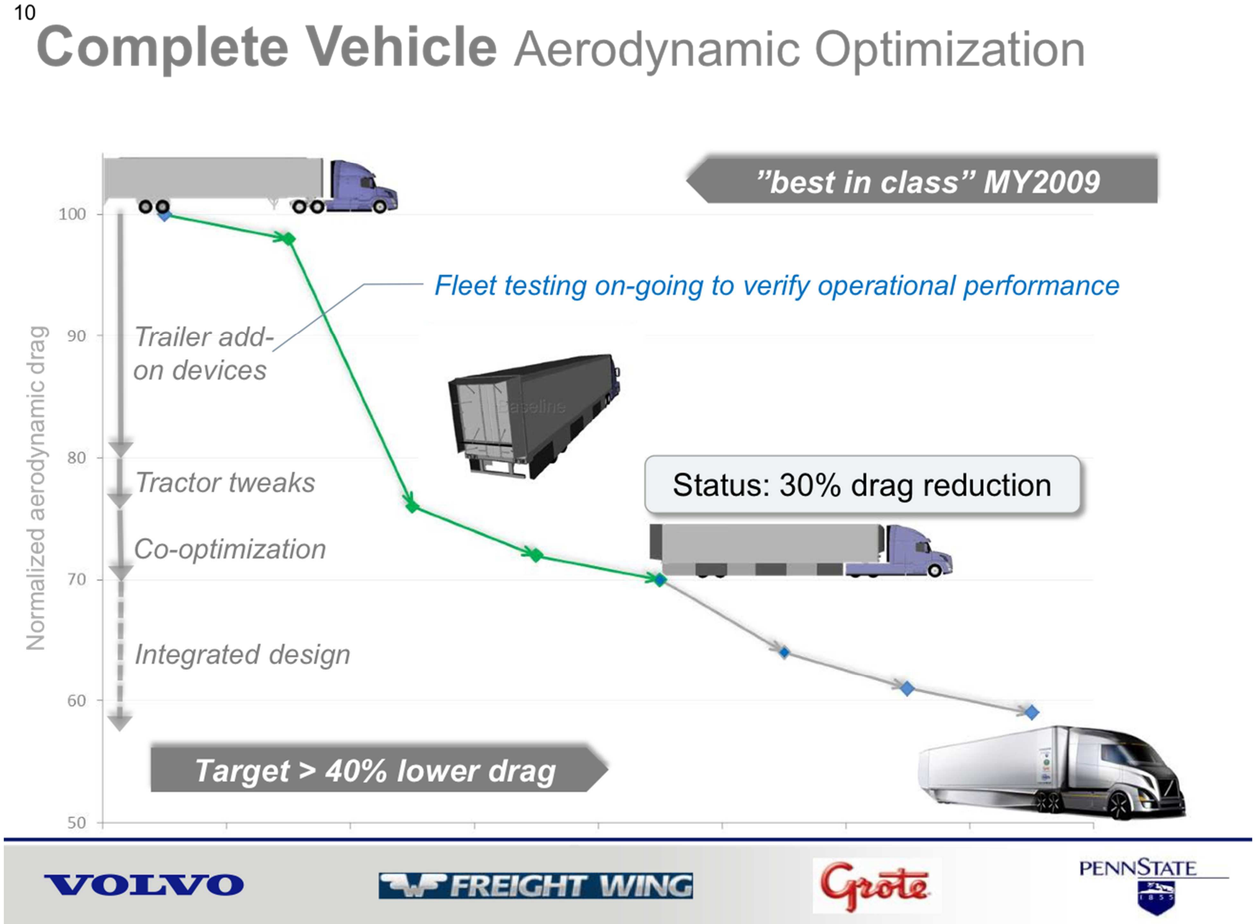
Table 3 of § 1037.520—Bin determinations for Phase 2 High-Roof Tractors Based on Aerodynamic Test Results (C_DA in m[2])

Tractor Type	Bin I	Bin II	Bin III	Bin IV	Bin V	Bin VI	Bin VII
Day Cabs	≥7.5	6.8-7.4	6.2-6.7	5.6-6.1	5.1-5.5	4.7-5.0	≤4.6
Sleeper Cabs	≥7.3	6.6-7.2	6.0-6.5	5.4-5.9	4.9-5.3	4.5-4.8	≤4.4



Source: Volvo comments on Phase 2 proposal, p.27

[10]



Source: Volvo http://energy.gov/sites/prod/files/2014/07/f17/vss081_amar_2014_o.pdf

Beyond bringing the standard trailer up to date, the agencies should consider allowing manufacturers to test tractors with still more advanced trailers; this would promote integration of tractor and trailer. In this case, the modeled fuel efficiency of the tractor would need to be adjusted upward to reflect the delta CdA of the aerodynamic trailer (relative to the standard trailer).

Hence, we recommend that the agencies redefine the standard trailer as one having delta CdA matching the average for the appropriate model year. The tractor standard stringency should then be adjusted accordingly. In addition, the agencies should consider allowing testing with more advanced/integrated trailers.

Certainty of savings from matching tractor and trailer

The fuel savings benefits of co-optimization and integration of tractor and trailer will not be realized if the equipment is not appropriately paired in real-world operation. Because tractors may tow a variety of trailers, ensuring such pairings would be difficult. This raises a question of whether it is prudent to provide credit for the benefits of tractor-trailer co-optimization and integration as recommended above.

Manufacturers and purchasers of co-optimized or integrated tractors and trailers presumably would seek to ensure that the correct pairings were made as a matter of course. The agencies note (p.40245) that "tractor-trailer pairings are almost always optimized." While this observation was made in the context of roof height and trailer type, the same considerations should apply here. In the case of integration, manufacturers and researchers are clearly working towards designs that would necessitate, or strongly favor, appropriate pairings. Furthermore, it is important to weigh the potential for unearned credits for tractor-trailer pairing against the value of the incentive to accelerate the aerodynamic integration of tractors and trailers.

In any case, the likelihood of reasonable agreement between compliance credit for tractor-trailer pairings and the real-world benefits could be increased for example by:

- Giving manufacturers credit only for vehicles sold to fleets with well-documented estimates of the percentage of miles traveled with matched set. (Credit computed case by case)
- Giving a fixed, partial credit to provide an incentive for co-optimization while recognizing the possibility of mismatches. (Partial credit across the board, e.g. 50%)
- Certifying tractors to be used only with certain trailers; this requirement would be shown on the tractor label. (100% credit)
- Awarding full credit to tractors having hardware to ensure pairing with appropriate trailers. (100% credit)

The agencies could adopt a combination of these approaches. Most fleets at present may be unwilling to accept the loss of flexibility required by the 3rd and 4th approaches, especially given the constraint this may impose on resale of the tractor. However, acceptance should increase over time, as integrated designs demonstrate major fuel savings, and trailer fleets are managed and optimized in real time.