Final Phase 1 EPA Heavy-Duty Vehicle and Engine Greenhouse Gas Emissions Compliance Report (Model Years 2014-20)

Final Phase 1 EPA Heavy-Duty Vehicle and Engine Greenhouse Gas Emissions Compliance Report (Model Years 2014-20)

Compliance Division
Office of Transportation and Air Quality
U.S. Environmental Protection Agency

NOTICE

This technical report does not necessarily represent final EPA decisions or positions. It is intended to present technical analysis of issues using data that are currently available. The purpose in the release of such reports is to facilitate the exchange of technical information and to inform the public of technical developments.

Table of Contents

1. Executive Summary

This report is part of the U.S. Environmental Protection Agency's (EPA's) commitment to provide the public with information about the heavy-duty vehicle and engine manufacturers' performance in meeting the agency's greenhouse gas emission (GHG) standards. It updates an otherwise largely similar report that EPA previously issued covering program compliance through model year 2018 by adding the results for the 2019 and 2020 model years. Where appropriate this report also extends the explanations and conclusions we draw from the information updated by the addition of these two latest model years. In 2011, EPA, along with the Department of Transportation's National Highway Traffic Safety Administration (NHTSA), adopted the first-ever greenhouse gas emission and fuel efficiency standards for heavy-duty engines and vehicles. The comprehensive program the agencies created was designed to address the intertwined challenges of reducing dependence upon oil, achieving energy security, and the amelioration of global climate change. The program also served to enhance American competitiveness and job creation, benefit consumers and businesses by reducing the costs of transportation of goods, and spur growth in the clean energy sector. The Phase 1 Heavy-Duty Vehicle and Engine Greenhouse Gas Rule became mandatory in 2014 and fully phased-in by the 2017 model year. The objective of the Phase 1 program was to reduce GHG emissions from the heavy-duty sector, the transportation sector's second largest contributor to GHG emissions. The program aimed to expand the use of more efficient commercially available technologies.

The commercial transportation industries that use the products covered through these regulations are incredibly diverse with a wide range of operating and use patterns. As a result, the heavy-duty vehicle and engine industry is itself quite diverse and offers an almost unbelievable range of different products and options in order to best serve the needs of their customers.   EPA and NHTSA in developing the Phase 1 program, included a number of design elements intended to improve fuel consumption and lower GHG emissions without limiting the ability of manufacturers to offer the diverse range of products their customers expected and need.   These flexibilities were expected to provide sufficient lead time for manufacturers to make necessary technological improvements, help increase the rate of which new technologies can be implemented, and reduce the overall cost of the program, without compromising overall environmental objectives. The primary flexibility is an engine and vehicle averaging, banking, and trading (ABT) program in which CO_2 credits may be generated for vehicles/engines that overachieve, relative to the standards. With these ABT provisions, manufacturers can offer the right product for the right consumer need (some of which may over or under perform against the fleet average GHG standards), balance market fluctuations impacting their sales volumes, and still move the entire fleet of vehicles toward increasing levels of energy efficiency and lower GHG emissions The EPA ABT program allows for emission credits to be averaged, banked, or traded within each of the "averaging sets" described in this report, allowing manufacturers the opportunity to comply on a fleet average basis with the emission standards. Participation in this ABT program is optional and manufacturers can alternatively choose to certify all of their heavy-duty vehicles/engines to meet the applicable standards.

This report provides an overview of the GHG compliance status of manufacturers of heavy-duty combination tractors, vocational vehicles, and the engines that power these vehicles. Heavy-duty combination tractors are the semi-trucks that typically pull trailers and are built to mainly move freight. Vocational vehicles consist of a very wide variety of truck and bus types including delivery, refuse, utility, dump, cement, transit bus, shuttle bus, school bus, emergency vehicles, motor homes, tow trucks, and many more. This report summarizes the current CO_2 credit situation at the conclusion of the Phase 1 portion (Model Year 2020) of the rulemaking (optional in model year 2013 then mandatory beginning in

model year 2014) to the new GHG standards for each manufacturer participating in either of the vehicle or engine ABT programs.

The success of the heavy-duty GHG program as documented in the pages of this report is measured in the industry's ability to create the systems and processes necessary to demonstrate compliance with the program, improve their products to lower their GHG emissions and fuel consumption, and finally through their reporting to the Agency demonstrate that the fleet of vehicles they produced complied with the aggregated fleet standards.   It is a significant accomplishment that the entire industry was able to implement and begin complying with this program and has demonstrated through their reporting that GHG emissions have been reduced to such an extent that all manufacturers are compliant and most have created significant credit banks reflecting better overall fleet performance than the agencies originally projected in setting up the program.

This report documents that all manufacturers (both for vehicles and engines) are not merely compliant, but that all manufacturers have generated a positive banked credit balance through model year 2020 in each of the three averaging sets for vehicles and engines. This clearly demonstrates full compliance of the Phase 1 regulatory requirements and the new standards that became mandatory in model year 2014 (summarized in Tables 1 and 11 of Section 3 in this report).

The Phase 2 Heavy-Duty Vehicle and Engine Greenhouse Gas Rule was adopted in 2016 and began implementation with the 2021 model year.   In designing the Phase 2 program, EPA considered credit balances in the Phase 1 program and concluded that manufacturers should be allowed to largely carry the Phase 1 credit balances into the Phase 2 program. However, some restrictions were adopted for certain circumstances, primarily to avoid the potential for credit disparities to disrupt the competitive marketplace. Nevertheless, the amount of credits potentially being carried into the Phase 2 program was deemed sufficiently large to be considered in setting the stringency of the Phase 2 standards (i.e., the Phase 2 standards are more stringent than they otherwise would have been had manufacturers not demonstrated the ability to over comply with the Phase 1 standards).

2. Program Background and Description

On September 15, 2011, the Environmental Agency (EPA) and the National Highway Traffic Safety Administration (NHTSA) issued a joint Final Rule that established the first phase of a national program with new greenhouse gas (GHG) and fuel economy standards for 2014 and later model year heavy-duty vehicles and engines.[1] The "Phase 1" standards established by this rule apply to medium- and heavy-duty vehicles, including (1) combination tractors, (2) heavy-duty pickup trucks and vans, and (3) vocational vehicles as well as another set of GHG standards for the engines that drive these vehicles. The Phase 1 standards apply to all on-road vehicles rated at a gross vehicle weight at or above 8,500 pounds (Classes 2b-8), and the engines that power them, except those covered by the light-duty GHG standards and heavy-duty pickup trucks and vans (Classes 2b-3) which are certified using a chassis dynamometer.

The Phase 1 rule provides some flexibility to manufacturers in how they can comply with these new GHG standards. The primary flexibility is an engine and vehicle averaging, banking, and trading (ABT)

---

[1] Federal Register "Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles; Final Rule" dated September 15, 2011

program in which CO_2 credits may be generated for certain groups of vehicles/engines that overachieve, relative to the standards. These credits may be used to offset other groups of vehicles/engines that underachieve, relative to the standards. The EPA ABT program allows for emission credits to be averaged, banked, or traded within each of the "averaging sets" (to be described), allowing manufacturers the opportunity to comply on average with the emission standards.

This report provides an overview of the GHG compliance status of manufacturers of heavy-duty combination tractors, vocational vehicles, and the engines that power these vehicles at the conclusion of the Phase 1 period (model year 2020). Heavy-duty combination tractors are the semi-trucks that typically pull trailers and are built to mainly move freight. Vocational vehicles consist of a very wide variety of truck and bus types including delivery, refuse, utility, dump, cement, transit bus, shuttle bus, school bus, emergency vehicles, motor homes, tow trucks, and many more. Even for cases in which engine and vehicle credits are both generated by a single corporate entity, engine and vehicle credits are segregated within the regulatory program and in this report.

a. Heavy-Duty Vehicles

The manufacturers of combination tractors and vocational vehicles demonstrated compliance with the GHG standards using a Greenhouse Gas Emissions Model (GEM), developed by EPA and used to calculate a vehicle's tailpipe CO_2 emissions. The CO_2 emissions calculation performed by GEM required input parameters for each vehicle, provided to the GEM model by the manufacturer. The calculated CO_2 value was then compared to the corresponding CO_2 standard for that vehicle classification in order to determine compliance.

There are three weight-based vehicle averaging sets for the two vehicle regulatory categories included in this report (combination tractors and vocational vehicles). The three averaging sets for these vehicles are:

1. Light Heavy-Duty (Class 2b-5 vocational vehicles only)
2. Medium Heavy-Duty (Class 6-7 vocational vehicles and Class 7 tractors)
3. Heavy Heavy-Duty (Class 8 vocational vehicles and tractors)

CO_2 standards for tractors and vocational vehicles vary based on averaging set and vehicle classification. The standards for all these vehicles and averaging sets can be found in Title 40 of the Code of Federal Regulations (CFR), Part 1037, Subpart B and are summarized later in this report. As described previously, manufacturers used the GEM model to estimate the CO_2 emissions level of a heavy-duty vehicle. This estimated value was then compared to the standard to determine if the vehicle either generated or consumed CO_2 credits for compliance. Credits generated in this process for one vehicle could then be used to offset any credit deficits produced by another vehicle, but only within the averaging set.

b. Heavy-Duty Engines

The emissions from the engines that power combination tractors and vocational vehicles are measured using an engine dynamometer. The engines are operated on the dynamometer over two different duty cycles, one simulating urban driving and another simulating steady-state highway operation. CO_2 and other pollutants are directly measured on these cycles for certification purposes. The measured CO_2 levels are compared to a set of engine standards to determine compliance. Engines must also meet standards for two additional GHG pollutants produced during engine combustion: N_2O (nitrous oxide),

and CH_4 (methane). The measured emissions levels of N_2O and CH_4 are also compared to a set of standards developed by EPA to determine compliance.

The structure of the ABT program for heavy-duty engines is similar to the vehicle program previously described. Each engine produced is certified to a certain set of GHG standards based on the engine's application (either tractor or vocational vehicle use). The manufacturer must test these engines on an engine dynamometer and measure GHG emissions (CO_2, N_2O, and CH_4) over two specific operating cycles: the transient Federal Test Procedure (FTP), and the steady-state Ramped Modal Cycle (RMC). The CO_2 emissions measured over the FTP cycle are used to determine compliance if the intended engine application is for a vocational vehicle. Similarly, if the intended application of the engine is for a tractor, then the CO_2 emissions level measured over the RMC cycle is compared to the standard to determine compliance. N_2O and CH_4 emissions levels are only measured over the FTP cycle and compared to the applicable standard for each. CO_2 credits, generated by an engine test result that is overachieving, relative to the standard may be used to offset any credit deficits in the same averaging set. There are four averaging sets for heavy-duty engines, which are:

1. Light Heavy-Duty Compression Ignition (CI) (intended for use in Class 2b-5 vocational vehicles)
2. Medium Heavy-Duty CI (intended for use in Class 6-7 vocational vehicles or Class 7 tractors)
3. Heavy Heavy-Duty CI (intended for use in Class 8 vocational vehicles or tractors)
4. All Heavy-Duty Spark Ignition (SI)[2]

Similar to vehicles, there are different CO_2 standards within each averaging set for engines. The differences in the CO2 standards are based upon the intended service of the engine, that being either for vocational or tractor use.[3] The standards for N_2O and CH_4 are the same for all heavy-duty CI engines regardless of averaging set or intended application.[4] Any credits or deficits generated by N_2O and CH_4 are converted into equivalent CO_2 values by using specified conversion factors and included in the "Net" CO_2 values presented in the following tables. The nuances of this process will be described in more detail in Section 4 of this document.

c. Additional Credit Programs

EPA also adopted three optional CO_2 credit provisions in the Phase 1 rule: an early credit program, an "off-cycle" credit program, and an advanced technology credit program.

The early credit option was for manufacturers who demonstrated that their products overachieved, relative to the standards prior to the model year that the Phase 1 standards became effective. This program allowed the manufacturers to certify their heavy-duty vehicles and CI engines in model year 2013, before the GHG standards became mandatory in model year 2014. As an incentive, any CO_2 credits generated using this option received a bonus 1.5X multiplier for model year 2013 only. Several manufacturers took advantage of this opportunity and the summary tables for model year 2013 are also included in the following credit summary tables.

The "off-cycle" credit program is intended to promote the development of innovative technologies that reduce vehicle CO_2 emissions, but for which the benefits are not accounted for when using the GEM model (for vehicles) or not captured on the FTP and/or RMC test procedures (for engines). These off-

---

[2] The engines produced in the Heavy-Duty SI averaging set are not included in this report
[3] See 40 CFR 1036 Subpart B.
[4] See 40 CFR 1036 Subpart B.

cycle credits are in addition to those credits being generated by CO_2 compliance (conventional credits) as previously described.

The advanced technology credit option is intended to promote implementation of advanced technologies, such as hybrid powertrains, engines with Rankine cycle waste heat recovery systems and electric or fuel cell vehicles. These advanced technology (AT) credits not only have a 1.5X multiplier, but, unlike other credits, they may be used to offset deficits in any averaging set in either the heavy-duty vehicle or engine sectors through model year 2020. AT credits generated in model year 2021 and later will be restricted to use only within the averaging set in which they were generated. Because of the unique and flexible nature of these credits, they must be tracked separately from the GEM generated "conventional" and off-cycle credits and thus are presented separately in the tables of this report.

3. Model Year 2020 Heavy-Duty Vehicle Compliance

a. Compliance of Heavy-Duty Vocational Vehicles Produced by Manufacturers Not Participating in Averaging, Banking and Trading

Model year 2014 was the first mandatory year for certifying heavy-duty vehicles to GHG standards. As part of the certification process, manufacturers could voluntarily participate in the GHG ABT program. Manufacturers participating in the ABT program are required to submit a report to EPA that includes production volume information and other vehicle data needed to determine the net CO_2 credits produced in each averaging set of their vehicle fleet. Manufacturers choosing to not participate in the ABT program simply certify their entire vehicle fleet to the standards, meaning that every one of their vehicles produced is required to meet the standard without the flexibility of the ABT program. Through model year 2020 the following ten manufacturers chose not to participate in the ABT program for the entirety of Phase 1 instead choosing to produce all of their vehicles with emissions at or below the applicable vehicle standards: Alexander Dennis, An Yuan Bus, ARBOC Specialty, BYD Auto, CHTC USA, Dennis Eagle, Envirotech Drives, Green Power Motor, Irizar Sociedad, and Lion Bus. Again, the ABT program is voluntary, and the manufacturers that chose not to participate are in full compliance with the new GHG standards for their vehicles. Manufacturers not using the ABT program are still required to provide EPA with an end-of-year production volume report describing certain vehicle parameters for each vehicle produced during the model year to determine compliance with the program standards, as all manufacturers are required to submit.

b. Compliance of Heavy-Duty Vocational Vehicles Produced by Manufacturers Participating in Averaging, Banking and Trading

Table 1 presents the applicable CO_2 emissions standards for heavy-duty vehicles applicable for model years 2014-20. The standards are presented for five vehicle regulatory subcategories which are:

1. Light heavy-duty (LHD) vocational vehicles (there is not a LHD tractor classification, therefore the entire LHD subcategory consists of only vocational vehicles)
2. Medium heavy-duty (MHD) vocational vehicles
3. Heavy heavy-duty (HHD) vocational vehicles
4. MHD vocational tractors (defined in Part 1037.630)
5. HHD vocational tractors (defined in Part 1037.630)

Each of these regulatory subcategories will have a separate table later in this report detailing the credits generated during model years 2013-20 for each manufacturer producing vehicles in this subcategory.

Table 1. Heavy Duty Vehicle GHG Emissions Standards for Model Years 2014-20.

Vehicle Type	GVWR (lbs)	CO2 (g/ton-mile) MY 2014-16	CO2 (g/ton-mile) MY 2017-20	Payload (tons)	Useful Life (miles)	Roof Height (inches)
Vocational Vehicles						
LHD Class 2b-5	8,501 - 19,500	388	373	2.85	*110,000	N/A
MHD Class 6-7	19,501 - 33,000	234	225	5.60	185,000	N/A
HHD Class 8	Greater than 33,000	226	222	7.50	435,000	N/A
Tractors						
Class 7 Low-Roof All Cabs	26,001 - 33,000	107	104	12.50	185,000	120 or less
Class 7 Mid-Roof All Cabs	26,001 - 33,000	119	115	12.50	185,000	121-147
Class 7 High-Roof All Cabs	26,001 - 33,000	124	120	12.50	185,000	148 or greater
Class 8 Low-Roof Day Cab	Greater than 33,000	81	80	19.00	435,000	120 or less
Class 8 Low-Roof Sleeper Cab	Greater than 33,000	68	66	19.00	435,000	120 or less
Class 8 Mid-Roof Day Cab	Greater than 33,000	88	86	19.00	435,000	121-147
Class 8 Mid-Roof Sleeper Cab	Greater than 33,000	76	73	19.00	435,000	121-147
Class 8 High-Roof Day Cab	Greater than 33,000	92	89	19.00	435,000	148 or greater
Class 8 High-Roof Sleeper Cab	Greater than 33,000	75	72	19.00	435,000	148 or greater

* Useful Life Changed to 150,000 miles for LHD Vehicles Starting in Model Year 2021

View this table at a larger text size by visiting:
https://www.epa.gov/system/files/documents/2022-11/420r22028-report-tables.pdf.

Presented in Table 1 are the gross vehicle weight ratings that define the appropriate averaging set for any given vehicle. In addition, Payload and Useful Life values are presented for each vehicle regulatory subcategory. Payload and Useful Life values are required in order to calculate ABT credits for a given vehicle. Vocational tractors are included as separate regulatory subcategories in this report because unique requirements exist for these vehicles. These unique requirements reflect the unique customer needs for vocational tractors which in turn dictate a different level of GHG performance and appropriate GHG standard. In regards to credit generation, vocational tractors are treated the same as other vocational vehicles in their respective averaging set.

Equation 1 is used to calculate CO_2 credits in each vehicle regulatory subcategory in the subsequent tables:

Eq. 1: Vehicle Credit Calculation

CO_2 credits (Mg) = (Std-FEL) X (Payload Tons) X (Volume) X (UL) X (10^-6)

Where:

STD = the emission standard associated with the specific tractor or vocational regulatory subcategory (g/ton-mile)

FEL = the family emission limit for the vehicle subfamily as calculated by the GEM model (g/ton-mile)

Payload Tons = the prescribed payload for each class of vehicle in tons (2.85 tons for light heavy-duty vocational vehicles, 5.6 tons for medium heavy-duty vocational vehicles, 7.5 tons for heavy heavy-duty vocational vehicles, 12.5 tons for medium heavy-duty tractors, and 19 tons for heavy heavy-duty tractors)

Volume = U.S. directed production volume of the vehicle subfamily. For example, if you produce three configurations with the same FEL, the subfamily production volume would be the sum of the production volumes for these three configurations

UL = useful life of the vehicle (110,000 miles for light heavy-duty vehicles, 185,000 for medium heavy-duty vehicles, and 435,000 for heavy heavy-duty vehicles). The Useful Life value for light-heavy duty vehicles was changed as part of the Phase 2 rulemaking but are calculated using the Phase 1 value (110,000 miles) in this report. Banked credit balances shown have been adjusted using the new useful life value for LHD vehicles and was conducted at the end of model year 2020 (last year of Phase 1 program) to determine the adjusted credit values carried forward into the Phase 2 program (described in more detail later in this report).

Vehicles with an agency-approved off-cycle technology receive an additional credit multiplier for each vehicle equipped with the approved technology. These off-cycle credits are similar to the CO_2 credits generated by conventional vehicles in that they can only be used within the averaging set in which they were generated. The off-cycle credits are calculated separately from the conventional credits and are determined based upon the additional GHG benefit achieved through the use of the technology beyond the FEL established for that vehicle using the GEM model (conventional credits). Since off-cycle credits are utilized and limited in the same ways as conventional credits, they are combined and presented as a single credit value in this report for each regulatory subcategory of vehicles. Both conventional and off-cycle credits have a 5-year life which means that they have to be used within five model years after the one in which they were generated, or they will expire. Navistar and Autocar were the only heavy-duty vehicle manufacturer to generate any off-cycle credits during the entirety of the Phase 1 program. Navistar generated some of their credits from an approved off-cycle technology, and both Navistar and Autocar generated off-cycle credits beginning in model year 2018 using the interim provisions provided by the Phase 2 rulemaking presented in Section 1037.150(y) for enhanced credit generation carrying into the Phase 2 program.

As discussed previously, hybrid vehicles with regenerative braking, vehicles equipped with Rankine-cycle engines, electric vehicles, and fuel cell vehicles qualify to generate advanced technology (AT) credits. These credits may be utilized differently than the conventional and off-cycle credits previously discussed. AT credits may not only be used to offset credit deficits in the averaging set in which they were generated (just like conventional and off-cycle credits) but may also be used to offset deficits in any other averaging set. This flexibility is extended to any credit deficits in the heavy-duty vehicle sector and to the heavy-duty engine sector (this flexibility of AT credits does not extend to the Phase 2 program beginning with MY2021 and these credits will be restricted for use only in the averaging set in which they were generated). These AT credits have a 1.5X multiplier for each credit generated. Advanced technology credits are also calculated separately based on the additional benefit they provide beyond the GEM calculated FEL of the vehicle resulting in a combination of conventional and AT credits for each of these vehicles. Only this extra benefit of the AT receives the 1.5X multiplier as previously described. Ten manufacturers (Blue Bird, Chanje, Gillig, Mitsubishi Fuso, Motor Coach Industries, New Flyer, PACCAR, Van Hool, Volvo Group, and XOS Trucks) generated advanced technology vehicle credits in model years 2013-20 as the following tables will indicate.

Tables 2-1 through 2-5 present a summary of the ABT credits generated by each vocational vehicle manufacturer participating in the ABT program during model years 2013-20 in the five vocational regulatory subcategories previously described. Manufacturer names are abbreviated versions of their full legal names in all of the tables and text of this report. This data is for those vehicles that were not certified on a chassis dynamometer but used only the GEM certification model. The first column of each model year represents the combined conventional and off-cycle credits generated by each manufacturer which were calculated using the GEM determined FEL value of CO_2 for each vehicle in that regulatory subcategory. Off-cycle credits were calculated by applying the off-cycle improvement factor to the GEM determined FEL value for additional credits for these technologies. The second column of each model year represents the AT credits generated for each manufacturer in that regulatory subcategory which is calculated based only on the AT improvement for each vehicle beyond the FEL determined by GEM. In all cases, a blank cell in any column means that the manufacturer did not produce any vehicles in that regulatory subcategory or model year. Because of the size of each of these tables, they are laid out in two sections. The upper section covers credits generated in model years 2013-17, and the lower section covers model years 2018-20 including aggregate columns at the end totaling all generated credits from the model years presented. There is also a link at the bottom of each table to allow the reader to view these tables in a larger format for ease of viewing.

Table 2-1. LHD Vocational Vehicles: GHG Credits (Mg CO2) Generated Summary – Model Years 2013-20.

Manufacturer	MY 2013 Conventional Plus Off-Cycle Credits Generated	MY 2013 Advanced Technology Credits Generated	MY 2014 Conventional Plus Off-Cycle Credits Generated	MY 2014 Advanced Technology Credits Generated	MY 2015 Conventional Plus Off-Cycle Credits Generated	MY 2015 Advanced Technology Credits Generated	MY 2016 Conventional Plus Off-Cycle Credits Generated	MY 2016 Advanced Technology Credits Generated	MY 2017 Conventional Plus Off-Cycle Credits Generated	MY 2017 Advanced Technology Credits Generated
Autocar										
Blue Bird Body										
Charje										4,385
Chrysler Group			7,823		10,612		15,121		8,014	
Daimler Coaches										
Daimler Trucks										
E-One										
El Dorado										
EVO Bus										
Ferrara Fire										
Ford Motor			338,493		54,320		40,201		31,639	
General Motors			45,803		62,030		2,591			
Gillig LLC										
Hino Manufacturing										
Hino Motors										
Isuzu Motors			42,816		55,820		64,177		43,559	
Kovatch Mobile										
Mitsubishi Fuso			1,360		2,445		882		3,361	
Motor Coach Ind.										
Navistar, Inc.				8,393						
New Flyer										
Oshkosh										
PACCAR, Inc.	5		212		67		65		37	
Rosenbauer Motors										
Spartan Fire										
Terex Corporation										
Tiffin Motor Homes										
Van Hool										
Volvo Group										
XOS Trucks										
TOTALS	5	0	436,507	8,393	185,294	0	123,037	0	86,610	4,385

Manufacturer	MY 2018 Conventional Plus Off-Cycle Credits Generated	MY 2018 Advanced Technology Credits Generated	MY 2019 Conventional Plus Off-Cycle Credits Generated	MY 2019 Advanced Technology Credits Generated	MY 2020 Conventional Plus Off-Cycle Credits Generated	MY 2020 Advanced Technology Credits Generated	TOTAL Conventional Plus Off-Cycle Credits Generated	TOTAL Advanced Technology Credits Generated
Autocar								
Blue Bird Body								
Charje		526						4,911
Chrysler Group	15,996		10,739		38,092		106,397	
Daimler Coaches								
Daimler Trucks								
E-One								
El Dorado								
EVO Bus								
Ferrara Fire								
Ford Motor	41,495		135,491		138,976		780,615	
General Motors			6,775		1,937		119,136	
Gillig LLC								
Hino Manufacturing								
Hino Motors			3,967				3,967	
Isuzu Motors	46,388		52,793		88,127		394,180	
Kovatch Mobile								
Mitsubishi Fuso	169	7,072	891		2,542		11,650	7,072
Motor Coach Ind.								
Navistar, Inc.					909		909	8,393
New Flyer								
Oshkosh								
PACCAR, Inc.	58		63		133		640	
Rosenbauer Motors								
Spartan Fire								
Terex Corporation								
Tiffin Motor Homes								
Van Hool								
Volvo Group								
XOS Trucks								
TOTALS	104,606	7,598	210,719	0	270,716	0	1,417,494	20,376

View this table at a larger text size by visiting:
https://www.epa.gov/system/files/documents/2022-11/420r22028-report-tables.pdf.

Table 2-2. MHD Vocational Vehicles: GHG Credits (Mg CO2) Generated Summary – Model Years 2013-20.

Manufacturer	MY 2013 Conventional Plus Off-Cycle Credits Generated	MY 2013 Advanced Technology Credits Generated	MY 2014 Conventional Plus Off-Cycle Credits Generated	MY 2014 Advanced Technology Credits Generated	MY 2015 Conventional Plus Off-Cycle Credits Generated	MY 2015 Advanced Technology Credits Generated	MY 2016 Conventional Plus Off-Cycle Credits Generated	MY 2016 Advanced Technology Credits Generated	MY 2017 Conventional Plus Off-Cycle Credits Generated	MY 2017 Advanced Technology Credits Generated
Autocar										
Blue Bird Body			58,034		69,126		71,126		70,911	
Chanje										
Chrysler Group										
Daimler Coaches										
Daimler Trucks	72,587		64,601		106,254		170,177		206,705	
E-One										
El Dorado										
EVO Bus										
Ferrara Fire										
Ford Motor			64,651		47,486		70,183		148,110	
General Motors										
Gillig LLC			438		386		126		53	
Hino Manufacturing										
Hino Motors										
Isuzu Motors										
Kovatch Mobile										
Mitsubishi Fuso										
Motor Coach Ind.										
Navistar, Inc.	142,054				68,834		54,000		127,160	
New Flyer					174		286		124	
Oshkosh										
PACCAR, Inc.	2,580		15,528		23,342		26,348		32,128	
Rosenbauer Motors										
Spartan Fire										
Terex Corporation										
Tiffin Motor Homes			1,256							
Van Hool										
Volvo Group										
XOS Trucks										
TOTALS	217,221	0	204,508	0	315,602	0	392,246	0	585,191	0

Manufacturer	MY 2018 Conventional Plus Off-Cycle Credits Generated	MY 2018 Advanced Technology Credits Generated	MY 2019 Conventional Plus Off-Cycle Credits Generated	MY 2019 Advanced Technology Credits Generated	MY 2020 Conventional Plus Off-Cycle Credits Generated	MY 2020 Advanced Technology Credits Generated	TOTAL Conventional Plus Off-Cycle Credits Generated	TOTAL Advanced Technology Credits Generated
Autocar	384		637		779		1,800	
Blue Bird Body	64,353		45,025	2,382	36,800	9,913	413,375	12,295
Chanje								
Chrysler Group								
Daimler Coaches								
Daimler Trucks	172,345		240,296		360,479		1,393,444	
E-One								
El Dorado								
EVO Bus								
Ferrara Fire								
Ford Motor	74,621		106,942		120,435		632,428	
General Motors			2,965		4,045		7,010	
Gillig LLC							1,003	
Hino Manufacturing			6,237		25		6,262	
Hino Motors			17,608		4,096		21,704	
Isuzu Motors	7,625		5,029		10,301		22,955	
Kovatch Mobile								
Mitsubishi Fuso								
Motor Coach Ind.								
Navistar, Inc.	157,167		212,387		389,621		1,151,223	
New Flyer							584	
Oshkosh								
PACCAR, Inc.	44,431		50,075		106,223	3,709	300,655	3,709
Rosenbauer Motors								
Spartan Fire								
Terex Corporation								
Tiffin Motor Homes							1,256	
Van Hool								
Volvo Group					3,063		3,063	
XOS Trucks					21	3,465	21	3,465
TOTALS	520,926	0	687,201	2,382	1,035,888	17,087	3,958,783	19,469

View this table at a larger text size by visiting:
https://www.epa.gov/system/files/documents/2022-11/420r22028-report-tables.pdf.

Table 2-3. HHD Vocational Vehicles: GHG Credits (Mg CO2) Generated Summary –
 Model Years 2013-20.

Manufacturer	MY 2013 Conventional Plus Off-Cycle Credits Generated	MY 2013 Advanced Technology Credits Generated	MY 2014 Conventional Plus Off-Cycle Credits Generated	MY 2014 Advanced Technology Credits Generated	MY 2015 Conventional Plus Off-Cycle Credits Generated	MY 2015 Advanced Technology Credits Generated	MY 2016 Conventional Plus Off-Cycle Credits Generated	MY 2016 Advanced Technology Credits Generated	MY 2017 Conventional Plus Off-Cycle Credits Generated	MY 2017 Advanced Technology Credits Generated
Autocar										
Blue Bird Body			24,740		28,439		30,348		34,142	
Chanje										
Chrysler Group										
Daimler Coaches										
Daimler Trucks	187,890		183,121		211,873		297,599		334,152	
E-One			4,267		0		0		5,667	
El Dorado			5,771		5,109		6,525		2,884	
EVO Bus			2,300		1,233		1,174		1,390	
Ferrara Fire									1,436	
Ford Motor							251		2,711	
General Motors										
Gillig LLC			22,397		20,162		22,590		28,570	1,033
Hino Manufacturing										
Hino Motors										
Isuzu Motors										
Kovatch Mobile							3,002		3,250	
Mitsubishi Fuso										
Motor Coach Ind.			18,312		18,975		20,456		17,967	
Navistar, Inc.	186,954				44,843		60,666		87,392	
New Flyer					14,055		31,620		30,765	23,265
Oshkosh			9,168		10,055		12,799		8,434	
PACCAR, Inc.	28,467		162,636		288,222		318,538		333,780	
Rosenbauer Motors										
Spartan Fire										
Terex Corporation			4,055		4,160		12,241		1,383	
Tiffin Motor Homes			17,180							
Van Hool									31,343	
Volvo Group			128,370		181,910		237,817		196,902	
XOS Trucks										
TOTALS	403,311	0	582,317	0	829,036	0	1,055,626	0	1,122,168	24,298

Manufacturer	MY 2018 Conventional Plus Off-Cycle Credits Generated	MY 2018 Advanced Technology Credits Generated	MY 2019 Conventional Plus Off-Cycle Credits Generated	MY 2019 Advanced Technology Credits Generated	MY 2020 Conventional Plus Off-Cycle Credits Generated	MY 2020 Advanced Technology Credits Generated	TOTAL Conventional Plus Off-Cycle Credits Generated	TOTAL Advanced Technology Credits Generated
Autocar	154,009		128,614		77,490		360,113	
Blue Bird Body	24,518	9,308	15,523	77,077	17,115	136,717	174,825	223,102
Chanje								
Chrysler Group								
Daimler Coaches			179				179	
Daimler Trucks	290,568		423,942		802,833		2,731,978	
E-One	10,019		5,253		8,394		33,600	
El Dorado	6,450		7,027		6,890		40,656	
EVO Bus	235						6,332	
Ferrara Fire	581		1,250		626		3,893	
Ford Motor	2,956		2,786		2,169		10,873	
General Motors								
Gillig LLC	36,657	3,098	35,565		23,516		189,437	4,131
Hino Manufacturing			10				10	
Hino Motors			483				483	
Isuzu Motors								
Kovatch Mobile	2,617		2,026		5,063		15,958	
Mitsubishi Fuso								
Motor Coach Ind.	32,067		28,204		43,029	2,046	179,010	2,046
Navistar, Inc.	106,628		156,828		273,195		916,506	
New Flyer	31,261	164,435	33,979	170,268	37,215	90,485	178,895	448,463
Oshkosh	19,428		21,983		34,468		116,335	
PACCAR, Inc.	413,134		516,072		951,502	1,037	3,012,351	1,037
Rosenbauer Motors					4,365		4,365	
Spartan Fire					6,049		6,049	
Terex Corporation	2,215		2,320		1,944		28,318	
Tiffin Motor Homes							17,180	
Van Hool	26,560		27,764		29,013	1,013	114,680	1,013
Volvo Group	243,089		236,701		502,458	5,236	1,727,247	5,236
XOS Trucks								
TOTALS	1,402,992	176,841	1,646,509	247,345	2,827,334	236,544	9,869,293	685,028

View this table at a larger text size by visiting:
https://www.epa.gov/system/files/documents/2022-11/420r22028-report-tables.pdf.

Table 2-4. MHD Vocational Tractors: GHG Credits (Mg CO2) Generated Summary – Model Years 2013-20.

Manufacturer	MY 2013 Conventional Plus Off-Cycle Credits Generated	MY 2013 Advanced Technology Credits Generated	MY 2014 Conventional Plus Off-Cycle Credits Generated	MY 2014 Advanced Technology Credits Generated	MY 2015 Conventional Plus Off-Cycle Credits Generated	MY 2015 Advanced Technology Credits Generated	MY 2016 Conventional Plus Off-Cycle Credits Generated	MY 2016 Advanced Technology Credits Generated	MY 2017 Conventional Plus Off-Cycle Credits Generated	MY 2017 Advanced Technology Credits Generated
Autocar										
Daimler Trucks	1,046		1,808		2,916		2,160		3,841	
Ford Motor							-26		76	
Hino Motors										
Kovatch Mobile										
Navistar, Inc.										
PACCAR, Inc.	1,742		1,355		1,272		662		645	
Volvo Group										
TOTALS	2,788	0	3,163	0	4,188	0	2,796	0	4,562	0

Manufacturer	MY 2018 Conventional Plus Off-Cycle Credits Generated	MY 2018 Advanced Technology Credits Generated	MY 2019 Conventional Plus Off-Cycle Credits Generated	MY 2019 Advanced Technology Credits Generated	MY 2020 Conventional Plus Off-Cycle Credits Generated	MY 2020 Advanced Technology Credits Generated	TOTAL Conventional Plus Off-Cycle Credits Generated	TOTAL Advanced Technology Credits Generated
Autocar								
Daimler Trucks	1,509		2,097		5,391		20,768	
Ford Motor	58		35		96		239	
Hino Motors								
Kovatch Mobile								
Navistar, Inc.	2,487		2,535		5,949		10,971	
PACCAR, Inc.	995		1,495		1,574		9,740	
Volvo Group								
TOTALS	5,049	0	6,162	0	13,010	0	41,718	0

View this table at a larger text size by visiting:
https://www.epa.gov/system/files/documents/2022-11/420r22028-report-tables.pdf.

Table 2-5. HHD Vocational Tractors: GHG Credits (Mg CO2) Generated Summary – Model Years 2013-20.

Manufacturer	MY 2013 Conventional Plus Off-Cycle Credits Generated	MY 2013 Advanced Technology Credits Generated	MY 2014 Conventional Plus Off-Cycle Credits Generated	MY 2014 Advanced Technology Credits Generated	MY 2015 Conventional Plus Off-Cycle Credits Generated	MY 2015 Advanced Technology Credits Generated	MY 2016 Conventional Plus Off-Cycle Credits Generated	MY 2016 Advanced Technology Credits Generated	MY 2017 Conventional Plus Off-Cycle Credits Generated	MY 2017 Advanced Technology Credits Generated
Autocar										
Daimler Trucks	23,163		15,686		23,617		34,638		21,650	
Ford Motor							52		29	
Hino Motors										
Kovatch Mobile									88	
Navistar, Inc.										
PACCAR, Inc.	4,341		46,484		66,314		41,705		30,221	
Volvo Group			113,551		26,981		23,992		18,104	
TOTALS	27,504	0	175,721	0	116,912	0	100,387	0	70,092	0

Manufacturer	MY 2018 Conventional Plus Off-Cycle Credits Generated	MY 2018 Advanced Technology Credits Generated	MY 2019 Conventional Plus Off-Cycle Credits Generated	MY 2019 Advanced Technology Credits Generated	MY 2020 Conventional Plus Off-Cycle Credits Generated	MY 2020 Advanced Technology Credits Generated	TOTAL Conventional Plus Off-Cycle Credits Generated	TOTAL Advanced Technology Credits Generated
Autocar	18,531		24,978		18,776		62,285	
Daimler Trucks	40,716		54,940		91,771		306,181	
Ford Motor	124		43		36		284	
Hino Motors			1,008				1,008	
Kovatch Mobile	26						114	
Navistar, Inc.	11,488		14,821		52,553		78,862	
PACCAR, Inc.	52,748		54,771		76,917		373,501	
Volvo Group	49,162		33,943		90,877		356,610	
TOTALS	172,795	0	184,504	0	330,930	0	1,178,845	0

View this table at a larger text size by visiting:
https://www.epa.gov/system/files/documents/2022-11/420r22028-report-tables.pdf.

For the most part, each manufacturer produced a positive number of conventional ABT credits in each of the five regulatory subcategories for vocational vehicles presented in tables 2-1 through 2-5, indicating that the manufacturers produced vocational vehicle fleets which were compliant with the regulations in model years 2013-20. As will be observed later in this report, any credit deficit generated

in one vehicle regulatory category above may be offset with vehicles produced in another category generating positive credits as long as both are within the same averaging set. For example, the credit deficit generated by Ford in model year 2016 with MHD vocational tractors (Table 2-4) was more than offset by positive credits generated by Ford's MHD vocational vehicles from the same model year (Table 2-2).

The reader of this report should, however exercise caution in interpreting the data. The very purpose of the ABT program design is to allow customers and manufacturers to find the right balance of vehicle attributes and low GHG technologies to best serve the often unique needs of individual customer applications while in aggregate improving the overall fleet GHG performance. As some manufacturers may specialize in products for particular market segments with inherently different GHG performance, their credit balance is as likely to reflect those market needs as it is to reflect anything about a manufacturer's ability to produce low GHG technologies.

Table 3 combines all the ABT credits generated in the five individual vocational vehicle regulatory subcategories into their appropriate averaging sets for each model year to date. As described previously, conventional and off-cycle credits are considered similar based on their restriction of being used only within the averaging set in which they were generated. Therefore, they are combined in Table 3. AT credits have much more flexibility in their use and are tracked separately. Table 3 also includes aggregate totals of all credits generated during model years 2013-20 in each averaging set for reference. These totals are merely an aggregate total of credits generated during model years 2013-2020 and are not reflective of the current amount of banked credits available to each manufacturer for future use in the Phase 2 program (discussed more later).

Table 3 indicates that all manufacturers demonstrated compliance with the GHG regulations for model years 2013-20 vocational vehicles based on the positive credit status in each averaging set for each model year. Credits generated by manufacturers may be banked for future use and have a 5-year life (a credit may be used for any of the five model years after the year in which it was generated). If a credit is not utilized within the five model year period, its value expires and it is removed from a manufacturer's available balance.

Table 3. All Heavy-Duty Vocational Vehicles: GHG Credits (Mg CO2) Generated Summary – Model Years 2013-20.

View this table at a larger text size by visiting:
https://www.epa.gov/system/files/documents/2022-11/420r22028-report-tables.pdf.

Table 4 presents the banked credit balances for each manufacturer in each of the three vocational vehicle averaging sets at the conclusion of Phase 1 (model year 2020). For the most part, Table 4 was generated by adding credits generated from each model year in each averaging set for model years 2013 through 2020 while removing the unused expired credits generated in model years 2013-2015. The Phase 2 rulemaking also provided an interim provision for extended credit life for LHD and MHD vocational vehicle credits generated in model years 2018-2021 that affects the life of certain credits in Table 4 below. Specifically, the vocational vehicle credits generated in the LHD and MHD averaging sets below from model years 2018-2021 for all manufacturers are no longer limited to a 5-year credit life but will remain available for compliance use through model year 2027 as described in Part 1037.150(y). Similarly, those manufacturers below that qualify as small manufacturers (meet the small business criteria specified in 13 CFR 121.201) receive a similar credit life extension for all of their vehicles (both vocational vehicles and tractors) certified in model years 2018-2021. The only two manufacturers that qualify as small manufacturers in the vehicle ABT program through model year 2020 are Autocar and XOS Trucks.

In the event that any other activity occurred with credits generated, Appendix A at the end of this report presents a list of such activity plus other notes effecting credit generation and use for each model year that resulted in a change of these banked credits. In addition, Appendix B contains links to additional spreadsheets for each manufacturer participating in the ABT program that details all credit activity involving the generated credits for each model year to date presented in this report. These detailed

spreadsheets summarize any credit activity at the conclusion of Phase 1 involving such transactions as credit trades, expired credits, error corrections/adjustments, etc. As noted previously, there are no CO_2 deficits in any averaging set in Table 4, thus showing full compliance to the Phase 1 GHG vocational vehicle regulations for each manufacturer participating in the ABT program through model year 2020.

Table 4. All Heavy-Duty Vocational Vehicles: GHG Credits (Mg CO2) Banked Summary – Through Model Year 2020.

Manufacturer	LHD Conventional Plus Off-Cycle Credit Balance	MHD Conventional Plus Off-Cycle Credit Balance	HHD Conventional Plus Off-Cycle Credit Balance	Advanced Technology Credit Balance
Autocar		1,800	422,398	
Blue Bird Body		288,215	121,646	235,397
Chanje				6,679
Chrysler Group	119,629			
Daimler Coaches			179	
Daimler Trucks		1,165,000	2,392,809	
E-One			29,333	
El Dorado			29,776	
EVO Bus			2,799	
Ferrara Fire			3,893	
Ford Motor	527,410	520,530	11,157	
General Motors	15,372	7,010		
Gillig LLC		179	146,898	4,131
Hino Manufacturing		6,262	10	
Hino Motors	5,395	21,704	1,491	
Isuzu Motors	401,940	22,955		
Kovatch Mobile			16,072	
Mitsubishi Fuso	10,670			9,618
Motor Coach Ind.			141,723	2,046
Navistar, Inc.	1,236	951,306	763,571	
New Flyer		410	164,840	448,463
Oshkosh			97,112	
PACCAR, Inc.	484	256,035	2,789,388	4,746
Rosenbauer Motors			4,365	
Spartan Fire			6,049	
Terex Corporation			20,103	
Tiffin Motor Homes		0	0	
Van Hool			114,680	1,013
Volvo Group		3,063	1,633,045	5,236
XOS Trucks		21		3,465
TOTALS	**1,082,136**	**3,244,490**	**8,913,337**	**720,794**

View this table at a larger text size by visiting:
https://www.epa.gov/system/files/documents/2022-11/420r22028-report-tables.pdf.

c. Compliance of Heavy-Duty Combination Tractors Produced by Manufacturers Participating in Averaging, Banking and Trading

A similar summary format is used in this section to describe the heavy-duty tractor sector as was used for the vocational vehicle sector. Table 5 presents the CO_2 emissions standards for heavy-duty tractors applicable for model years 2014-20. The standards are presented for the nine tractor regulatory subcategories. Each regulatory subcategory has a separate table in this section detailing the credits generated during model years 2013-20 for each manufacturer active in the subcategory. All Class 7 tractors fall in the MHD averaging set and all the Class 8 tractors fall in the HHD averaging set in the following tables. In addition to the CO_2 standard for each tractor subcategory, the table also contains payload and useful life data that is used in the ABT credit calculations for this sector. The roof height data is not relevant to credit calculations but is presented as a reference for the reader.

Table 5. Heavy-Duty Vehicle GHG Emissions Standards for Model Years 2014-20.

Vehicle Type	GVWR (lbs)	CO2 (g/ton-mile) MY 2014-16	CO2 (g/ton-mile) MY 2017-20	Payload (tons)	Useful Life (miles)	Roof Height (inches)
Vocational Vehicles						
LHD Class 2b-5	8,501 - 19,500	388	373	2.85	*110,000	N/A
MHD Class 6-7	19,501 - 33,000	234	225	5.60	185,000	N/A
HHD Class 8	Greater than 33,000	226	222	7.50	435,000	N/A
Tractors						
Class 7 Low-Roof All Cabs	26,001 - 33,000	107	104	12.50	185,000	120 or less
Class 7 Mid-Roof All Cabs	26,001 - 33,000	119	115	12.50	185,000	121-147
Class 7 High-Roof All Cabs	26,001 - 33,000	124	120	12.50	185,000	148 or greater
Class 8 Low-Roof Day Cab	Greater than 33,000	81	80	19.00	435,000	120 or less
Class 8 Low-Roof Sleeper Cab	Greater than 33,000	68	66	19.00	435,000	120 or less
Class 8 Mid-Roof Day Cab	Greater than 33,000	88	86	19.00	435,000	121-147
Class 8 Mid-Roof Sleeper Cab	Greater than 33,000	76	73	19.00	435,000	121-147
Class 8 High-Roof Day Cab	Greater than 33,000	92	89	19.00	435,000	148 or greater
Class 8 High-Roof Sleeper Cab	Greater than 33,000	75	72	19.00	435,000	148 or greater

* Useful Life Changed to 150,000 miles for LHD Vehicles Starting in Model Year 2021

View this table at a larger text size by visiting:
https://www.epa.gov/system/files/documents/2022-11/420r22028-report-tables.pdf.

Tables 6-1 through 6-9 present a summary of the ABT credits generated by each tractor manufacturer participating in the ABT program in model years 2013-20 in each of the nine tractor regulatory subcategories. All of these vehicles were certified using the GEM model. The layout of these tables is similar to those presented for vocational vehicles. The first column represents the conventional plus off-cycle credits generated by each manufacturer, which were calculated using the GEM-determined CO_2 FEL value for each vehicle in that regulatory subcategory. There are only four manufacturers that certify tractors, and each of these four manufacturers is participating in the ABT credit program. Only Navistar produced tractors that generated any off-cycle credits included in the following tables. Both PACCAR and Volvo Group became the first manufacturers to generate AT credits for tractors starting in model year 2020. As was the case before, a blank cell in any column means that the manufacturer did not produce any vehicles in that regulatory subcategory during the applicable model year.

Table 6-1. MHD Tractors – Class 7 Low-Roof All Cabs: GHG Credits (Mg CO2) Generated Summary – Model Years 2013-20.

Manufacturer	MY 2013 Conventional Plus Off-Cycle Credits Generated	MY 2013 Advanced Technology Credits Generated	MY 2014 Conventional Plus Off-Cycle Credits Generated	MY 2014 Advanced Technology Credits Generated	MY 2015 Conventional Plus Off-Cycle Credits Generated	MY 2015 Advanced Technology Credits Generated	MY 2016 Conventional Plus Off-Cycle Credits Generated	MY 2016 Advanced Technology Credits Generated	MY 2017 Conventional Plus Off-Cycle Credits Generated	MY 2017 Advanced Technology Credits Generated
Daimler Trucks	-2,720		918		241		81		-217	
Navistar, Inc.	2,410				511		458		937	
PACCAR, Inc.			32		-25		698		160	
Volvo Group										
TOTALS	-310	0	950	0	727	0	1,237	0	880	0

Manufacturer	MY 2018 Conventional Plus Off-Cycle Credits Generated	MY 2018 Advanced Technology Credits Generated	MY 2019 Conventional Plus Off-Cycle Credits Generated	MY 2019 Advanced Technology Credits Generated	MY 2020 Conventional Plus Off-Cycle Credits Generated	MY 2020 Advanced Technology Credits Generated	TOTAL Conventional Plus Off-Cycle Credits Generated	TOTAL Advanced Technology Credits Generated
Daimler Trucks	99		356		722		-520	
Navistar, Inc.	1,004		645		2,990		8,955	
PACCAR, Inc.	-155		56		518		1,284	
Volvo Group								
TOTALS	948	0	1,057	0	4,230	0	9,719	0

View this table at a larger text size by visiting:
https://www.epa.gov/system/files/documents/2022-11/420r22028-report-tables.pdf.

Table 6-2. MHD Tractors – Class 7 Mid-Roof All Cabs: GHG Credits (Mg CO2) Generated Summary – Model Years 2013-20.

Manufacturer	MY 2013 Conventional Plus Off-Cycle Credits Generated	MY 2013 Advanced Technology Credits Generated	MY 2014 Conventional Plus Off-Cycle Credits Generated	MY 2014 Advanced Technology Credits Generated	MY 2015 Conventional Plus Off-Cycle Credits Generated	MY 2015 Advanced Technology Credits Generated	MY 2016 Conventional Plus Off-Cycle Credits Generated	MY 2016 Advanced Technology Credits Generated	MY 2017 Conventional Plus Off-Cycle Credits Generated	MY 2017 Advanced Technology Credits Generated
Daimler Trucks	7,219		11,056		10,656		12,076		5,848	
Navistar, Inc.					23		12		143	
PACCAR, Inc.					-5		5		5	
Volvo Group										
TOTALS	7,219	0	11,056	0	10,674	0	12,093	0	5,996	0

Manufacturer	MY 2018 Conventional Plus Off-Cycle Credits Generated	MY 2018 Advanced Technology Credits Generated	MY 2019 Conventional Plus Off-Cycle Credits Generated	MY 2019 Advanced Technology Credits Generated	MY 2020 Conventional Plus Off-Cycle Credits Generated	MY 2020 Advanced Technology Credits Generated	TOTAL Conventional Plus Off-Cycle Credits Generated	TOTAL Advanced Technology Credits Generated
Daimler Trucks	5,141		8,360		16,583		76,939	
Navistar, Inc.	16		13		37		244	
PACCAR, Inc.			-5		-9		-9	
Volvo Group								
TOTALS	5,157	0	8,368	0	16,611	0	77,174	0

View this table at a larger text size by visiting:
https://www.epa.gov/system/files/documents/2022-11/420r22028-report-tables.pdf.

Table 6-3. MHD Tractors – Class 7 High-Roof All Cabs: GHG Credits (Mg CO2) Generated Summary – Model Years 2013-20.

Manufacturer	MY 2013 Conventional Plus Off-Cycle Credits Generated	MY 2013 Advanced Technology Credits Generated	MY 2014 Conventional Plus Off-Cycle Credits Generated	MY 2014 Advanced Technology Credits Generated	MY 2015 Conventional Plus Off-Cycle Credits Generated	MY 2015 Advanced Technology Credits Generated	MY 2016 Conventional Plus Off-Cycle Credits Generated	MY 2016 Advanced Technology Credits Generated	MY 2017 Conventional Plus Off-Cycle Credits Generated	MY 2017 Advanced Technology Credits Generated
Daimler Trucks	37,428		49,409		38,973		50,366		33,097	
Navistar, Inc.	396				6,487		15,621		10,709	
PACCAR, Inc.			-9		435		-1,085		-3,346	
Volvo Group										
TOTALS	37,824	0	49,400	0	45,895	0	64,902	0	40,460	0

Manufacturer	MY 2018 Conventional Plus Off-Cycle Credits Generated	MY 2018 Advanced Technology Credits Generated	MY 2019 Conventional Plus Off-Cycle Credits Generated	MY 2019 Advanced Technology Credits Generated	MY 2020 Conventional Plus Off-Cycle Credits Generated	MY 2020 Advanced Technology Credits Generated	TOTAL Conventional Plus Off-Cycle Credits Generated	TOTAL Advanced Technology Credits Generated
Daimler Trucks	61,679		67,685		68,457		407,094	
Navistar, Inc.	5,208		21,395		44,775		104,591	
PACCAR, Inc.	-1,727		-2,629		-1,027		-9,388	
Volvo Group								
TOTALS	65,160	0	86,451	0	112,205	0	502,297	0

View this table at a larger text size by visiting:
https://www.epa.gov/system/files/documents/2022-11/420r22028-report-tables.pdf.

Table 6-4. HHD Tractors – Class 8 Low-Roof Day Cabs: GHG Credits (Mg CO2) Generated Summary – Model Years 2013-20.

Manufacturer	MY 2013 Conventional Plus Off-Cycle Credits Generated	MY 2013 Advanced Technology Credits Generated	MY 2014 Conventional Plus Off-Cycle Credits Generated	MY 2014 Advanced Technology Credits Generated	MY 2015 Conventional Plus Off-Cycle Credits Generated	MY 2015 Advanced Technology Credits Generated	MY 2016 Conventional Plus Off-Cycle Credits Generated	MY 2016 Advanced Technology Credits Generated	MY 2017 Conventional Plus Off-Cycle Credits Generated	MY 2017 Advanced Technology Credits Generated
Daimler Trucks	-21,423		33,721		10,521		31,539		49,755	
Navistar, Inc.	29,780				8,637		9,001		27,729	
PACCAR, Inc.			4,885		63,136		83,931		134,645	
Volvo Group			8,538		24,307		31,655		48,722	
TOTALS	8,357	0	47,144	0	106,601	0	156,126	0	260,851	0

Manufacturer	MY 2018 Conventional Plus Off-Cycle Credits Generated	MY 2018 Advanced Technology Credits Generated	MY 2019 Conventional Plus Off-Cycle Credits Generated	MY 2019 Advanced Technology Credits Generated	MY 2020 Conventional Plus Off-Cycle Credits Generated	MY 2020 Advanced Technology Credits Generated	TOTAL Conventional Plus Off-Cycle Credits Generated	TOTAL Advanced Technology Credits Generated
Daimler Trucks	58,599		91,717		150,894		405,323	
Navistar, Inc.	30,531		47,251		84,791		237,720	
PACCAR, Inc.	187,144		237,065		419,945	9,547	1,130,751	9,547
Volvo Group	53,532		72,335		136,885		375,974	
TOTALS	329,806	0	448,368	0	792,515	9,547	2,149,768	9,547

View this table at a larger text size by visiting:
https://www.epa.gov/system/files/documents/2022-11/420r22028-report-tables.pdf.

Table 6-5. HHD Tractors – Class 8 Mid-Roof Day Cabs: GHG Credits (Mg CO2) Generated Summary – Model Years 2013-20.

Manufacturer	MY 2013 Conventional Plus Off-Cycle Credits Generated	MY 2013 Advanced Technology Credits Generated	MY 2014 Conventional Plus Off-Cycle Credits Generated	MY 2014 Advanced Technology Credits Generated	MY 2015 Conventional Plus Off-Cycle Credits Generated	MY 2015 Advanced Technology Credits Generated	MY 2016 Conventional Plus Off-Cycle Credits Generated	MY 2016 Advanced Technology Credits Generated	MY 2017 Conventional Plus Off-Cycle Credits Generated	MY 2017 Advanced Technology Credits Generated
Daimler Trucks	72,562		83,162		87,196		98,940		60,566	
Navistar, Inc.										
PACCAR, Inc.			49		1,529		529		1,099	
Volvo Group										
TOTALS	72,562	0	83,211	0	88,725	0	99,469	0	61,665	0

Manufacturer	MY 2018 Conventional Plus Off-Cycle Credits Generated	MY 2018 Advanced Technology Credits Generated	MY 2019 Conventional Plus Off-Cycle Credits Generated	MY 2019 Advanced Technology Credits Generated	MY 2020 Conventional Plus Off-Cycle Credits Generated	MY 2020 Advanced Technology Credits Generated	TOTAL Conventional Plus Off-Cycle Credits Generated	TOTAL Advanced Technology Credits Generated
Daimler Trucks	103,040		138,042		231,205		874,713	
Navistar, Inc.								
PACCAR, Inc.	1,488		860		1,405		6,959	
Volvo Group								
TOTALS	104,528	0	138,902	0	232,610	0	881,672	0

View this table at a larger text size by visiting:
https://www.epa.gov/system/files/documents/2022-11/420r22028-report-tables.pdf.

Table 6-6. HHD Tractors – Class 8 High-Roof Day Cabs: GHG Credits (Mg CO2) Generated Summary – Model Years 2013-20.

Manufacturer	MY 2013 Conventional Plus Off-Cycle Credits Generated	MY 2013 Advanced Technology Credits Generated	MY 2014 Conventional Plus Off-Cycle Credits Generated	MY 2014 Advanced Technology Credits Generated	MY 2015 Conventional Plus Off-Cycle Credits Generated	MY 2015 Advanced Technology Credits Generated	MY 2016 Conventional Plus Off-Cycle Credits Generated	MY 2016 Advanced Technology Credits Generated	MY 2017 Conventional Plus Off-Cycle Credits Generated	MY 2017 Advanced Technology Credits Generated
Daimler Trucks	265,827		284,531		412,663		520,976		320,054	
Navistar, Inc.	179,814				164,002		234,544		176,953	
PACCAR, Inc.			4,918		78,360		93,451		126,000	
Volvo Group			72,335		218,981		438,194		274,067	
TOTALS	445,641	0	361,784	0	874,006	0	1,287,165	0	897,074	0

Manufacturer	MY 2018 Conventional Plus Off-Cycle Credits Generated	MY 2018 Advanced Technology Credits Generated	MY 2019 Conventional Plus Off-Cycle Credits Generated	MY 2019 Advanced Technology Credits Generated	MY 2020 Conventional Plus Off-Cycle Credits Generated	MY 2020 Advanced Technology Credits Generated	TOTAL Conventional Plus Off-Cycle Credits Generated	TOTAL Advanced Technology Credits Generated
Daimler Trucks	364,288		461,237		846,468		3,476,044	
Navistar, Inc.	154,448		245,132		457,046		1,611,939	
PACCAR, Inc.	175,284		167,763		301,582		947,358	
Volvo Group	265,323		313,566		578,252	14,270	2,160,718	14,270
TOTALS	959,343	0	1,187,698	0	2,183,348	14,270	8,196,059	14,270

View this table at a larger text size by visiting:
https://www.epa.gov/system/files/documents/2022-11/420r22028-report-tables.pdf.

Table 6-7. HHD Tractors – Class 8 Low-Roof Sleeper Cabs: GHG Credits (Mg CO2) Generated Summary – Model Years 2013-20.

Manufacturer	MY 2013 Conventional Plus Off-Cycle Credits Generated	MY 2013 Advanced Technology Credits Generated	MY 2014 Conventional Plus Off-Cycle Credits Generated	MY 2014 Advanced Technology Credits Generated	MY 2015 Conventional Plus Off-Cycle Credits Generated	MY 2015 Advanced Technology Credits Generated	MY 2016 Conventional Plus Off-Cycle Credits Generated	MY 2016 Advanced Technology Credits Generated	MY 2017 Conventional Plus Off-Cycle Credits Generated	MY 2017 Advanced Technology Credits Generated
Daimler Trucks	-49,180		-31,746		-56,226		-29,713		-3,818	
Navistar, Inc.					-5,736		-3,827		-3,240	
PACCAR, Inc.			-6,662		-110,230		-72,839		-36,655	
Volvo Group			-12,422		-13,942		-13,546		-6,686	
TOTALS	-49,180	0	-50,830	0	-186,134	0	-119,925	0	-50,399	0

Manufacturer	MY 2018 Conventional Plus Off-Cycle Credits Generated	MY 2018 Advanced Technology Credits Generated	MY 2019 Conventional Plus Off-Cycle Credits Generated	MY 2019 Advanced Technology Credits Generated	MY 2020 Conventional Plus Off-Cycle Credits Generated	MY 2020 Advanced Technology Credits Generated	TOTAL Conventional Plus Off-Cycle Credits Generated	TOTAL Advanced Technology Credits Generated
Daimler Trucks	-6,753		-8,323		-11,877		-197,636	
Navistar, Inc.	-2,190		-3,926		-5,356		-24,275	
PACCAR, Inc.	-51,375		-79,947		-161,168		-518,876	
Volvo Group	-6,579		-5,670		-15,241		-74,086	
TOTALS	-66,897	0	-97,866	0	-193,642	0	-814,873	0

View this table at a larger text size by visiting:
https://www.epa.gov/system/files/documents/2022-11/420r22028-report-tables.pdf.

Table 6-8. HHD Tractors – Class 8 Mid-Roof Sleeper Cabs: GHG Credits (Mg CO2) Generated Summary – Model Years 2013-20.

Manufacturer	MY 2013 Conventional Plus Off-Cycle Credits Generated	MY 2013 Advanced Technology Credits Generated	MY 2014 Conventional Plus Off-Cycle Credits Generated	MY 2014 Advanced Technology Credits Generated	MY 2015 Conventional Plus Off-Cycle Credits Generated	MY 2015 Advanced Technology Credits Generated	MY 2016 Conventional Plus Off-Cycle Credits Generated	MY 2016 Advanced Technology Credits Generated	MY 2017 Conventional Plus Off-Cycle Credits Generated	MY 2017 Advanced Technology Credits Generated
Daimler Trucks	-169,077		-74,550		-79,790		-112,197		-94,271	
Navistar, Inc.					-43,813		-35,317		-26,886	
PACCAR, Inc.			-14,513		-225,237		-239,495		-180,970	
Volvo Group			-37,498		-47,532		-50,177		-29,332	
TOTALS	-169,077	0	-126,561	0	-396,372	0	-437,186	0	-331,459	0

Manufacturer	MY 2018 Conventional Plus Off-Cycle Credits Generated	MY 2018 Advanced Technology Credits Generated	MY 2019 Conventional Plus Off-Cycle Credits Generated	MY 2019 Advanced Technology Credits Generated	MY 2020 Conventional Plus Off-Cycle Credits Generated	MY 2020 Advanced Technology Credits Generated	TOTAL Conventional Plus Off-Cycle Credits Generated	TOTAL Advanced Technology Credits Generated
Daimler Trucks	-94,287		-114,999		-223,610		-962,781	
Navistar, Inc.	-27,382		-42,482		-63,657		-239,537	
PACCAR, Inc.	-212,551		-311,376		-573,847		-1,757,989	
Volvo Group	-33,192		-33,911		-68,302		-299,944	
TOTALS	-367,412	0	-502,768	0	-929,416	0	-3,260,251	0

View this table at a larger text size by visiting:
https://www.epa.gov/system/files/documents/2022-11/420r22028-report-tables.pdf.

Table 6-9. HHD Tractors – Class 8 High-Roof Sleeper Cabs: GHG Credits (Mg CO2) Generated Summary – Model Years 2013-20.

Manufacturer	MY 2013 Conventional Plus Off-Cycle Credits Generated	MY 2013 Advanced Technology Credits Generated	MY 2014 Conventional Plus Off-Cycle Credits Generated	MY 2014 Advanced Technology Credits Generated	MY 2015 Conventional Plus Off-Cycle Credits Generated	MY 2015 Advanced Technology Credits Generated	MY 2016 Conventional Plus Off-Cycle Credits Generated	MY 2016 Advanced Technology Credits Generated	MY 2017 Conventional Plus Off-Cycle Credits Generated	MY 2017 Advanced Technology Credits Generated
Daimler Trucks	967,290		879,024		877,908		1,669,315		612,114	
Navistar, Inc.					326,906		283,242		78,889	
PACCAR, Inc.			6,438		202,484		532,340		255,298	
Volvo Group			3,876		244,933		675,812		173,053	
TOTALS	967,290	0	889,338	0	1,652,231	0	3,160,709	0	1,119,354	0

Manufacturer	MY 2018 Conventional Plus Off-Cycle Credits Generated	MY 2018 Advanced Technology Credits Generated	MY 2019 Conventional Plus Off-Cycle Credits Generated	MY 2019 Advanced Technology Credits Generated	MY 2020 Conventional Plus Off-Cycle Credits Generated	MY 2020 Advanced Technology Credits Generated	TOTAL Conventional Plus Off-Cycle Credits Generated	TOTAL Advanced Technology Credits Generated
Daimler Trucks	611,660		814,937		1,788,050		8,220,298	
Navistar, Inc.	149,142		319,756		406,613		1,564,548	
PACCAR, Inc.	247,785		412,043		843,270		2,499,658	
Volvo Group	173,722		305,251		603,279		2,179,926	
TOTALS	1,182,309	0	1,851,987	0	3,641,212	0	14,464,430	0

View this table at a larger text size by visiting:
https://www.epa.gov/system/files/documents/2022-11/420r22028-report-tables.pdf.

As is allowed under the ABT program, some of these regulatory subcategories display a credit (or compliance) deficit for a given manufacturer and model year. These deficits are summarized in the appropriate averaging set regardless of the regulatory subcategory in which they were produced. A manufacturer's compliance determination is made at each averaging set. For example, the credit deficits generated by each manufacturer in the Class 8 Mid-Roof Sleeper Cabs subcategory (Table 6-8) can be offset by the positive credits generated in the Class 8 High-Roof Sleeper Cabs subcategory (Table 6-9) or any other HHD vehicle subcategory. Taking this one step farther, the credits generated in each averaging set in the tractor sector will also get combined with the respective averaging set credits generated in the vocational vehicle sector in the subsequent section of this report.

Table 7 combines all the credits generated in the individual tractor subcategories from Tables 6-1 through 6-9 into their appropriate averaging sets. As previously described, conventional and off-cycle credits are considered similar based on the restriction of applicability only within the averaging set in which they were generated, so they are combined in Table 7. AT credits have much more flexibility in their use and are kept separate in Table 7, summarizing all tractors through model year 2020. This table shows that PACCAR created a credit deficit in the MHD averaging set in the tractor sector during multiple model years. As the next section will show, PACCAR is still compliant for these model years in the MHD vehicle averaging set because these credits still need to be combined with those generated in the vocational vehicle sector for each averaging set (again compliance to the standards is done on the averaging set level for all vehicles produced in that averaging set). The other three manufacturers show compliance to the tractor GHG regulations for each model year based on the positive credit generation in each tractor averaging set.

Table 7. All Heavy-Duty Tractors: GHG Credits (Mg CO2) Generated Summary – Model Years 2013-20.

Manufacturer	MY 2013 MHD Conventional Plus Off-Cycle Credits Generated	MY 2013 HHD Conventional Plus Off-Cycle Credits Generated	MY 2013 Advanced Technology Credits Generated	MY 2014 MHD Conventional Plus Off-Cycle Credits Generated	MY 2014 HHD Conventional Plus Off-Cycle Credits Generated	MY 2014 Advanced Technology Credits Generated	MY 2015 MHD Conventional Plus Off-Cycle Credits Generated	MY 2015 HHD Conventional Plus Off-Cycle Credits Generated	MY 2015 Advanced Technology Credits Generated	MY 2016 MHD Conventional Plus Off-Cycle Credits Generated	MY 2016 HHD Conventional Plus Off-Cycle Credits Generated	MY 2016 Advanced Technology Credits Generated	MY 2017 MHD Conventional Plus Off-Cycle Credits Generated	MY 2017 HHD Conventional Plus Off-Cycle Credits Generated	MY 2017 Advanced Technology Credits Generated
Daimler Trucks	41,927	1,065,999		61,383	1,174,142		49,870	1,252,272		62,523	2,178,860		38,728	944,400	
Navistar, Inc.	2,806	209,594					7,021	449,996		16,091	487,643		11,789	253,446	
PACCAR, Inc.				23	-4,885		405	10,042		-382	397,917		-3,182	299,416	
Volvo Group					34,829			426,747			1,081,938			459,823	
TOTALS	44,733	1,275,593	0	61,406	1,204,086	0	57,296	2,139,057	0	78,232	4,146,358	0	47,335	1,957,085	0

Manufacturer	MY 2018 MHD Conventional Plus Off-Cycle Credits Generated	MY 2018 HHD Conventional Plus Off-Cycle Credits Generated	MY 2018 Advanced Technology Credits Generated	MY 2019 MHD Conventional Plus Off-Cycle Credits Generated	MY 2019 HHD Conventional Plus Off-Cycle Credits Generated	MY 2019 Advanced Technology Credits Generated	MY 2020 MHD Conventional Plus Off-Cycle Credits Generated	MY 2020 HHD Conventional Plus Off-Cycle Credits Generated	MY 2020 Advanced Technology Credits Generated	TOTAL MHD Conventional Plus Off-Cycle Credits Generated	TOTAL HHD Conventional Plus Off-Cycle Credits Generated	TOTAL Advanced Technology Credits Generated
Daimler Trucks	66,919	1,036,547		76,400	1,382,611		85,762	2,781,131		483,512	11,813,962	
Navistar, Inc.	6,227	304,548		22,053	565,731		47,802	879,437		113,769	3,130,395	
PACCAR, Inc.	-1,882	347,774		-2,578	428,408		-518	831,186	9,547	-8,114	2,307,838	9,547
Volvo Group		452,807			651,571			1,234,873	14,270		4,342,588	14,270
TOTALS	71,264	2,141,676	0	95,875	3,026,321	0	133,046	5,726,627	23,817	589,187	21,616,883	23,817

View this table at a larger text size by visiting:
https://www.epa.gov/system/files/documents/2022-11/420r22028-report-tables.pdf.

Table 8 presents the banked credit balances for each tractor manufacturer in each of the two applicable averaging sets at the conclusion of Phase 1 or model year 2020. Similar to Table 4 for vocational vehicles, Table 8 for tractors was generated by adding the credits generated from each model year in each averaging set for model years 2013 through 2020 while removing the unused expired credits generated in model year 2013-15. There was not a credit life extension provision similar to vocational vehicles in the tractor sector unless the manufacturer qualified as a small manufacturer meeting the small business criteria. All banked tractor credits in the table below expire after a 5-year life. Appendix A at the end of this report presents a more detailed breakdown of each of these credit calculations for each model year that resulted in a change of these banked credits. In addition, Appendix B contains links to spreadsheets for each manufacturer participating in the ABT program that details all credit activity related to the generated credits for each model year to date. These detailed spreadsheets

summarize any credit activity involving such transactions as credit trades, expired credits, corrections/adjustments, etc. and the subsequent number of banked credits available for future use. In summary, there are no CO_2 deficits in any tractor averaging set in Table 8, thus showing full compliance to the Phase 1 GHG tractor vehicle regulations for each manufacturer participating in the ABT program through the conclusion of the Phase 1 program (model year 2020).

Table 8. All Heavy-Duty Tractors: GHG Credits (Mg CO2)
Banked Summary – Through Model Year 2020.

	MHD	HHD	
	Conventional Plus Off-Cycle	Conventional Plus Off-Cycle	Advanced Technology
Manufacturer	Credit Balance	Credit Balance	Credit Balance
Daimler Trucks	330,332	8,323,549	
Navistar, Inc.	103,962	2,490,805	
PACCAR, Inc.	0	2,302,701	9,547
Volvo Group		3,881,012	14,270
TOTALS	434,294	16,998,067	23,817

View this table at a larger text size by visiting:
https://www.epa.gov/system/files/documents/2022-11/420r22028-report-tables.pdf.

d. Heavy-Duty Vehicle Compliance Summary

Table 9 presents a comprehensive summary of credits earned in model years 2013-20 in each of the three heavy-duty vehicle averaging sets that can be carried over to subsequent model years for use. This table was generated by adding the credits earned in each averaging set in the vocational vehicle sector (Table 3) to those earned in the tractor sector (Table 7) for each model year. AT credits are again tracked separately due to their flexibility of use in future model years. It is at the averaging set level that any deficits need to be offset by using previous model year credits. If no positive credits are available from the previous model years in the appropriate averaging set, a manufacturer must reconcile any deficit within three model years from the model year in which the deficit was generated as described in Part 1037.745.

Table 9. Heavy-Duty Vehicles Averaging Set Summary: GHG Credits (Mg CO2) Generated Summary – Model Years 2013-20.

View this table at a larger text size by visiting:
https://www.epa.gov/system/files/documents/2022-11/420r22028-report-tables.pdf.

Based on the positive credit totals for each manufacturer in each of the averaging sets for each model year, compliance to the Phase 1 GHG regulations for the entire heavy-duty vehicle industry occurred. If a deficit credit situation had appeared in any averaging sets in Table 9, this deficit would need to be remedied first with any banked credits carried forward from previous model years or within the next three model years in order to show compliance with the Phase I GHG program.

Table 10 presents the banked credit balances for each manufacturer in the three heavy-duty vehicle averaging sets after the conclusion of model year 2020. All the manufacturers participating in the ABT program carry positive credit balances in all the averaging sets at the conclusion of model year 2020 thus showing all manufacturers are compliant with the Phase 1 GHG heavy-duty vehicle standards through the entirety of the Phase 1 program (model years 2014-2020). The banked credit totals in this table fully carry forward into the Phase 2 program with no reductions. The LHD averaging set banked credit values have also been adjusted for an increased useful life of 150,000 miles. For a more detailed analysis on how these banked credit values were determined, please review the spreadsheets in Appendix B that summarize all credit activities for each manufacturer individually from model years 2013-20.

Table 10. Heavy-Duty Vehicles Averaging Set Summary: GHG Credits (Mg CO2) Banked Summary – Through Model Year 2020.

Manufacturer	LHD Conventional Plus Off-Cycle Credit Balance	MHD Conventional Plus Off-Cycle Credit Balance	HHD Conventional Plus Off-Cycle Credit Balance	Advanced Technology Credit Balance
Autocar		1800	422,398	
Blue Bird Body		288,215	121,646	235,397
Chanje				6,679
Chrysler Group	119,629			
Daimler Coaches			179	
Daimler Trucks		1,495,332	10,716,358	
E-One			29,333	
El Dorado			29,776	
EVO Bus			2,799	
Ferrara Fire			3,893	
Ford Motor	527,410	520,530	11,157	
General Motors	15,372	7,010		
Gillig LLC		179	146,898	4,131
Hino Manufacturing		6,262	10	
Hino Motors	5,395	21,704	1,491	
Isuzu Motors	401,940	22,955		
Kovatch Mobile			16,072	
Mitsubishi Fuso	10,670			9,618
Motor Coach Ind.			141,723	2,046
Navistar, Inc.	1,236	1,055,268	3,254,376	0
New Flyer		410	164,840	448,463
Oshkosh			97,112	
PACCAR, Inc.	484	256,035	5,092,089	14,293
Rosenbauer Motors			4,365	
Spartan Fire			6,049	
Terex Corporation			20,103	
Tiffin Motor Homes		0	0	
Van Hool			114,680	1,013
Volvo Group		3,063	5,514,057	19,506
XOS Trucks		21		3,465
TOTALS	**1,082,136**	**3,678,784**	**25,911,404**	**744,611**

View this table at a larger text size by visiting:
https://www.epa.gov/system/files/documents/2022-11/420r22028-report-tables.pdf.

4. Model Year 2020 Heavy-Duty Compression Ignition (CI) Engine Compliance

The new GHG requirements in the heavy-duty compression ignition (CI) engine sector are very similar to those already discussed in the heavy-duty vehicle sector.   Model year 2014 was also the first mandatory year for certifying heavy-duty CI engines to GHG standards. Manufacturers could also voluntarily participate in a GHG ABT program which required them to submit the same two reports as the vehicle manufacturers listed in Table 10. The ABT report submitted by the engine manufacturers would allow the determination of credits generated in each averaging set as well as determining the intended application of each engine as equipped in either a vocational vehicle or a tractor.   If a manufacturer chose not to participate in the ABT program, they were still required to provide an end-of-year production volume report down to individual engine serial number. Of the ten on-highway CI engine manufacturers certifying their products with EPA during model years 2013-2020, two manufacturers chose not to participate in the GHG ABT program (Hino Motors and General Motors). This means that each of their engine products had GHG performance at, or below, the applicable fleet average standard for the regulatory category, and hence, all of their products are compliant with the applicable model year GHG standards without the use of the ABT provisions.

Equation 2 is used to calculate CO_2 credits in each engine averaging set in the subsequent tables:

Eq. 2: Engine Credit Calculation

CO_2 credits (Mg) = (Std-FCL) X (CF) X (Volume) X (UL) X (10^-6)

Where:

STD = the emission standard in g/hp-hr

FCL = the family compliance limit for the engine family in g/hp-hr measured over the transient test cycle for vocational engines or the RMC for tractor engines rounded to the same decimal places as the emission standard

CF = a transient cycle conversion factor (hp-hr/mile) calculated by dividing the total (integrated) horsepower-hours over the duty cycle (average of either vocational or tractor engine configurations weighted by their production volumes) by 6.5 miles for compression ignition engines. This represents the average work performed by the vocational/tractor engine in the family over the mileage represented by operation over the appropriate duty cycle.

Volume = the number of engines eligible to participate in the ABT program with the given engine family during the model year.

UL = useful life for the given engine family in miles (110,000 miles for light heavy-duty engines, 185,000 for medium heavy-duty engines, and 435,000 for heavy heavy-duty engines). Similar to HD vehicles, beginning with model year 2021, the useful life for light heavy-duty engines has also been changed to 150,000 miles. The credits presented in this report were calculated using

the original value of 110,000 mile applicable for Phase 1 and were adjusted at the conclusion of model year 2020 for carry over into Phase 2 (discussed further below).

Table 11 presents the applicable CO_2 emissions standards for heavy-duty CI engines applicable for model years 2014-2020. The standards are presented for five regulatory subcategories which are:

1. Light Heavy-Duty (LHD) Total (there is not a LHD tractor classification, so vocational application represents the total in the LHD averaging set)
2. Medium Heavy-Duty (MHD) with Vocational Application
3. Medium Heavy-Duty (MHD) with Tractor Application
4. Heavy Heavy-Duty (HHD) with Vocational Application
5. Heavy Heavy-Duty (HHD) with Tractor Application

Table 11. Heavy-Duty Engine GHG Emissions Standards for Model Years 2014-20.

	Model Years 2014-16			Model Years 2017-20		
	LHD CI	MHD CI	HHD CI	LHD CI	MHD CI	HHD CI
GHG Emissions Standards - Vocationals						
Carbon Dioxide CO2	600	600	567	576	576	555
Nitrous Oxide N2O	0.10	0.10	0.10	0.10	0.10	0.10
Methane CH4	0.10	0.10	0.10	0.10	0.10	0.10
Test Cycle Required for CO2 (FTP or RMC)	FTP	FTP	FTP	FTP	FTP	FTP
GHG Emissions Standards - Tractors						
Carbon Dioxide CO2	N/A	502	475	N/A	487	460
Nitrous Oxide N2O	N/A	0.10	0.10	N/A	0.10	0.10
Methane CH4	N/A	0.10	0.10	N/A	0.10	0.10
Test Cycle Required for CO2 (FTP or RMC)	N/A	RMC	RMC	N/A	RMC	RMC
Other Relevant Info						
Vehicle Class	Class 2b-5	Class 6-7	Class 8	Class 2b-5	Class 6-7	Class 8
GVWR (lbs)	Less than 19,501	19,501 - 33,000	Greater than 33,000	Less than 19,501	19,501 - 33,000	Greater than 33,000
Useful Life (miles)	110,000*	185,000	435,000	110,000*	185,000	435,000

Test Cycle Required for N2O and CH4 measurement is always FTP regardless of vocational or tractor application
* Useful Life for LHD Engines Changed to 150,000 Starting in Model Year 2021

View this table at a larger text size by visiting:
https://www.epa.gov/system/files/documents/2022-11/420r22028-report-tables.pdf.

Similar to the heavy-duty vehicle sector, engines with an agency-approved off-cycle technology receive an additional credit multiplier for each engine equipped with the technology.[5] These off-cycle credits are similar to CO_2 credits generated by conventional engines in that they can only be used within the averaging set in which they were generated. These off-cycle credits are calculated separately from conventional credits and are determined by the incremental GHG benefit the technology contributes beyond the FCL established for that engine using the engine dynamometer certification testing procedure. Since these off-cycle credits are similar to conventional credits in how they can be used, they are presented together in this report for each regulatory subcategory of CI engines. Both conventional and off-cycle credits have a 5-year life similar to the vehicle sector which means that they have to be used within five model years after the one in which they were generated, or they will expire. There were no off-cycle credits generated by any heavy-duty CI engine manufacturer during the entirety of the Phase 1 program (model years 2013 through 2020), so the credit values presented in the following tables were "conventional only" for every model year.

---

[5] See 40 CFR 1036.610

Similar to the provision described in the heavy-duty vehicle sector, AT credits can also be generated in the heavy-duty engine sector in the Phase 1 program only. A manufacturer can generate AT credits for hybrid powertrains that include energy storage systems and regenerative braking (including regenerative engine braking) and for engines that include Rankine-cycle (or other bottoming cycle) exhaust energy recovery systems. There were no engines certified that generated AT credits in the entirety of the Phase 1 program (model years 2013 through 2020), so the tables displaying engine credit information will not contain columns for those credits as they are all zero. The Phase 2 program beginning with model year 2021 no longer allows engine certifiers to generate AT credits. The generation of off-cycle credits remains an option for manufacturers carrying over into Phase 2.

Tables 12-1 through 12-3 summarize the model year 2013-2020 credits generated for each manufacturer in the heavy-duty CI engine sector that certified using an engine dynamometer. Heavy-duty engines installed in chassis certified vehicles are not included in this report. The credits produced in each averaging set (LHD, MHD, and HHD) are presented separately as well as being further broken down by the intended application of the engine as either tractor or vocational (again all LHD engines are considered vocational only engines, so no tractor engine credits are applicable). Although spark ignited (SI) engines are a separate averaging set in the heavy-duty sector, these engines are not included in this report. There were also no off-cycle or advanced technology credits generated to date, so only conventional engine credits are presented in the following tables. As was the case before, a blank cell in any column means that the manufacturer did not produce any engines in that regulatory subcategory for each model year.

Table 12-1. LHD CI Engine Averaging Set: GHG Credits (Mg CO2) Generated Summary – Model Years 2013-20.

Manufacturer	MY 2013 Vocational Engine Credits Generated Net CO2	MY2014 Vocational Engine Credits Generated Net CO2	MY 2015 Vocational Engine Credits Generated Net CO2	MY2016 Vocational Engine Credits Generated Net CO2	MY2017 Vocational Engine Credits Generated Net CO2
Cummins Inc.					
Detroit Diesel					
Ford Motor		252,236	217,062	161,215	11,289
FPT Powertrain		1,215		6,492	-456
Isuzu Motors			56,886	54,534	
Navistar, Inc.		-681			
PACCAR, Inc.					
Volvo Group					
TOTALS	**0**	**252,770**	**273,948**	**222,241**	**10,833**

Manufacturer	MY2018 Vocational Engine Credits Generated Net CO2	MY2019 Vocational Engine Credits Generated Net CO2	MY2020 Vocational Engine Credits Generated Net CO2	TOTAL Vocational Engine Credits Generated Net CO2
Cummins Inc.				
Detroit Diesel				
Ford Motor	9,003	22,124	359,461	1,032,390
FPT Powertrain				7,251
Isuzu Motors		8,983	4,599	125,002
Navistar, Inc.		28,161	35,577	63,057
PACCAR, Inc.				
Volvo Group				
TOTALS	**9,003**	**59,268**	**399,637**	**1,227,700**

View this table at a larger text size by visiting:
https://www.epa.gov/system/files/documents/2022-11/420r22028-report-tables.pdf.

Table 12-2. MHD CI Engine Averaging Set: GHG Credits (Mg CO2) Generated Summary – Model Years 2013-20.

	MY 2013		MY2014		MY 2015		MY2016		MY2017	
	Vocational Engine Credits Generated Net CO2	Tractor Engine Credits Generated Net CO2	Vocational Engine Credits Generated Net CO2	Tractor Engine Credits Generated Net CO2	Vocational Engine Credits Generated Net CO2	Tractor Engine Credits Generated Net CO2	Vocational Engine Credits Generated Net CO2	Tractor Engine Credits Generated Net CO2	Vocational Engine Credits Generated Net CO2	Tractor Engine Credits Generated Net CO2
Manufacturer										
Cummins Inc.	2,431,980	36,721	3,410,912	43,789	4,133,398	15,849	759,201	-11,977	2,317,429	-4,467
Detroit Diesel									19,499	
Ford Motor							26,165	-1,694	16,742	-1,034
FPT Powertrain										
Isuzu Motors										
Navistar, Inc.			-6,211	-1,048	83,030	-50	70,179	-167	1,752	
PACCAR, Inc.										
Volvo Group										
TOTALS	2,431,980	36,721	3,404,701	42,741	4,216,428	15,799	855,545	-13,838	2,355,422	-5,501

	MY2018		MY2019		MY2020		TOTAL	
	Vocational Engine Credits Generated Net CO2	Tractor Engine Credits Generated Net CO2	Vocational Engine Credits Generated Net CO2	Tractor Engine Credits Generated Net CO2	Vocational Engine Credits Generated Net CO2	Tractor Engine Credits Generated Net CO2	Vocational Engine Credits Generated Net CO2	Tractor Engine Credits Generated Net CO2
Manufacturer								
Cummins Inc.	2,045,886	9,008	2,120,459	-12,265	1,962,551	-12,431	19,181,816	64,227
Detroit Diesel	55,375	-698	268,453	1,481	41,808	278	385,135	1,061
Ford Motor	17,924		36,783		71,427		169,041	-2,728
FPT Powertrain					0			
Isuzu Motors								
Navistar, Inc.							148,750	-1,265
PACCAR, Inc.								
Volvo Group								
TOTALS	2,119,185	8,310	2,425,695	-10,784	2,075,786	-12,153	19,884,742	61,295

View this table at a larger text size by visiting:
https://www.epa.gov/system/files/documents/2022-11/420r22028-report-tables.pdf.

Table 12-3. HHD CI Engine Averaging Set: GHG Credits (Mg CO2) Generated Summary – Model Years 2013-20.

	MY 2013		MY2014		MY 2015		MY2016		MY2017	
	Vocational Engine Credits Generated Net CO2	Tractor Engine Credits Generated Net CO2	Vocational Engine Credits Generated Net CO2	Tractor Engine Credits Generated Net CO2	Vocational Engine Credits Generated Net CO2	Tractor Engine Credits Generated Net CO2	Vocational Engine Credits Generated Net CO2	Tractor Engine Credits Generated Net CO2	Vocational Engine Credits Generated Net CO2	Tractor Engine Credits Generated Net CO2
Manufacturer										
Cummins Inc.	452,659	2,354,276	502,112	3,160,240	441,967	1,639,452	-531,266	-874,489	581,624	-308,689
Detroit Diesel	447,299	1,231,159	612,654	2,041,851	685,880	2,312,587	492,178	512,697	788,844	395,642
Ford Motor										
FPT Powertrain										
Isuzu Motors										
Navistar, Inc.			130,740	-53,184	158,828	4,234	110,497	5,619	53,616	3,014
PACCAR, Inc.			326,065	34,426	537,598	67,663	718,430	71,794	730,166	33,112
Volvo Group			409,923	834,350	1,176,895	610,293	399,166	467,712	682,271	-438,947
TOTALS	899,958	3,585,435	1,981,494	6,017,683	3,001,168	4,634,229	1,189,005	183,333	2,836,521	-315,868

	MY2018		MY2019		MY2020		TOTAL	
	Vocational Engine Credits Generated Net CO2	Tractor Engine Credits Generated Net CO2	Vocational Engine Credits Generated Net CO2	Tractor Engine Credits Generated Net CO2	Vocational Engine Credits Generated Net CO2	Tractor Engine Credits Generated Net CO2	Vocational Engine Credits Generated Net CO2	Tractor Engine Credits Generated Net CO2
Manufacturer								
Cummins Inc.	108,061	75,513	899,669	77,690	747,117	250,436	3,201,943	6,374,429
Detroit Diesel	891,787	743,510	1,041,857	768,702	-122,071	-71,985	4,838,428	7,934,163
Ford Motor								
FPT Powertrain								
Isuzu Motors								
Navistar, Inc.	113,836	58,919	237,206	62,769	158,145	37,718	962,868	119,089
PACCAR, Inc.	875,172	47,235	1,175,446	275,695	266,169	-209,767	4,629,046	320,158
Volvo Group	604,416	-202,446	794,938	-195,230	5,477	-167,529	4,073,086	908,203
TOTALS	2,593,272	722,731	4,149,116	989,626	1,054,837	-161,127	17,705,371	15,656,042

View this table at a larger text size by visiting:
https://www.epa.gov/system/files/documents/2022-11/420r22028-report-tables.pdf.

One significant difference between the heavy-duty vehicle and heavy-duty engine regulatory programs is that CO_2 is not the only GHG pollutant for which a heavy-duty manufacturer is required to meet a

standard for certification (as viewed in Table 11). Nitrous oxide (N_2O) and methane (CH_4) are also regulated constituents in the heavy-duty engine program. N_2O and CH_4 credit deficits for one engine family must be offset by CO_2 credits generated by the same or another family within the same averaging set. Any credit deficit from N_2O or CH_4 is converted into an equivalent CO_2 value using the Global Warming Potential (GWP) value for either pollutant. N_2O has a GWP value of 298, meaning that a 1 Mg N_2O deficit needs to be offset by 298 Mg of CO_2 credits. Similarly, the GWP value for CH_4 in Phase 1 is 25 (this value changes to 34 beginning in model year 2021), and these deficits also need to be offset by equivalent CO_2 credits. One additional regulatory option from previous model years was the possibility of generating additional CO_2 credits when certifying to N_2O levels below 0.04 g/hp-hr during model years 2014-2016 only. Beginning in model year 2017, CO_2 credits could no longer be generated from N_2O for compliance. However, any N_2O deficits generated must be offset using CO_2 credits in 2017 and future years. CH_4 has no option for generating credits. Similar to N_2O, CH_4 deficits may be offset with equivalent CO_2 credits. The credit values presented in Table 12 are "Net CO_2" credits which means that any N_2O and CH_4 deficits have already been accounted for in the credit calculations. Again, there were no off-cycle or AT credits generated for any engine manufacturer in model years 2013 through 2020.

In certain instances, presented in Tables 12-1 through 12-3, a manufacturer demonstrated a deficit in either the tractor or vocational engine regulatory category as allowed under the program. These deficits would first be offset using any available credits generated in either the vocational or tractor category within the same model year. If the available credits were not enough to offset the deficit, banked credits from a previous model year would need to be used.

Table 13 summarizes the credits generated in model years 2013-20 for each manufacturer in each of the averaging set. Note that the regulations regarding ABT credit generation do not differentiate between tractor or vocational vehicle application. Table 13 was generated by summing vocational and tractor credits generated from each individual model year in each averaging set for model years 2013 through 2020. There were a few cases in which a manufacturer generated a deficit in an averaging set. In each of these cases, the deficit was offset by using banked credits from a previous model year. One example of note is that of the deficits in both the LHD and MHD engine averaging sets generated in model year 2014 by Navistar. As presented in the table, there were no credits available to Navistar to offset these deficits at the time. In this case Navistar demonstrated compliance by using advanced technology credits generated in model year 2014 from the heavy-duty vehicle sector (specifically LHD category) to offset both of these deficits. In the other cases where a manufacturer ran a deficit (Cummins and FPT Powertrain for instance), these deficits were offset by just using banked engine credits available to them from a previous model year.

Another note for Table 13 below is that three manufacturers (Detroit Diesel, PACCAR, and Volvo Group) chose to certify their model year 2020 engine products using the interim provision provided in the Phase 2 rulemaking (Part 1036.150(p)). The use of this optional interim provision required the certification of model year 2020 MHD and HHD engines to the more stringent model year 2021 Phase 2 standards early in exchange for an extended credit life. Specifically, manufacturers that chose this option will have their banked credits in the MHD and HHD engine averaging sets from model years 2018 and beyond available for compliance use through model year 2030 (no expiration in 5 years). This interim provision was not available for engines in the LHD averaging set. The use of this interim provision resulted in both Detroit Diesel and Volvo Group generating a HHD engine credit deficit in model year 2020 which was offset by using banked credits from a previous year. However, the credit balances now available from model years 2018 and beyond will not expire in 5 years and will be available for use in any model year through 2030.

Table 13. All Heavy-Duty CI Engines - Averaging Set Summary: GHG Credits (Mg CO2) Generated Summary – Model Years 2013-20.

Manufacturer	MY 2013 LHD Credits Generated Net CO2	MY 2013 MHD Credits Generated Net CO2	MY 2013 HHD Credits Generated Net CO2	MY2014 LHD Credits Generated Net CO2	MY2014 MHD Credits Generated Net CO2	MY2014 HHD Credits Generated Net CO2	MY 2015 LHD Credits Generated Net CO2	MY 2015 MHD Credits Generated Net CO2	MY 2015 HHD Credits Generated Net CO2	MY2016 LHD Credits Generated Net CO2	MY2016 MHD Credits Generated Net CO2	MY2016 HHD Credits Generated Net CO2	MY2017 LHD Credits Generated Net CO2	MY2017 MHD Credits Generated Net CO2	MY2017 HHD Credits Generated Net CO2
Cummins Inc.		2,468,701	2,806,935		3,454,701	3,662,352		4,149,247	2,081,419		747,224	-1,405,755		2,312,962	272,935
Detroit Diesel			1,678,458			2,654,505			2,998,467			1,004,875		19,489	1,184,486
Ford Motor				252,236			217,062			161,215	24,471		11,289	13,708	
FPT Powertrain				1,215						6,492			-456		
Isuzu Motors							56,886			54,534					
Navistar, Inc.				-681	-7,259	77,556		82,980	163,062		70,012	116,116		1,752	56,630
PACCAR, Inc.						360,491			605,261			790,234			783,278
Volvo Group						1,244,273			1,787,188			866,878			243,324
TOTALS	0	2,468,701	4,485,393	252,770	3,447,442	7,999,177	273,948	4,232,227	7,635,397	222,241	841,707	1,372,338	10,833	2,349,921	2,520,653

Manufacturer	MY2018 LHD Credits Generated Net CO2	MY2018 MHD Credits Generated Net CO2	MY2018 HHD Credits Generated Net CO2	MY2019 LHD Credits Generated Net CO2	MY2019 MHD Credits Generated Net CO2	MY2019 HHD Credits Generated Net CO2	MY2020 LHD Credits Generated Net CO2	MY2020 MHD Credits Generated Net CO2	MY2020 HHD Credits Generated Net CO2	TOTAL LHD Credits Generated Net CO2	TOTAL MHD Credits Generated Net CO2	TOTAL HHD Credits Generated Net CO2
Cummins Inc.		2,054,894	183,574		2,108,194	977,359		1,950,120	997,553		19,246,043	9,576,372
Detroit Diesel		54,677	1,635,297		269,934	1,810,559		42,086	-194,056		386,196	12,772,591
Ford Motor	9,003	17,924		22,124	36,783		359,461	71,427		1,032,390	166,313	
FPT Powertrain				8,983						7,251	0	
Isuzu Motors							4,599		0	125,002		0
Navistar, Inc.			172,755	28,161		299,975	35,577		195,863	63,057	147,485	1,081,957
PACCAR, Inc.			922,407			1,451,141			56,402			4,949,204
Volvo Group			401,970			599,708			-162,052			4,981,289
TOTALS	9,003	2,127,495	3,316,003	59,268	2,414,911	5,138,742	399,637	2,063,633	893,710	1,227,700	19,946,037	33,361,413

View this table at a larger text size by visiting:
https://www.epa.gov/system/files/documents/2022-11/420r22028-report-tables.pdf.

Appendix A at the end of this report presents a more detailed list of credit activities (e.g., error corrections) plus other notes effecting credit generation and use for each model year that resulted in a change of any banked credits. In addition, Appendix B contains links to spreadsheets for each manufacturer participating in the ABT program that details any credit activity to the generated credits presented in the tables above for each model year to date. These detailed spreadsheets summarize all credit activity involving such transactions as credit trades, expired credits, error corrections, etc. and the subsequent number of banked credits available for future use.

Table 14 presents the cumulative credit balances (banked credits) for each engine manufacturer in each of the three averaging sets at the conclusion of model year 2020. There are no deficits in any averaging set of Table 14 showing that all manufacturers were able to comply with the GHG heavy-duty CI engine standards for the entirety of the Phase 1 program (model years 2014 through 2020). All engine manufacturers have positive credit balances for use in compliance to the GHG standards for future model years of the Phase 2 program.

In addition to the optional early certification provision to the Phase 2 standards described above, there were two other provisions in the Phase 2 rulemaking that affected credit balance values presented in Table 14 below. Similar as the vehicle ABT program, all banked engine credits in the LHD averaging set were multiplied by a value of 1.36 for the increased useful life provision for these engines increasing from 110,000 to 150,000 miles. The other provision affecting banked engine credits in the table below was the limitation of vocational engine credits carrying into the Phase 2 program starting in model year 2021 as described in Part 1036.701(j). Vocational engine banked credits (tractor engine credits carried through fully into Phase 2) were reduced for only those generated in the MHD and HHD averaging sets using the standards provided in Part 1036.701(j). The CO_2 standards provided in this section were much more stringent than the original applicable standards and resulted in extensive reductions to the quantity of banked credits carried over into model year 2021 (Phase 2). For a more detailed analysis of this reduction, please see the credit summary spreadsheets in Appendix B which present the magnitude of these reductions for each manufacture in the ABT program.

Table 14. All Heavy-Duty CI Engines – Averaging Set Summary:
GHG Credits (Mg CO2) Banked Summary – Through Model Year 2020.

Manufacturer	LHD Credit Balance Net CO2	MHD Credit Balance Net CO2	HHD Credit Balance Net CO2	Advanced Technology Credit Balance Net CO2
Cummins Inc.		3,338,125	403,639	
Detroit Diesel		259,503	3,243,179	
Ford Motor	765,805	15,759		
FPT Powertrain	8,829			
Isuzu Motors	92,638	0		
Navistar, Inc.	86,684	0	312,984	
PACCAR, Inc.			2,028,708	
Volvo Group			467,712	
TOTALS	**953,956**	**3,613,387**	**6,456,222**	**0**

View this table at a larger text size by visiting:
https://www.epa.gov/system/files/documents/2022-11/420r22028-report-tables.pdf.

5. Conclusions

As indicated previously, the success of the Phase 1 heavy-duty GHG program as documented in the pages of this report has been measured in the industry's ability to create the systems and processes necessary to demonstrate compliance with the program, improve their products to lower their GHG emissions and fuel consumption, as well as to document through submission of reports that the fleet of vehicles they produced complies with the aggregated fleet standards.   It is a significant accomplishment that the entire industry was able to implement and begin complying with this program and has demonstrated through their reporting that GHG emissions have been reduced to such an extent that all manufacturers are compliant and most have created significant credit banks reflecting better overall fleet performance than the agencies originally projected in setting up the program.

This report documents that all manufacturers were not merely compliant for the entirety of the Phase 1 program, but that all manufacturers have generated a positive banked credit balance moving into Phase 2 program in each of the three averaging sets for vehicles. This clearly demonstrates full compliance with the new standards that became mandatory in model year 2014 (summarized in Table 10 Section 3 of this report). EPA expects more manufacturers to participate in the vehicle ABT program beginning in Phase 2 as small manufacturers that qualify as small businesses will no longer be exempt for certification as they were for the entirety of the Phase 1 program. Similarly, all heavy-duty engine manufacturers also show full compliance through model year 2020 with the engine GHG standards (summarized in Table 14 Section 3 of this report).

Appendix A: Credit Activity Overview for Each Model Year

Optional Early Model Year 2013 Heavy-Duty Vehicle and CI Engine Summary

EPA's Phase 1 GHG program allows manufacturers to certify their vehicles to the Phase 1 GHG standards a model year early to earn additional credits. As an incentive, the credits that were generated from early certification are multiplied by X1.5, for the 2013 model year only. Three vehicle manufacturers (Daimler Trucks, Navistar, and PACCAR) chose to utilize this option, generating early credits in model year 2013. The credits generated by these manufacturers in model year 2013 were carried forward to subsequent model years for use. There were no vehicles certified in model year 2013 that generated either IT or AT credits.

One requirement for utilizing this early certification option was that a manufacturer must certify their entire product line within a regulatory subcategory so that they could not just pick the credit generating vehicles/engines within a subcategory for certification. Similarly, as previously described, these credit totals for each regulatory subcategory were then combined at the averaging set level. The only difference at this point regarding early model year 2013 certification is that any averaging set resulting in a credit deficit would be reset to zero as the regulations state that a manufacturer can't generate a deficit if early certifying (Part 1037.150). This was indeed the case involving Navistar vehicles for model year 2013 where their LHD vehicle averaging set resulted in a credit deficit of -1,056 Mg CO_2. This value was reset to zero in the various tables of this report which carried forward to model year 2014.

These credits generated in model year 2013 were then banked for future use through model year 2018. Any model year 2013 credits that were not used to offset any credit deficit generated before or during model year 2018 expired as this represents the extent of their five-year lifetime. The amount of expired credits for each manufacturer can again be viewed in the detailed manufacturer spreadsheets available in Appendix B.

The Phase 1 rule provided the same optional credit earning opportunity for engines as for vehicles by allowing manufacturers to certify a year early (model year 2013) to the mandatory GHG standards starting January 1, 2014 while earning a bonus 1.5X multiplier on any credits earned early in model year 2013. Two heavy-duty engine manufacturers (Cummins and Detroit Diesel) made use of this option and certified their engines in model year 2013. However, both Cummins and Detroit Diesel chose to certify using the Alternate Phase-In option described in 40 CFR § 1036.150, which does not allow for the 1.5X multiplier on model year 2013 generated credits. Similar to vehicles, these banked credits carried forward to offset any credit deficits through model year 2018 at which point they expired. The amount of expired credits for each manufacturer can again be viewed in the detailed manufacturer spreadsheets available in Appendix B.

Model Year 2014 Heavy-Duty Vehicle and CI Engine Summary

Beginning on January 1, 2014, manufacturers were required to certify their heavy-duty vehicles and engines to the Phase 1 GHG standards. The credits generated in model year 2014 could be banked for future use through model year 2019. If not used to offset any credit deficit generated before or during model year 2019, these model year 2014 generated credits will expire as this represents the extent of their five-year lifetime.

Navistar certified AT vehicles in model year 2014, utilizing an interim provision in the regulations (Part 1037.150) that allowed manufacturers to certify electric vehicles produced in model years before 2014 to the 2014 model year GHG standards for AT credit generation. Electric vehicles have a defined FEL of zero for the purpose of computing these AT credits. Using this interim provision, Navistar certified some LHD electric vehicles in model year 2014 that were produced during model years 2010-2012 which generated 8,393 Mg CO_2 of AT credits.

Another point to note is that Navistar pulled ahead their model year 2014 vehicle production start date to better align their engine and vehicle product cycles. Therefore, no ABT information for conventional and off-cycle vehicles is presented for model year 2014. The bulk of the vehicles that they did produce during the model year 2014 timeframe showed up in the model year 2015 data. The only vehicles showing up in this model year data for Navistar are the previously referenced LHD electric vehicles.

Navistar also utilized the alternate CO_2 standard described in 40 CFR § 1036.620 for certifying their LHD engine family. When using this provision, they are not allowed to generate any CO_2 credits to help offset a CH_4 deficit generated within this family. When converted to an equivalent CO_2 basis, the magnitude of this deficit was 681 Mg CO_2 in the LHD averaging set. Navistar also produced a similar CO_2 deficit of 7,259 Mg CO_2 in the MHD engine averaging set this time due to an N_2O deficit. As the spreadsheet available in Appendix B will indicate, Navistar offset these deficits using AT credits earned in the heavy-duty vehicle sector previously described in this appendix. After offsetting these two engine deficits, Navistar was left with a balance of 453 Mg CO_2 of AT credits from the original 8,393 Mg amount generated in the heavy-duty vehicle sector. There were no other credit deficits generated by other manufacturers in any other engine/vehicle averaging set for this model year.

Model Year 2015 Heavy-Duty Vehicle and CI Engine Summary

Beginning on January 1, 2014, manufacturers were required to certify their heavy-duty vehicles and engines to the Phase 1 GHG standards. The credits generated in model year 2015 can be banked for future use through model year 2020. If not used to offset any credit deficit generated before or during model year 2020, these model year 2015 generated credits will expire as this represents the extent of their five-year lifetime.

Tiffin Motor Homes opted to not participate in the heavy-duty vehicle ABT program starting this model year, but their MHD and HHD vocational vehicle ABT credits generated in model year 2014 will remain available to them for use through the 2019 model year.

PACCAR resubmitted their model year 2014 ABT report in order to correct an error that reduced the credits generated in the HHD tractor engine sector by 225 Mg CO_2 for that year. This correction was submitted after EPA finalized the model year 2014 credit values in the spreadsheet found in Appendix B, therefore, this correction is reflected in the subsequent model year 2015 data as can be viewed in the spreadsheet available in Appendix B.

Navistar became the first manufacturer to receive EPA and NHTSA approval on an off-cycle technology and began generating additional credits using this technology in model year 2015. Navistar remains the only manufacture to receive approval on an off-cycle technology during the Phase 1 program.

Also reflected in model year 2015 is that FPT Industrial did not certify any engines this year, Isuzu joined the heavy-duty engine ABT program and New Flyer joined the heavy-duty vehicle ABT program. There were no credit deficits generated in any engine/vehicle averaging set this model year.

Model Year 2016 Heavy-Duty Vehicle and CI Engine Summary

The credits generated in model year 2016 can be banked for future use through model year 2021. If not used to offset any credit deficit generated before or during model year 2021, these model year 2016 generated credits will expire as this represents the extent of their five-year lifetime.

Cummins reported a credit deficit in the HHD engine averaging set of -1,405,755 Mg CO_2 which was offset using banked credits generated from previous model years. There were no other credit deficits generated in any other engine/vehicle averaging set this model year. During model year 2016 Kovatch joined the vehicle ABT program this model year and Ford introduced MHD engine products.

Model Year 2017 Heavy-Duty Vehicle and CI Engine Summary

The credits generated in model year 2017 can be banked for future use through model year 2022. If not used to offset any credit deficit generated before or during model year 2022, these model year 2017 generated credits will expire as this represents the extent of their five-year lifetime.

CO_2 emissions standards became more stringent this model year, as indicated in the standards setting sections of Part 1036 for engines, Part 1037 for vehicles, and in the standards tables provided earlier in this report. The more stringent standards potentially resulted in reduced credit generation for a certain vehicle/engine.

Fiat Powertrain had the sole deficit generated in the engine and vehicle averaging sets, with a magnitude of 456 Mg in the LHD engine averaging set. The deficit was offset using banked credits available from a previous model year.

New Flyer, Gillig, and Chanje generated AT credits during model year 2017. They were the first to do so since Navistar used the interim provision during model year 2014. Additionally, Kovatch and Ford began certifying vocational tractors while Chanje, New Flyer, Van Hool, Kovatch, and Ferrara Fire joined the vehicle ABT program.

Model Year 2018 Heavy-Duty Vehicle and CI Engine Summary

The credits generated in model year 2018 may be banked for future use through model year 2023. If not used to offset any credit deficit generated before or during model year 2023, these model year 2018 generated credits will expire as this represents the extent of their five-year lifetime.

Model year 2018 represented the first model year in which credits earned during the program were expired. Credits earned during model year 2013 expired if not used prior to the completion of model year 2018. The quantity of expired credits are presented in the detailed credit activity spreadsheets for each manufacturer found in Appendix B.

Cummins submitted revised reports during this model year timeframe. The reports reflected increased declared CO_2 values for a single engine tractor family for model years 2013 through 2016. This higher

CO_2 value subsequently resulted in a reduction of the credits generated during these four model years. These credit reductions can also be viewed in the detailed credit summary spreadsheet included in Appendix B.

Model year 2018 was the first year that vehicle manufacturers were able to use pre-approved off-cycle credit generation paths provided in the Phase 2 rulemaking described in Part 1037.150. These pre-approved off-cycle credit generation options do not require prior approval from both EPA and NHTSA and were available to manufacturers as interim provisions allowed for enhanced credit generation starting in model year 2018. Autocar joined the ABT program using the small business provisions of Part 1037.150(y)(3) to begin generating enhanced credits for natural-gas fueled vehicles in model year 2018. These provisions were added in the Phase 2 rulemaking and were optional for manufacturers to use early in the Phase 1 program to generate additional credits before converting to the Phase 2 program starting in model year 2021.

There were no credit deficits generated during model year 2018 in any of the engine or vehicle averaging sets. Two additional manufacturers (Blue Bird and Mitsubishi Fuso) began generating AT credits this year joining New Flyer, Gillig, and Chanje.

Model Year 2019 Heavy-Duty Vehicle and CI Engine Summary

The credits generated in model year 2019 may be banked for future use through model year 2024. If not used to offset any credit deficit generated before or during model year 2023, these model year 2019 generated credits will expire as this represents the extent of their five-year lifetime.

Navistar and Autocar continued as the only vehicle manufacturers to generate off-cycle credits. Bluebird and New Flyer were the only vehicle manufacturers to generate AT credits this model year. Hino Motors, Hino Manufacturing, and Daimler Coaches joined the vehicle ABT program this model year. GM began to certify vehicles again under Part 1037 and participated in the ABT program. Isuzu Motors also rejoined the engine ABT program this model year.

Model Year 2020 Heavy-Duty Vehicle and CI Engine Summary

The credits generated in model year 2020 may be banked for future use through model year 2025. If not used to offset any credit deficit generated before or during model year 2025, these model year 2020 generated credits will expire as this represents the extent of their five-year lifetime. This was also the last model year of the Phase 1 program. The Phase 2 rulemaking provided some additional provisions regarding banked credits carrying over into model year 2021 which represents the first year of the Phase 2 program as described below.

The first of these provisions involved the increase of the LHD engine and vehicle useful life from 110,000 miles to 150,000 miles. As a result, all banked credits in these averaging sets were multiplied by a value of 1.36 and carried into Phase 2. This rulemaking also provided an interim provision for extended credit life for LHD and MHD vocational vehicles generated in model years 2018-2021 for all manufacturers participating in ABT. Such credits are no longer limited to a 5-year credit life and will remain available for compliance use through model year 2027 as described in Part 1037.150(y). This provision was only for vocational vehicles produced during model years 2018-2021, and tractor vehicle credits generated during these same model years remain restricted to the same 5-year credit life limitation as before. An additional provision in the Phase 2 rulemaking also allows small manufacturers meeting the small

business criteria specified in 13 CFR 121.201 to have an extended life for all of their credits generated by both vocational and tractor vehicles. Specifically, all vehicle credits generated during model years 2018-2021 can be used for compliance through model year 2027 by these qualifying small manufacturers. There were only two qualifying small manufacturers that optionally participated in the vehicle ABT program during the entirety of Phase 1 which were Autocar and XOS Trucks.

The engine sector had two other revisions provided by the Phase 2 rulemaking that affected banked credits which could be carried into model year 2021. The first of these was an optional certification path in model year 2020 involving certifying early to the Phase 2 standards in exchange for an extended credit life for only MHD and HHD engines (both vocational and tractor engines). Specifically, if manufacturers optionally chose to certify all of their MHD and HHD engines early in model year 2020 to the 2021 standards, then any banked credits in these two averaging sets from model years 2018-2024 would have an extended credit life for compliance use through model year 2030 as described in Part 1036.150(p). All other banked credits remained limited to the 5-year credit life limitation. Three manufacturers chose this optional path which included Detroit Diesel, PACCAR, and Volvo Group.

The second revision to banked credits which could be carried into model year 2021 involved banked credits associated with MHD and HHD vocational engines. The initial rulemaking did not allow for any of these vocational engine credits generated in Phase 1 to be carried though into Phase 2 (starting with model year 2021). However, the subsequent Technical Amendments to this rule allowed for a limited quantity of banked credits from these engines to be carried forward. Part 1036.701(j) allowed for the adjustment of vocational engine banked credits from Phase 1 to be carried into model year 2021. Specifically, new emissions standards were provided in this part for MHD and HHD vocational engines only that required a recalculation of model year 2016-20 generated credits that were allowed to carry over into Phase 2 (LHD and all tractor credits were unaffected and carried over fully into Phase 2). Those certifying early to the Phase 2 standards as described in the paragraph above were not subjected to a reduction of vocational engine credits for model year 2020 only (model years 2016-19 still resulted in reductions). Appendix B provides a more detailed description as to the magnitude of these reductions for each manufacturer.

Rosenbauer Motors, Spartan Fire, and XOS Trucks were new to the vehicle ABT program this model year. Navistar and Autocar remain the only vehicle manufacturers that produced off-cycle credits during the entirety of the Phase 1 program. Volvo Group and PACCAR became the first tractor manufacturers to generate AT credits this model year. Other vehicle manufacturers generating AT vocational vehicle credits were Bluebird, PACCAR, XOS Trucks, Motorcoach Industries, New Flyer, Van Hool, and Volvo Group.

Both Detroit Diesel and Volvo Group generated a credit deficit in the HHD engine averaging set which was offset by using banked credits from a previous year. Hino Motors did not certify any engines this model year. Isuzu Motors certified engines in the MHD averaging set for the first time, however, these engines were certified at the standard and thus did not generate any credits.

Appendix B: Individual Manufacturer Detailed Credit Summaries

Readers of this report should use the following link to obtain the credit summary for each participating manufacturer: (https://nepis.epa.gov/Exe/ZyPDF.cgi/P1016962.PDF?Dockey=P1016962.PDF).

Each summary includes, for each model year of participation the current balance of banked credits in each of the vehicle and engine averaging sets presented in this report. There are two tabs to each spreadsheet, one being for heavy-duty engines and the other for vehicles. These spreadsheets are also sent to each manufacturer participating in the ABT program that determines their current credit status with EPA. NHTSA uses a separate credit tracking system for their credit program and provides separate summaries to each manufacturer.