
Phase 1 EPA Heavy-Duty Vehicle and Engine Greenhouse Gas Emissions Compliance Report (Model Years 2014-18)

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

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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. 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 CO₂ 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 just certify all 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 CO₂ credit situation after the first six years of

certification (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 programs¹.

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 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 are not merely compliant, but that all manufacturers have generated a positive banked credit balance through model year 2018 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). Similarly, all heavy-duty engine manufacturers also show full compliance through model year 2018 with the engine GHG standards (summarized in Table 14 Section 3 of this report).

The Phase 2 Heavy-Duty Vehicle and Engine Greenhouse Gas Rule was adopted in 2016 and began implementation in 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.² 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.

¹ The reporting deadline for the 2019 compliance year is xxx and had not passed when this report was drafted. EPA will report out on subsequent compliance years in a future report.

² Federal Register "Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles; Final Rule" dated September 15, 2011

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) program in which CO₂ 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. 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 CO₂ emissions. The CO₂ emissions calculation performed by GEM required input parameters for each vehicle, provided to the GEM model by the manufacturer. The calculated CO₂ value was then compared to the corresponding CO₂ 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)

CO₂ 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 CO₂ 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 CO₂ 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. CO₂ and other pollutants are directly measured on these cycles for certification purposes. The measured CO₂ 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: N₂O (nitrous oxide), and CH₄ (methane). The measured emissions levels of N₂O and CH₄ 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 (CO₂, N₂O, and CH₄) over two specific operating cycles: the transient Federal Test Procedure (FTP), and the steady-state Ramped Modal Cycle (RMC). The CO₂ 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 CO₂ emissions level measured over the RMC cycle is compared to the standard to determine compliance. N₂O and CH₄ emissions levels are only measured over the FTP cycle and compared to the applicable standard for each. CO₂ 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)³

Similar to vehicles, there are different CO₂ 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.⁴ The standards for N₂O and CH₄ are the same for all heavy-duty CI engines regardless of averaging set or intended application.⁵ Any credits or deficits generated by N₂O and CH₄ are converted into equivalent CO₂ values by using specified conversion factors and included in the "Net" CO₂ 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 CO₂ 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 CO₂ 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 CO₂ emissions, but for which the benefits are not accounted for when using the GEM

³ The engines produced in the Heavy-Duty SI averaging set are not included in this report

⁴ See 40 CFR 1036 Subpart B.

⁵ See 40 CFR 1036 Subpart B.

model (for vehicles) or not captured on the FTP and/or RMC test procedures (for engines). These off-cycle credits are in addition to those credits being generated by CO₂ 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 2018 Heavy-Duty Vehicle Compliance

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 CO₂ 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 2018 the following twelve manufacturers chose not to participate in the ABT program instead choosing to produce all of their vehicles with emissions at or below the applicable averaging set standards: Alexander Dennis, An Yuan Bus, ARBOC Specialty, BYD Auto, CHTC USA, Dennis Eagle, Green Power Motor, Hino Motors Limited, Hino Motors Manufacturing, Irizar Sociedad, Lion Bus, and XOS Trucks. Again, the ABT program is voluntary, and the manufacturers that chose not to participate in model years 2014 through 2018 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, as all manufacturers are required to submit.

a. Heavy-Duty Vocational Vehicles

Table 1 presents the applicable CO₂ 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 2013-18 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)	CO ₂ (g/ton-mile) MY 2014-16	CO ₂ (g/ton-mile) MY 2017-20	Payload (tons)	Useful Life	Roof Height (inches)
Vocational Vehicles						
LHD Class 2b-5	8,501 - 19,500	388	373	2.85	10yrs/110,000miles	N/A
MHD Class 6-7	19,501 - 33,000	234	225	5.60	10yrs/185,000miles	N/A
HHD Class 8	Greater than 33,000	226	222	7.50	10yrs/435,000miles	N/A
Tractors						
Class 7 Low-Roof All Cabs	26,001 - 33,000	107	104	12.50	10yrs/185,000miles	120 or less
Class 7 Mid-Roof All Cabs	26,001 - 33,000	119	115	12.50	10yrs/185,000miles	121-147
Class 7 High-Roof All Cabs	26,001 - 33,000	124	120	12.50	10yrs/185,000miles	148 or greater
Class 8 Low-Roof Day Cab	Greater than 33,000	81	80	19.00	10yrs/435,000miles	120 or less
Class 8 Low-Roof Sleeper Cab	Greater than 33,000	68	66	19.00	10yrs/435,000miles	120 or less
Class 8 Mid-Roof Day Cab	Greater than 33,000	88	86	19.00	10yrs/435,000miles	121-147
Class 8 Mid-Roof Sleeper Cab	Greater than 33,000	76	73	19.00	10yrs/435,000miles	121-147
Class 8 High-Roof Day Cab	Greater than 33,000	92	89	19.00	10yrs/435,000miles	148 or greater
Class 8 High-Roof Sleeper Cab	Greater than 33,000	75	72	19.00	10yrs/435,000miles	148 or greater

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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.

Equation 1 is used to calculate CO₂ credits in each vehicle regulatory subcategory in the subsequent tables:

Eq. 1: Vehicle Credit Calculation

$$\text{CO}_2 \text{ credits (Mg)} = (\text{Std-FEL}) \times (\text{Payload Tons}) \times (\text{Volume}) \times (\text{UL}) \times (10^{-6})$$

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 is calculated using the Phase 1 value (110,000 miles) in this report. Credits generated using the new useful life value will be 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.

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 CO₂ 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 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 was the only heavy-duty vehicle manufacturer to generate any credits from an approved off-cycle technology through model year 2018.

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 where beginning MY2021 and these credits will be restricted to 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. Only this extra benefit of the AT receives the 1.5X multiplier as previously described. Five manufacturers (Blue Bird, Chanje, Gillig, Mitsubishi Fuso, and New Flyer) generated advanced technology vehicle credits in model years 2013-18 as the following tables will indicate. Each of these manufacturers generated these AT credits by producing electric-powered vocational vehicles during these model years.

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 2013-18 in any of 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 CO₂ 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.

Table 2-1. LHD Vocational Vehicles: GHG Credits (Mg CO₂) Generated Summary – Model Years 2013-18.

Manufacturer	MY 2013		MY 2014		MY 2015		MY 2016		MY 2017		MY 2018		TOTAL	
	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated
Autocar													0	0
Blue Bird Body													0	0
Chanje										4,385		526	0	4,911
Chrysler Group			7,823		10,612		15,121		8,014		15,996		57,566	0
Daimler Trucks													0	0
EcOne													0	0
El Dorado													0	0
EVG Bus													0	0
Ferrara Fire													0	0
Ford Motor			338,493		54,320		40,201		31,639		41,495		506,148	0
General Motors			45,803		62,030		2,591						110,424	0
Gillig LLC													0	0
Isuzu Motors			42,816		55,820		64,177		45,559		46,888		253,260	0
Kovatch Mobile													0	0
Mitsubishi Fuso			1,360		2,445		882		3,361		169	7,072	8,217	7,072
Motor Coach Ind.													0	0
Navistar, Inc.				8,393									0	8,393
New Flyer													0	0
Oshkosh													0	0
PACCAR, Inc.	5		212		67		65		37		58		484	0
Terex Corporation													0	0
Tiffin Motor Homes													0	0
Van Hool													0	0
Volvo Group													0	0
TOTALS	5	0	496,507	8,393	185,294	0	123,037	0	86,610	4,385	104,606	7,598	936,059	20,376

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Table 2-2. MHD Vocational Vehicles: GHG Credits (Mg CO2) Generated Summary – Model Years 2013-18.

Manufacturer	MY 2013		MY 2014		MY 2015		MY 2016		MY 2017		MY 2018		TOTAL	
	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated
Autocar													384	0
Blue Bird Body			58,034		69,126		71,126		70,911		64,353		333,550	0
Chanje													0	0
Chrysler Group													0	0
Daimler Trucks	72,587		64,601		106,254		170,177		206,705		172,345		792,669	0
E-One													0	0
El Dorado													0	0
EVO Bus													0	0
Ferrara Fire													0	0
Ford Motor			64,651		47,486		70,183		148,110		74,621		405,051	0
General Motors													0	0
Gillig LLC			438		386		126		53				1,003	0
Isuzu Motors											7,625		7,625	0
Kovatch Mobile													0	0
Mitsubishi Fuso													0	0
Motor Coach Ind.													0	0
Navistar, Inc.	142,054				68,834		54,000		127,160		157,167		549,215	0
New Flyer					174		286		124				584	0
Oshkosh													0	0
PACCAR, Inc.	2,500		15,528		23,342		26,348		32,128		44,431		144,357	0
Tarex Corporation													0	0
Tiffin Motor Homes			1,256										1,256	0
Van Hool													0	0
Volvo Group													0	0
TOTALS	217,221	0	204,508	0	315,602	0	392,266	0	585,191	0	520,926	0	2,235,694	0

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Table 2-3. HHD Vocational Vehicles: GHG Credits (Mg CO2) Generated Summary – Model Years 2013-18.

Manufacturer	MY 2013		MY 2014		MY 2015		MY 2016		MY 2017		MY 2018		TOTAL	
	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated
Autocar													154,009	0
Blue Bird Body			24,740		28,439		30,348		34,142		24,518	9,308	142,187	9,308
Chanje													0	0
Chrysler Group													0	0
Daimler Trucks	187,890		183,121		211,873		297,599		334,452		290,568		1,505,203	0
E-One			4,287	0	0		5,887		10,018		10,018		19,953	0
El Dorado			5,771		5,109		6,525		2,884		6,450		26,739	0
EVO Bus			2,300		1,233		1,174		1,390		235		6,332	0
Ferrara Fire									1,436		381		2,017	0
Ford Motor							251		2,711		2,956		5,918	0
General Motors													0	0
Gillig LLC			22,397		20,162		22,590		28,570	1,033	36,657	3,094	130,376	4,131
Isuzu Motors							3,002		5,250		2,617		8,869	0
Kovatch Mobile													0	0
Mitsubishi Fuso													0	0
Motor Coach Ind.			18,312		18,975		20,456		17,947		32,067		107,777	0
Navistar, Inc.	186,954				44,843		60,646		87,392		106,628		486,433	0
New Flyer					14,055		31,620		30,765	23,285	31,263	164,435	107,701	187,700
Oshkosh			9,160		10,055		12,799		8,434		19,422		59,884	0
PACCAR, Inc.	20,467		142,896		288,222		318,538		335,700		415,134		1,544,777	0
Tarex Corporation			4,055		4,160		12,241		1,383		2,218		24,054	0
Tiffin Motor Homes			17,180										17,180	0
Van Hool									26,348				57,903	0
Volvo Group			128,370		181,910		237,817		196,902		245,089		988,008	0
TOTALS	409,311	0	582,317	0	829,836	0	1,095,626	0	1,322,166	24,288	1,460,992	176,841	5,385,450	201,139

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Table 2-4. MHD Vocational Tractors: GHG Credits (Mg CO2) Generated Summary – Model Years 2013-18.

Manufacturer	MY 2013		MY 2014		MY 2015		MY 2016		MY 2017		MY 2018		TOTAL	
	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated
Autocar													0	0
Daimler Trucks	1,046		1,808		2,916		2,160		3,844		1,509		13,280	0
Ford Motor							-26		76		58		108	0
Kovatch Mobile													0	0
Navistar, Inc.											2,487		2,487	0
PACCAR, Inc.	1,742		1,355		1,272		662		645		995		6,671	0
Volvo Group													0	0
TOTALS	2,788	0	3,163	0	4,188	0	2,796	0	4,565	0	5,049	0	22,546	0

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Table 2-5. HHD Vocational Tractors: GHG Credits (Mg CO2) Generated Summary – Model Years 2013-18.

Manufacturer	MY 2013		MY 2014		MY 2015		MY 2016		MY 2017		MY 2018		TOTAL	
	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated
Autocar													18,531	18,531
Daimler Trucks	23,163		15,686		23,617		34,638		21,650		40,716		159,470	0
Ford Motor							52		29		124		205	0
Kovatch Mobile									88		26		114	0
Nissan, Inc.											11,468		11,468	0
PACCAR, Inc.	4,341		46,484		66,314		41,705		30,221		52,748		241,813	0
Volvo Group			113,551		26,981		23,392		18,104		49,162		231,790	0
TOTALS	27,504	0	175,721	0	116,912	0	100,387	0	70,092	0	172,795	0	663,411	0

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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 2013-18. As will be observed later in this report, any credit deficit generated in one vehicle regulatory category 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 2013-18 in each averaging set for reference. These totals are merely an aggregate total of credits generated during model years 2013-2018 are not reflective of the current amount of banked credits available to each manufacturer for future use.

Table 3 indicates that all manufacturers demonstrated compliance with the GHG regulations for model years 2013-18 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 2013-18.

Manufacturer	MY 2013				MY 2014				MY 2015				MY 2016			
	LHD Conventional Plus Off-Cycle Credits Generated	MHD Conventional Plus Off-Cycle Credits Generated	HD Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	LHD Conventional Plus Off-Cycle Credits Generated	MHD Conventional Plus Off-Cycle Credits Generated	HD Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	LHD Conventional Plus Off-Cycle Credits Generated	MHD Conventional Plus Off-Cycle Credits Generated	HD Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	LHD Conventional Plus Off-Cycle Credits Generated	MHD Conventional Plus Off-Cycle Credits Generated	HD Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated
Autorcar																
Blue Bird Body					58,054		24,740			65,126		28,439			71,126	30,348
Chryler Group					7,823				10,612				15,121			
Daimler Trucks		73,633	211,053			66,409	198,907			199,170		235,490		173,337		332,237
E-One							4,267					0				0
E Dorado							5,771					5,109				6,525
EVD Bus							2,300					1,233				1,174
Ferrara Fire																
Ford Motor					338,485	64,851			54,320	47,486			40,201	70,157		305
General Motors					48,903				62,030				2,591			22,590
Gillig LLC						436	22,397			368		20,182		126		
Isuzu Motors					42,816				55,820				64,177			3,002
Kovatch Mobile																
Mitsubishi Fuso					1,360				2,445				882			
Motor Coach Ind.							18,312					16,975				28,456
Navistar, Inc.	142,054		186,954					6,393		88,834		44,843		54,000		80,666
New Flyer										174		14,055		266		21,820
Oshkosh												10,055				11,799
PACCAR, Inc.	5	4,322	32,800		212	18,583	209,120		67	24,614		354,536		65	27,000	360,243
Terex Corporation							4,055									12,242
Tiffin Motor Homes						1,156	17,180									
Van Hool							241,811					206,081				261,009
Veolia Group																
TOTALS	5	220,000	430,815	0	436,507	207,671	758,038	8,393	185,204	319,790	945,948	0	123,037	395,042	1,156,813	0

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Table 3. All Heavy-Duty Vocational Vehicles: GHG Credits (Mg CO₂) Generated Summary – Model Years 2013-18, continued.

Manufacturer	MY 2017				MY 2018				TOTAL			
	LHD Conventional Plus Off-Cycle Credits Generated	MHD Conventional Plus Off-Cycle Credits Generated	HD Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	LHD Conventional Plus Off-Cycle Credits Generated	MHD Conventional Plus Off-Cycle Credits Generated	HD Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	LHD Conventional Plus Off-Cycle Credits Generated	MHD Conventional Plus Off-Cycle Credits Generated	HD Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated
Autorcar												
Blue Bird Body		70,911	34,142				384		172,540		384	172,540
Chang				4,305				9,308		333,550		142,187
Chryler Group	8,014				15,996			526				4,911
Daimler Trucks		210,546	355,002			173,854						0
E-One												18,953
E Dorado												26,739
EVD Bus												8,332
Ferrara Fire												2,017
Ford Motor	31,639	148,186	2,740		41,495	74,679	3,060		506,148	405,159		6,123
General Motors									110,424			0
Gillig LLC										1,003		130,376
Isuzu Motors	43,559			1,093	46,888	7,625		3,098	253,260	7,625		0
Kovatch Mobile												8,983
Mitsubishi Fuso	3,361								8,217			7,072
Motor Coach Ind.												107,777
Navistar, Inc.		127,180	87,392			159,854						551,702
New Flyer		124	30,765	23,265								584
Oshkosh												59,884
PACCAR, Inc.	37	32,774	364,001		58	45,426	465,882		444	151,029		1,786,590
Terex Corporation												2,215
Tiffin Motor Homes												0
Van Hool												1,256
Veolia Group												57,803
TOTALS	86,610	589,754	1,192,260	28,689	104,606	525,975	1,575,787	184,439	936,059	2,258,241	6,058,861	221,515

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Table 4 presents the banked credit balances for each manufacturer in each of the three vocational vehicle averaging sets at the conclusion of model year 2018. 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 2018 while removing the unused expired credits generated in model year 2013. In the event 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 embedded spreadsheets for each manufacturer participating in the ABT program that details all credit activity in involving the generated credits for each model year to date presented in this report. These detailed spreadsheets summarize any credit activity involving such transactions as credit trades, expired credits, error corrections, etc. As noted previously, there are no CO₂ 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 2018.

**Table 4. All Heavy-Duty Vocational Vehicles: GHG Credits (Mg CO₂)
Banked Summary – Through Model Year 2018.**

Manufacturer	LHD	MHD	HHD	Advanced Technology
	Conventional Plus Off-Cycle Credit Balance	Conventional Plus Off-Cycle Credit Balance	Conventional Plus Off-Cycle Credit Balance	Technology Credit Balance
Autocar		384	172,540	
Blue Bird Body		333,550	142,187	9,308
Chanje				4,911
Chrysler Group	57,566			
Daimler Trucks		732,316	1,453,620	
E-One			19,953	
El Dorado			26,739	
EVO Bus			6,332	
Ferrara Fire			2,017	
Ford Motor	506,148	405,159	6,123	
General Motors	110,424			
Gillig LLC		1,003	130,376	4,131
Isuzu Motors	253,260	7,625		
Kovatch Mobile			8,983	
Mitsubishi Fuso	8,217			7,072
Motor Coach Ind.			107,777	
Navistar, Inc.		409,648	311,017	453
New Flyer		584	107,701	187,700
Oshkosh			59,884	
PACCAR, Inc.	439	141,261	1,748,897	
Terex Corporation			24,054	
Tiffin Motor Homes		1,256	17,180	
Van Hool			57,903	
Volvo Group			1,219,878	
TOTALS	936,054	2,032,786	5,623,161	213,575

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b. Heavy-Duty Combination Tractors

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 CO₂ 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 2013-18 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 CO₂ 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)	CO ₂ (g/ton-mile)		Payload (tons)	Useful Life	Roof Height (inches)
		MY 2014-16	MY 2017-20			
Vocational Vehicles						
LHD Class 2b-5	8,501 - 19,500	388	373	2.85	10yrs/110,000miles	N/A
MHD Class 6-7	19,501 - 33,000	234	225	5.60	10yrs/185,000miles	N/A
HHD Class 8	Greater than 33,000	226	222	7.50	10yrs/435,000miles	N/A
Tractors						
Class 7 Low-Roof All Cabs	26,001 - 33,000	107	104	12.50	10yrs/185,000miles	120 or less
Class 7 Mid-Roof All Cabs	26,001 - 33,000	119	115	12.50	10yrs/185,000miles	121-147
Class 7 High-Roof All Cabs	26,001 - 33,000	124	120	12.50	10yrs/185,000miles	148 or greater
Class 8 Low-Roof Day Cab	Greater than 33,000	81	80	19.00	10yrs/435,000miles	120 or less
Class 8 Low-Roof Sleeper Cab	Greater than 33,000	68	66	19.00	10yrs/435,000miles	120 or less
Class 8 Mid-Roof Day Cab	Greater than 33,000	88	86	19.00	10yrs/435,000miles	121-147
Class 8 Mid-Roof Sleeper Cab	Greater than 33,000	76	73	19.00	10yrs/435,000miles	121-147
Class 8 High-Roof Day Cab	Greater than 33,000	92	89	19.00	10yrs/435,000miles	148 or greater
Class 8 High-Roof Sleeper Cab	Greater than 33,000	75	72	19.00	10yrs/435,000miles	148 or greater

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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 2013-18 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 CO₂ 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. There were no tractors produced generating any AT credits since the inception of this program (from model years 2013 through 2018). 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 2013-18.

Manufacturer	MY 2013		MY 2014		MY 2015		MY 2016		MY 2017		MY 2018		TOTAL	
	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated
Daimler Trucks	-2,720		918		241		81		-217		95		-1,558	0
Navistar, Inc.	2,410				511		458		937		1,004		5,320	0
PACCAR, Inc.			32		-25		698		160		-155		710	0
Volvo Group													0	0
TOTALS	-310	0	950	0	727	0	1,237	0	880	0	948	0	4,432	0

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Table 6-2. MHD Tractors – Class 7 Mid-Roof All Cabs: GHG Credits (Mg CO₂) Generated Summary – Model Years 2013-18.

Manufacturer	MY 2013		MY 2014		MY 2015		MY 2016		MY 2017		MY 2018		TOTAL	
	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated
Daimler Trucks	7,219		11,056		10,656		12,076		5,848		5,141		51,996	0
Navistar, Inc.					23		12		149		16		194	0
PACCAR, Inc.					-5		5		5				5	0
Volvo Group													0	0
TOTALS	7,219	0	11,056	0	10,674	0	12,093	0	5,996	0	5,157	0	52,195	0

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Table 6-3. MHD Tractors – Class 7 High-Roof All Cabs: GHG Credits (Mg CO₂) Generated Summary – Model Years 2013-18.

Manufacturer	MY 2013		MY 2014		MY 2015		MY 2016		MY 2017		MY 2018		TOTAL	
	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated
Daimler Trucks	37,428		49,409		38,973		50,366		33,097		61,679		270,952	0
Navistar, Inc.	396		6,487		6,487		15,621		10,709		5,208		38,421	0
PACCAR, Inc.			-9		435		-1,085		-3,346		-1,727		-5,732	0
Volvo Group													0	0
TOTALS	37,824	0	49,400	0	45,895	0	64,902	0	40,460	0	65,160	0	303,641	0

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Table 6-4. HHD Tractors – Class 8 Low-Roof Day Cabs: GHG Credits (Mg CO₂) Generated Summary – Model Years 2013-18.

Manufacturer	MY 2013		MY 2014		MY 2015		MY 2016		MY 2017		MY 2018		TOTAL	
	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated
Daimler Trucks	-21,423		33,721		10,521		31,539		49,755		98,599		162,712	0
Navistar, Inc.	29,780		8,637		8,637		9,001		27,279		30,531		105,679	0
PACCAR, Inc.			4,885		63,136		83,931		134,645		187,144		473,741	0
Volvo Group			8,538		24,307		31,655		48,722		53,532		166,754	0
TOTALS	8,357	0	47,144	0	106,601	0	156,126	0	260,851	0	329,806	0	808,885	0

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Table 6-5. HHD Tractors – Class 8 Mid-Roof Day Cabs: GHG Credits (Mg CO₂) Generated Summary – Model Years 2013-18.

Manufacturer	MY 2013		MY 2014		MY 2015		MY 2016		MY 2017		MY 2018		TOTAL	
	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated
Daimler Trucks	72,562		83,162		87,196		98,940		60,566		103,040		505,466	0
Navistar, Inc.													0	0
PACCAR, Inc.			49		1,529		529		1,099		1,488		4,694	0
Volvo Group													0	0
TOTALS	72,562	0	83,211	0	88,725	0	99,469	0	61,665	0	104,528	0	510,160	0

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Table 6-6. HHD Tractors – Class 8 High-Roof Day Cabs: GHG Credits (Mg CO2) Generated Summary – Model Years 2013-18.

Manufacturer	MY 2013		MY 2014		MY 2015		MY 2016		MY 2017		MY 2018		TOTAL	
	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated
Daimler Trucks	265,827		284,531		412,663		520,976		320,054		364,288		2,168,339	0
Navistar, Inc.	179,814				164,002		234,544		176,953		154,448		909,761	0
PACCAR, Inc.			4,918		78,360		93,451		126,000		175,284		478,013	0
Volvo Group			72,335		218,981		438,194		274,067		265,323		1,268,900	0
TOTALS	445,641	0	361,784	0	874,006	0	1,287,165	0	897,074	0	959,343	0	4,825,013	0

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Table 6-7. HHD Tractors – Class 8 Low-Roof Sleeper Cabs: GHG Credits (Mg CO2) Generated Summary – Model Years 2013-18.

Manufacturer	MY 2013		MY 2014		MY 2015		MY 2016		MY 2017		MY 2018		TOTAL	
	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated
Daimler Trucks	-49,180		-31,746		-56,226		-29,713		-3,818		-6,793		-177,496	0
Navistar, Inc.					-5,736		-3,827		-3,240		-2,190		-14,993	0
PACCAR, Inc.			-6,642		-110,230		-72,839		-36,655		-51,375		-277,961	0
Volvo Group			-12,422		-13,942		-13,546		-6,686		-6,579		-53,175	0
TOTALS	-49,180	0	-50,830	0	-186,134	0	-119,925	0	-50,399	0	-66,897	0	-523,365	0

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Table 6-8. HHD Tractors – Class 8 Mid-Roof Sleeper Cabs: GHG Credits (Mg CO2) Generated Summary – Model Years 2013-18.

Manufacturer	MY 2013		MY 2014		MY 2015		MY 2016		MY 2017		MY 2018		TOTAL	
	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated
Daimler Trucks	-169,077		-78,550		-79,790		-112,197		-94,771		-94,287		-624,172	0
Navistar, Inc.					-43,813		-35,117		-36,886		-27,382		-131,998	0
PACCAR, Inc.			-14,513		-225,237		-239,495		-180,970		-212,551		-872,766	0
Volvo Group			-37,498		-47,532		50,177		-29,332		-33,182		197,731	0
TOTALS	-169,077	0	-126,541	0	-396,372	0	-497,136	0	-331,459	0	-367,312	0	-1,828,967	0

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Table 6-9. HHD Tractors – Class 8 High-Roof Sleeper Cabs: GHG Credits (Mg CO2) Generated Summary – Model Years 2013-18.

Manufacturer	MY 2013		MY 2014		MY 2015		MY 2016		MY 2017		MY 2018		TOTAL	
	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated
Daimler Trucks	967,290		879,024		877,908		1,669,315		612,114		611,660		5,617,311	0
Navistar, Inc.					205,906		281,247		78,889		149,182		818,179	0
PACCAR, Inc.			6,438		202,484		532,340		255,296		247,785		1,246,145	0
Volvo Group			3,876		244,913		675,812		173,073		173,722		1,271,396	0
TOTALS	967,290	0	889,338	0	1,452,231	0	3,160,709	0	1,119,354	0	1,182,309	0	8,971,231	0

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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 2018. This table shows that PACCAR created a credit deficit in the MHD averaging set in the tractor sector only 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 2013-18.

Manufacturer	MY 2013			MY 2014			MY 2015			MY 2016		
	MHD Conventional Plus Off-Cycle Credits Generated	HHD Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	MHD Conventional Plus Off-Cycle Credits Generated	HHD Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	MHD Conventional Plus Off-Cycle Credits Generated	HHD Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	MHD Conventional Plus Off-Cycle Credits Generated	HHD Conventional Plus Off-Cycle Credits Generated	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	
Navistar, Inc.	2,806	209,594					7,021	449,996		16,091	487,643	
PACCAR, Inc.				23	-4,885	34,829	405	10,042		-582	597,917	
Volvo Group								426,747			1,081,958	
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

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Table 7. All Heavy-Duty Tractors: GHG Credits (Mg CO₂) Generated Summary – Model Years 2013-18, continued.

Manufacturer	MY 2017			MY 2018			TOTAL		
	MHD Conventional Plus Off-Cycle Credits Generated	HHD Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	MHD Conventional Plus Off-Cycle Credits Generated	HHD Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	MHD Conventional Plus Off-Cycle Credits Generated	HHD Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated
Daimler Trucks	38,728	944,400		66,919	1,036,547		321,350	7,652,220	0
Navistar, Inc.	11,789	253,446		6,227	304,548		43,934	1,705,227	0
PACCAR, Inc.	-3,182	299,416		-1,882	347,774		-5,018	1,050,264	0
Volvo Group		459,823			452,807		0	2,456,144	0
TOTALS	47,335	1,957,085	0	71,264	2,141,676	0	360,266	12,863,855	0

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Table 8 presents the banked credit balances for each tractor manufacturer in each of the two applicable averaging sets at the conclusion of model year 2018. 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 2018 while removing the unused expired credits generated in model year 2013. 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 embedded 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, etc. In summary, there are no CO₂ 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 model year 2018.

Table 8. All Heavy-Duty Tractors: GHG Credits (Mg CO₂) Banked Summary – Through Model Year 2018.

Manufacturer	MHD	HHD	Advanced Technology
	Conventional Plus Off-Cycle Credit Balance	Conventional Plus Off-Cycle Credit Balance	
Daimler Trucks	279,423	6,586,221	0
Navistar, Inc.	41,128	1,495,633	0
PACCAR, Inc.	428	1,055,149	0
Volvo Group		2,456,144	0
TOTALS	320,979	11,593,147	0

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c. Heavy-Duty Vehicle Compliance Summary

Table 9 presents a comprehensive summary of credits earned in model years 2013-18 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 2013-18.

Manufacturer	MY 2013				MY 2014				MY 2015				MY 2016			
	LHD Conventional Plus Off-Cycle Credits Generated	MHD Conventional Plus Off-Cycle Credits Generated	HHD Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	LHD Conventional Plus Off-Cycle Credits Generated	MHD Conventional Plus Off-Cycle Credits Generated	HHD Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	LHD Conventional Plus Off-Cycle Credits Generated	MHD Conventional Plus Off-Cycle Credits Generated	HHD Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	LHD Conventional Plus Off-Cycle Credits Generated	MHD Conventional Plus Off-Cycle Credits Generated	HHD Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated
Auxcar																
Blue Bird Body					58,054		24,740									
Chang																
Chryslr Group																
Daimler Trucks		115,560	1,277,052		7,823				38,812				15,124			
E-One																
El Dorado																
EVO Bus																
Ferrara Fire																
Ford Motor					338,483	64,651			54,320	47,406			46,355	70,157		505
General Motors					45,903				62,000				2,591			
Gillig LLC																
Huac Motors					42,616	433	22,397		55,820	386	20,162		64,177	126	22,590	
Hough Mobile																
Mitsubishi Fuso					1,360				2,445				822			
Motor Coach Ind.																
Navistar, Inc.		144,060	396,540								6,383		75,855	486,839		38,056
New Flyer													174	14,055		31,620
Onion														38,055		12,799
PACCAR, Inc.		5	4,322	32,000												
Terex Corporation					212	18,906	204,235		67	25,018	366,578		65	26,632		758,160
Trillium Motor Homes						1,256	17,180									
Van Hool																
Volvo Group																
TOTALS	5	284,742	1,706,608	0	436,507	269,677	1,962,124	6,383	185,294	377,086	3,085,065	0	123,037	473,274	5,362,371	0

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Table 9. Heavy-Duty Vehicles Averaging Set Summary: GHG Credits (Mg CO2) Generated Summary – Model Years 2013-18, continued.

Manufacturer	MY2017				MY2018				TOTAL			
	LHD Conventional Plus Off-Cycle Credits Generated	MHD Conventional Plus Off-Cycle Credits Generated	HHD Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	LHD Conventional Plus Off-Cycle Credits Generated	MHD Conventional Plus Off-Cycle Credits Generated	HHD Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated	LHD Conventional Plus Off-Cycle Credits Generated	MHD Conventional Plus Off-Cycle Credits Generated	HHD Conventional Plus Off-Cycle Credits Generated	Advanced Technology Credits Generated
Autocar						384	172,540		0	384	172,540	0
Blue Bird Body		70,911	34,142		64,353	24,518	9,308	0	333,550	142,187	9,308	0
Chanje				4,385			526	0	0	0	4,911	0
Chrysler Group	8,014				15,996			57,566	0	0	0	0
Daimler Trucks		249,274	1,900,202			240,773	1,367,831	0	1,127,299	9,316,893	0	0
EC One			5,667				10,019	0	0	19,953	0	0
El Dorado			2,854				6,450	0	0	28,739	0	0
EVO Bus			1,390				235	0	0	6,332	0	0
Ferrara Fire			1,436				561	0	0	2,017	0	0
Ford Motor	31,639	148,186	2,740		41,495	74,679	3,000	506,148	405,159	6,123	0	0
General Motors								110,424	0	0	0	0
Gillig LLC		53	28,570	1,039			36,657	3,098	0	1,003	130,376	4,131
Isuzu Motors	43,559				46,688	7,625	2,643	253,260	7,625	0	0	0
Kovatch Mobile			3,338				2,643	0	0	8,963	0	0
Mitsubishi Fuso	3,361				169			8,217	0	0	7,071	0
Motor Coach Ind.			17,967				32,067	0	0	107,777	0	0
Navistar, Inc.		138,949	340,838			165,081	422,664	0	595,636	2,203,190	8,393	0
New Flyer		124	30,765	23,265			31,261	164,435	0	584	107,701	187,700
Oshkosh			8,434				19,428	0	0	59,884	0	0
PACCAR, Inc.	37	29,592	663,417		58	43,544	813,656	444	146,011	2,836,854	0	0
Terex Corporation			1,383				2,215	0	0	24,054	0	0
Tiffin Motor Homes								0	1,256	17,180	0	0
Van Hool			31,343				26,500	0	0	57,903	0	0
Volvo Group			674,829				745,050	0	0	3,676,022	0	0
TOTALS	86,610	637,089	3,148,345	28,683	104,606	597,239	3,717,463	184,439	536,059	2,618,507	18,922,716	221,515

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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 2018. All the manufacturers participating in the ABT program carry positive credit balances in all the averaging sets at the conclusion of model year 2018 thus showing all manufacturers are compliant with the Phase 1 GHG heavy-duty vehicle standards through the first five mandatory years of the program (model years 2014-2018). For a more detailed analysis on how these banked credit values were determined, please look to the embedded spreadsheets in Appendix B that summarize all credit activities for each manufacturer individually for model years 2013-18.

Table 10. Heavy-Duty Vehicles Averaging Set Summary: GHG Credits (Mg CO₂) Banked Summary – Through Model Year 2018.

Manufacturer	LHD	MHD	HHD	Advanced Technology
	Conventional Plus Off-Cycle Credit Balance	Conventional Plus Off-Cycle Credit Balance	Conventional Plus Off-Cycle Credit Balance	
Autocar		384	172,540	
Blue Bird Body		333,550	142,187	9,308
Chanje				4,911
Chrysler Group	57,566			
Daimler Trucks		1,011,739	8,039,841	
E-One			19,953	
El Dorado			26,739	
EVO Bus			6,332	
Ferrara Fire			2,017	
Ford Motor	506,148	405,159	6,123	
General Motors	110,424			
Gillig LLC		1,003	130,376	4,131
Isuzu Motors	253,260	7,625		
Kovatch Mobile			8,983	
Mitsubishi Fuso	8,217			7,072
Motor Coach Ind.			107,777	
Navistar, Inc.		450,776	1,806,650	453
New Flyer		584	107,701	187,700
Oshkosh			59,884	
PACCAR, Inc.	439	141,689	2,804,046	
Terex Corporation			24,054	
Tiffin Motor Homes		1,256	17,180	
Van Hool			57,903	
Volvo Group			3,676,022	
TOTALS	936,054	2,353,765	17,216,308	213,575

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4. Model Year 2018 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 the model years 2013-2018, 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.

The following formula is used to calculate CO₂ credits in each engine averaging set in the subsequent tables:

$$\text{CO}_2 \text{ credits (Mg)} = (\text{Std-FCL}) \times (\text{CF}) \times (\text{Volume}) \times (\text{UL}) \times (10^{-6})$$

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, the useful life for light heavy-duty engines has also been changed to 150,000 miles starting in model year 2021. The credits presented in this report were calculated using the original value of 110,000 mile applicable for Phase 1 and will be adjusted at the conclusion of model year 2020 for carry over into Phase 2.

Table 11 presents the applicable CO₂ emissions standards for heavy-duty CI engines applicable for model years 2014-20. 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 MY2014-16 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 MY2014-16 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

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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.⁶ These off-cycle credits are similar to CO₂ 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 model years 2013 through 2018, so the credit values presented in the following tables were “conventional only” for every model year.

Similar to the provision described in the heavy-duty vehicle sector, AT credits can also be generated in the heavy-duty engine sector. 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 model years 2013 through 2018, so the tables displaying engine credit information will not contain columns for those credits as they are all zero.

Tables 12-1 through 12-3 summarize the model year 2013-18 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

⁶ See 40 CFR 1036.610

(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 2013-18.

Manufacturer	MY 2013	MY2014	MY 2015	MY2016	MY2017	MY2018	TOTAL
	Vocational Engine Credits Generated Net CO ₂	Vocational Engine Credits Generated Net CO ₂	Vocational Engine Credits Generated Net CO ₂	Vocational Engine Credits Generated Net CO ₂	Vocational Engine Credits Generated Net CO ₂	Vocational Engine Credits Generated Net CO ₂	Vocational Engine Credits Generated Net CO ₂
Cummins Inc.							0
Detroit Diesel							0
Ford Motor		252,236	217,062	161,215	11,289	9,003	650,805
FPT Powertrain		1,215		6,492	-456		7,251
Isuzu Motors			56,886	54,534			111,420
Navistar, Inc.		-681					-681
PACCAR, Inc.							0
Volvo Group							0
TOTALS	0	252,770	273,948	222,241	10,833	9,003	768,795

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Table 12-2. MHD CI Engine Averaging Set: GHG Credits (Mg CO₂) Generated Summary – Model Years 2013-18.

Manufacturer	MY 2013		MY2014		MY 2015		MY2016		MY2017		MY2018		TOTAL	
	Vocational Engine Credits Generated Net CO ₂	Tractor Engine Credits Generated Net CO ₂	Vocational Engine Credits Generated Net CO ₂	Tractor Engine Credits Generated Net CO ₂	Vocational Engine Credits Generated Net CO ₂	Tractor Engine Credits Generated Net CO ₂	Vocational Engine Credits Generated Net CO ₂	Tractor Engine Credits Generated Net CO ₂	Vocational Engine Credits Generated Net CO ₂	Tractor Engine Credits Generated Net CO ₂	Vocational Engine Credits Generated Net CO ₂	Tractor Engine Credits Generated Net CO ₂	Vocational Engine Credits Generated Net CO ₂	Tractor Engine Credits Generated Net CO ₂
Cummins Inc.	2,431,800	36,721	3,110,912	43,759	4,113,191	13,349	739,201	-11,977	2,317,429	-4,167	2,041,359	9,000	13,092,006	18,913
Detroit Diesel							19,409	19,409	35,375		698		74,814	469
Ford Motor							26,165	-1,894	38,742	-1,054	27,824		40,131	-2,312
FPT Powertrain													0	0
ISUZU MOTORS													0	0
Navistar, Inc.			-4,211	-1,448	11,070	-36	70,179	-65	1,751				141,796	-1,285
PACCAR, Inc.													0	0
Volvo Group													0	0
TOTALS	2,431,800	36,721	3,096,701	42,311	4,218,420	13,293	855,545	43,038	2,855,422	-5,881	2,119,335	9,100	13,369,261	18,432

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Table 12-3. HHD CI Engine Averaging Set: GHG Credits (Mg CO₂) Generated Summary – Model Years 2013-18.

Manufacturer	MY 2013		MY2014		MY 2015		MY2016		MY2017		MY2018		TOTAL	
	Vocational Engine Credits Generated Net CO ₂	Tractor Engine Credits Generated Net CO ₂	Vocational Engine Credits Generated Net CO ₂	Tractor Engine Credits Generated Net CO ₂	Vocational Engine Credits Generated Net CO ₂	Tractor Engine Credits Generated Net CO ₂	Vocational Engine Credits Generated Net CO ₂	Tractor Engine Credits Generated Net CO ₂	Vocational Engine Credits Generated Net CO ₂	Tractor Engine Credits Generated Net CO ₂	Vocational Engine Credits Generated Net CO ₂	Tractor Engine Credits Generated Net CO ₂	Vocational Engine Credits Generated Net CO ₂	Tractor Engine Credits Generated Net CO ₂
Cummins Inc.	402,659	2,354,276	502,112	3,140,240	441,367	3,679,492	-511,764	-874,409	581,624	-103,609	108,061	75,111	3,555,157	6,046,301
Detroit Diesel	447,299	1,231,159	612,654	2,041,851	685,880	2,312,587	492,178	512,697	788,814	395,642	891,787	743,510	3,916,642	7,237,416
Ford Motor													0	0
FPT Powertrain													0	0
Isuzu Motors			130,740	-53,184	150,828	4,234	110,497	5,619	53,616	3,014	113,836	58,919	567,517	18,602
Navistar, Inc.			126,065	34,426	537,588	47,663	718,430	71,794	730,166	33,112	875,172	47,235	3,187,451	254,230
PACCAR, Inc.			409,923	814,170	1,176,995	610,291	399,164	467,712	682,271	-410,947	104,416	-202,446	3,272,671	1,270,962
Volvo Group													0	0
TOTALS	899,958	3,585,435	1,981,434	6,017,685	3,001,168	4,634,229	1,189,005	189,333	2,836,521	-315,868	2,593,772	722,731	12,501,418	14,817,543

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There are a few additional requirements for determining a CO₂ credit value in the heavy-duty engine sector that were not present in the vehicle sector. The first requirement is that CO₂ is not the only GHG pollutant for which a manufacturer is required to meet a standard for certification (as viewed in Table 11). Nitrous oxide (N₂O) and methane (CH₄) are also required to be measured during the official

emissions testing in addition to CO₂. N₂O and CH₄ credit deficits for one engine family need to be offset by CO₂ credits generated by the same or another family within the same averaging set. Any credit deficit from N₂O or CH₄ is converted into an equivalent CO₂ value using the Global Warming Potential (GWP) value for either pollutant. N₂O has a GWP value of 298, meaning that a 1 Mg N₂O deficit needs to be offset by 298 Mg of CO₂ credits. Similarly, the GWP value for CH₄ is 25 (this value changes to 34 beginning in model year 2021), and these deficits also need to be offset by equivalent CO₂ credits. One additional regulatory option from previous model years was the possibility of generating additional CO₂ credits when certifying to N₂O levels below 0.04 g/hp-hr during model years 2014-2016 only. Beginning in model year 2017, CO₂ credits can no longer be generated from N₂O over compliance. However, N₂O deficits can still be offset using CO₂ credits in 2017 and future years. Methane has no option for generating credits. Similar to N₂O, CH₄ deficits can be offset with equivalent CO₂ credits. The credit values presented in Table 12 are “Net CO₂” credits which means that any N₂O and CH₄ 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 2018.

In certain instances presented in Tables 12-1 through 12-3, a manufacturer ran a deficit in either 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 first 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 2013-18 for each manufacturer in each of the averaging sets because 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 2018. There were a few cases in which a manufacturer generated a deficit in an averaging set which is allowable. 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 two cases where a manufacturer ran a deficit (Cummins and FPT Powertrain), these deficits were offset by just using banked engine credits available to them from a previous model year.

Table 13. All Heavy-Duty Ci Engines - Averaging Set Summary: GHG Credits (Mg CO₂) Generated Summary – Model Years 2013-18.

Manufacturer	MY 2013			MY 2014			MY 2015			MY 2016		
	LHD Credits Generated Net CO ₂	MHD Credits Generated Net CO ₂	HHD Credits Generated Net CO ₂	LHD Credits Generated Net CO ₂	MHD Credits Generated Net CO ₂	HHD Credits Generated Net CO ₂	LHD Credits Generated Net CO ₂	MHD Credits Generated Net CO ₂	HHD Credits Generated Net CO ₂	LHD Credits Generated Net CO ₂	MHD Credits Generated Net CO ₂	HHD Credits Generated Net CO ₂
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
Detroit Diesel			1,678,458			2,654,505			2,998,467			1,004,875
Ford Motor				252,236			217,062			161,215	24,471	
FPT Powertrain				1,215						6,492		
Isuzu Motors							56,886			54,534		
Navistar, Inc.				-681	-7,259	77,556		82,980	163,062		70,012	116,116
PACCAR, Inc.						360,491			605,261			790,224
Volvo Group						1,244,273			1,787,188			866,878
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

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Table 13. All Heavy-Duty CI Engines – Averaging Set Summary: GHG Credits (Mg CO2) Generated Summary – Model Years 2013-18, continued.

Manufacturer	MY2017			MY2018			TOTAL		
	LHD Credits Generated Net CO2	MHD Credits Generated Net CO2	HHD Credits Generated Net CO2	LHD Credits Generated Net CO2	MHD Credits Generated Net CO2	HHD Credits Generated Net CO2	LHD Credits Generated Net CO2	MHD Credits Generated Net CO2	HHD Credits Generated Net CO2
Cummins Inc.		2,312,962	272,935		2,054,894	183,574	0	15,187,729	7,601,460
Detroit Diesel		19,499	1,184,486		54,677	1,635,297		74,176	11,156,088
Ford Motor	11,289	15,708		9,003	17,924		650,805	58,103	0
FPT Powertrain	-456						7,251	0	0
Isuzu Motors							111,420	0	0
Navistar, Inc.		1,752	56,630			172,755	-681	147,485	586,119
PACCAR, Inc.			763,278			922,407	0	0	3,441,661
Volvo Group			243,324			401,970	0	0	4,543,633
TOTALS	10,833	2,349,921	2,520,653	9,003	2,127,495	3,316,003	768,795	15,467,493	27,328,961

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In the event any other activity occurred with credits generated (i.e. error corrections, etc.), 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 any banked credits. In addition, Appendix B contains links to embedded spreadsheets for each manufacturer participating in the ABT program that details any credit activity to the generated credits for each model year to date. These detailed spreadsheets summarize all credit activity involving such transactions as credit trades, expired credits, error corrections, etc.

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 2018. There are no deficits in any averaging set of Table 14 showing that all manufacturers were able to comply with the Phase 1 GHG heavy-duty CI engine standards for the first five years of mandatory certification to these standards (model years 2014 through 2018). All engine manufacturers show a strong credit balance for use in compliance to the GHG standards for future model years.

Table 14. All Heavy-Duty CI Engines – Averaging Set Summary: GHG Credits (Mg CO2) Banked Summary – Through Model Year 2018.

Manufacturer	LHD Credit Balance Net CO2	MHD Credit Balance Net CO2	HHD Credit Balance Net CO2	Advanced Technology Credit Balance Net CO2
Cummins Inc.		12,719,028	4,424,922	
Detroit Diesel		74,176	9,477,630	
Ford Motor	650,805	58,103		
FPT Powertrain	7,251			
Isuzu Motors	111,420			
Navistar, Inc.		154,744	586,119	
PACCAR, Inc.			3,441,436	
Volvo Group			4,543,633	
TOTALS	769,476	13,006,051	22,473,740	0

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5. Conclusions

As indicated previously, the success of the 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 are not merely compliant, but that all manufacturers have generated a positive banked credit balance through model year 2018 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). Similarly, all heavy-duty engine manufacturers also show full compliance through model year 2018 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 CO₂. 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 CO₂ 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 CO₂ standard described in 40 CFR § 1036.620 for certifying their LHD engine family. When using this provision, they are not allowed to generate any CO₂ credits to help offset a CH₄ deficit generated within this family. When converted to an equivalent CO₂ basis, the magnitude of this deficit was 681 Mg CO₂ in the LHD averaging set. Navistar also produced a similar CO₂ deficit of 7,259 Mg CO₂ in the MHD engine averaging set this time due to an N₂O 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 CO₂ 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 CO₂ 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 manufacturer to receive approval on an off-cycle technology to date.

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 CO₂ 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. 2016 represented the last year that General Motors participated in the heavy-duty vehicle ABT program described in this report. They chose to certify all their heavy-duty products using the chassis dynamometer testing method of Part 86, Subpart S. Any ABT data reported using that certification method is not part of this report. Additionally, 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.

CO₂ 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 CO₂ values for a single engine tractor family for model years 2013 through 2016. This higher CO₂ 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 and 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.

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/P1013CC3.PDF?Dockey=P1013CC3.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.