

# Greenhouse Gas Emissions Performance for the 2024 Model Year Light-Duty Vehicle Fleet

In relation to the Passenger Automobile and Light Truck Greenhouse Gas  
Emission Regulations under the *Canadian Environmental Protection Act, 1999*



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## List of acronyms

AC – Air conditioner

ATV – Advanced technology vehicle

CAFE – Corporate average fuel economy

CEPA – Canadian Environmental Protection Act, 1999

CO – Carbon monoxide

CO<sub>2</sub> – Carbon dioxide

CO<sub>2</sub>e – Carbon dioxide equivalent

CREE – Carbon related exhaust emissions

CWF – Carbon weight fraction

EPA – Environmental Protection Agency

FCEV – Fuel cell electric vehicle

FTP – Federal test procedure

GHG – Greenhouse gas

g/mi – grams per mile

HC – Hydrocarbons

HFET – Highway fuel economy test

LT – Light truck

NO<sub>x</sub> – Oxides of nitrogen

N<sub>2</sub>O – Nitrous oxide

PA – Passenger automobile

PM – Particulate matter

TOF – Temporary optional fleet

VMT – Vehicle miles travelled

ZEV – Zero emission vehicle

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## Executive summary

The *Passenger Automobile and Light Truck Greenhouse Gas Emission Regulations* (hereinafter referred to as the “regulations”) establish greenhouse gas (GHG) emission standards for new 2011 and later model year light-duty on-road vehicles offered for sale in Canada. These regulations require importers and manufacturers of new vehicles to meet fleet average emission standards for greenhouse gases. The Regulations also establish annual compliance reporting requirements. This report summarizes the fleet average greenhouse gas emission performance of the fleets of light-duty vehicles. It also provides a compliance summary for each of the obligated companies including their individual fleet average carbon dioxide equivalent (CO<sub>2e</sub>)<sup>1</sup> emissions value (referred to as the “compliance value”) and the status of their emission credits.

The CO<sub>2e</sub> emission standards are company-unique and are based on the footprint and the quantity of vehicles offered for sale in a given model year. These footprint-based target values are aligned with those of the United States Environmental Protection Agency (EPA) and have increased in stringency from the 2012 through 2026 model years<sup>2</sup>. Since the Canadian greenhouse gas standards were introduced prior to the U.S. EPA program, the 2011 model year target values in Canada were instead based on the U.S. Corporate Average Fuel Economy (CAFE) levels. Since the introduction of the regulations, the fleet average standards for passenger automobiles and for light trucks have become more stringent by 45.7% and 40.9% respectively.

A company’s performance relative to its standard is determined through its sales weighted fleet average emissions performance for the given model year for its new passenger automobile and light truck offerings, expressed in grams per mile of CO<sub>2e</sub> based on standardized emissions tests simulating city and highway driving cycles. The emissions measured during these test procedures include CO<sub>2</sub> and other carbon related combustion products, namely carbon monoxide (CO) and hydrocarbons (HC). This ensures that all carbon containing exhaust emissions are also recognized. These regulations also set limits for the release of other greenhouse gases such as methane (CH<sub>4</sub>) and nitrous oxide (N<sub>2</sub>O). A number of mechanisms are incorporated into the regulations which provide companies with a series of options to achieve the applicable greenhouse gas standards while incentivizing the deployment of new greenhouse gas reducing technologies. These mechanisms include allowances for vehicle improvements and complementary innovative technologies that contribute to the reduction of greenhouse gas emissions in ways that are not directly measured during standard tailpipe emissions testing. Flexibility mechanisms include recognition of the emission benefits of dual-fuel capability, electrification and other technologies that contribute to improved greenhouse gas performance. The regulations also include an emission credit system that allows companies to generate emission credits if their fleet average performance is superior to the standard. Emission credits can be accumulated for future use to offset emission deficits (a deficit is incurred if a company’s fleet performance is above their applicable standard). This allows companies to

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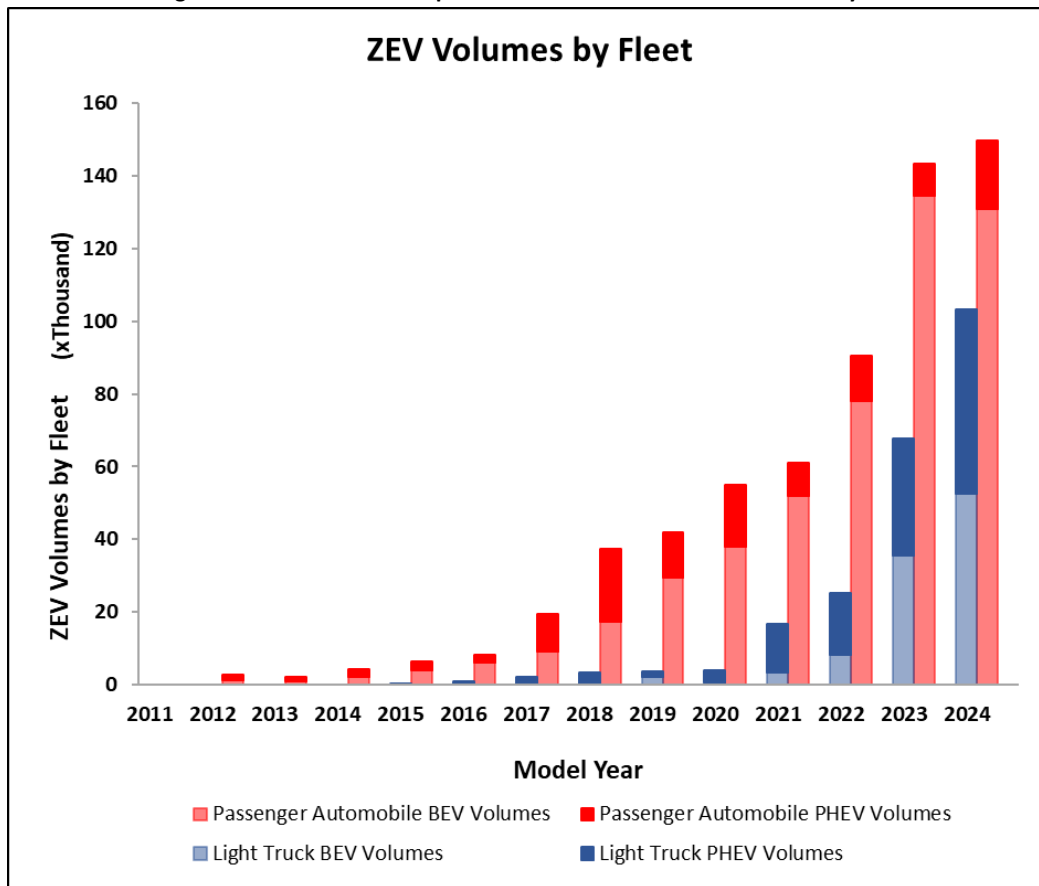
<sup>1</sup> CO<sub>2e</sub> is used throughout this report as a common unit to standardize the environmental impacts of different greenhouse gases (such as N<sub>2</sub>O & CH<sub>4</sub>) in terms of an equivalent amount of CO<sub>2</sub>.

<sup>2</sup> In December 2021, the U.S. EPA published its Final Rule which increased the stringency of GHG standards for model years 2023 to 2026.

maintain regulatory compliance as their product mix and demands change year to year and through product cycles which may result in fleet average performance above the standard. Companies that generate emission credits may transfer those credits to other companies. Emission credits generated for performance superior to the standard have a lifespan which is determined based on the model year in which they were generated, whereas deficits generated for performance worse than the standard must be offset within 3 years from the model year in which the deficit was incurred. Compliance to the regulations and the corresponding tracking of credits is monitored, in part, through the annual reports and companies are required to maintain all relevant records relating to their vehicle greenhouse gas emissions performance.

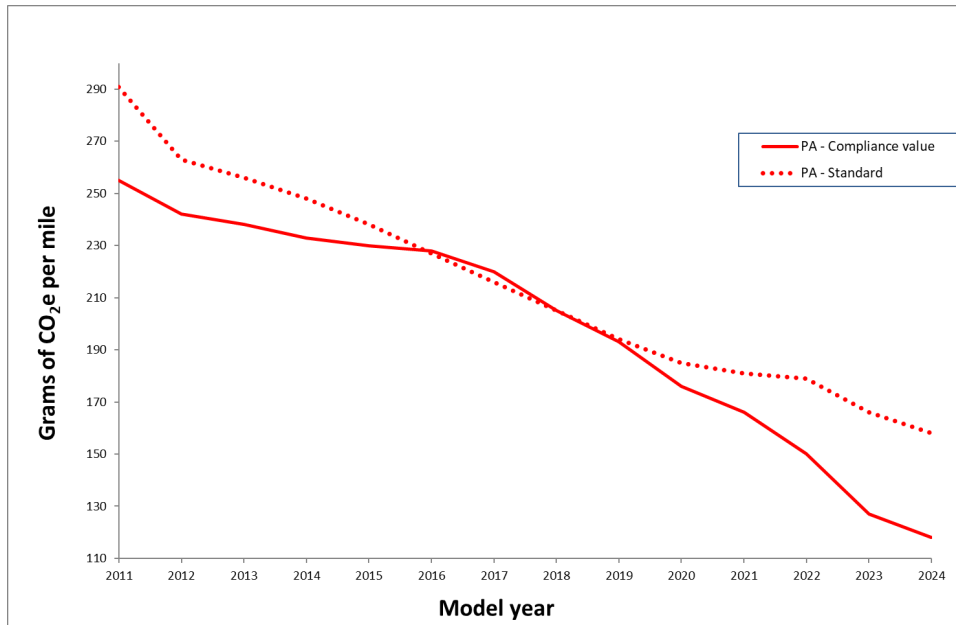
The regulations have been instrumental in influencing companies to make progressive improvements to the efficiency and GHG reductions of their new light duty vehicle fleets available in Canada since the 2011 model year. These regulations have required companies to meet progressively more stringent GHG standards which has pushed new approaches and engineering changes to meet the requirements through the introduction of a wide variety of new and innovative technologies. To meet the regulatory standards, companies have continued to refine and improve upon conventional internal combustion engine technologies as well as incorporate an array of other innovative approaches such as active aerodynamics, advanced materials for light-weighting, solar reflective paint, high efficiency lighting and more. As a result of the regulations companies have been driven to look at alternative propulsion technologies (such as hybrid electric vehicles) and increase the availability of advanced technology vehicles with lower to zero GHG emissions, which consist of battery electric vehicles (BEV), plug-in hybrid electric vehicles (PHEV), and fuel cell electric vehicles (FCEV), collectively referred to as zero emission vehicles (ZEVs), and natural gas vehicles (NGVs). In fact, since the introduction of the regulation, the volume of ZEVs reached 14.8% for the 2024 model year. More specifically, battery electric vehicles have increased from 198 to 184,402 representing 10.7% of the total fleet in 2024, and the volume of plug-in hybrid electric vehicles has increased from 0 to 69,598 representing 4.0% of the total fleet in 2024. The sum of these developments within the Canadian vehicle fleets have resulted in measurable improvements to GHG emissions performance, and an increasing number of ZEVs are expected to continue to gain market share as standards continue to increase in stringency.

Figure ES-1. Increase in ZEV production from the 2011 to 2024 model years



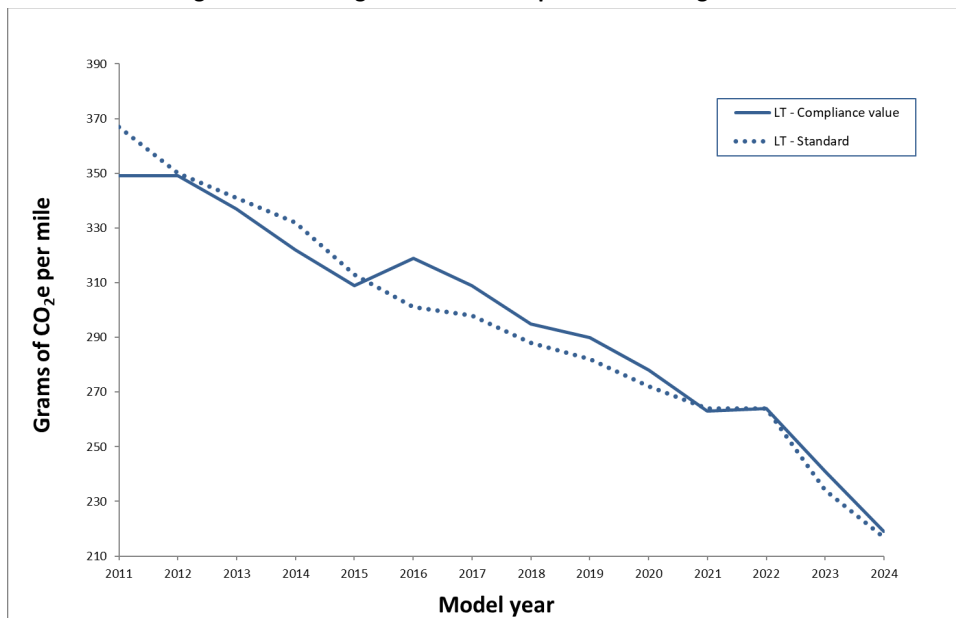
Results from annual regulatory compliance reports indicate that companies continue to be in compliance through the 2024 model year. The average compliance value for the fleet of new passenger automobiles has decreased from 255 g/mi to 118 g/mi since the introduction of the regulation, representing a 53.7% reduction.

Figure ES-2. average GHG emissions performance - passenger automobiles



The compliance value for light trucks decreased by 37.3%, from 349 g/mi to 219 g/mi since the introduction of the regulation. All companies remained in compliance with the regulations by either meeting their applicable standard, through the use of their own accumulated emission credits or by purchasing credits from other companies.

Figure ES-3. average GHG emissions performance - light trucks



Under the regulations, companies have generated a total of approximately 124.9 million credits, of which, approximately 31.9 million are available for future use. A total of 42.4 million credits have been used to offset emission deficits by individual companies over the 2011 to 2024 model years, of which 3.4

million credits were used to offset deficits accrued in the 2024 model year. The remaining 50.6 million credits have expired.

## 1. Purpose of the report

The purpose of this report is to provide company specific results for the fleet average greenhouse gas emission (GHG) performance of the Canadian fleets of passenger automobiles (PA) and of light trucks (LT)<sup>3</sup>. Building on the previous GHG emissions performance report for the 2023 model year, this report focuses on the GHG emissions performance of the last 4 model years (2021-2024). The results presented herein are based on data submitted by companies in their annual regulatory compliance reports, pursuant to the *Passenger Automobile and Light Truck Greenhouse Gas Emission Regulations*, which have undergone a thorough review by Environment and Climate Change Canada (ECCC). The report assists with identifying trends in the Canadian automotive industry including the adoption and emergence of technologies that have the potential to reduce GHG emissions. It also serves to describe emission credit trading under the regulations.

## 2. Overview of the regulations

In October 2010, the Government of Canada published the *Passenger Automobile and Light Truck Greenhouse Gas Emission Regulations*<sup>4</sup> (regulations) under CEPA. This was the first Government of Canada regulation targeting GHG's and was a major milestone for ECCC towards addressing GHG emissions from the Canadian transportation sector. The regulations and the subsequent amendments introduced progressively more stringent GHG emission targets for new light-duty vehicles of model years 2011 to 2026 in alignment with the U.S. national standards, thereby establishing a common North American approach.

The department assesses compliance with the fleet average requirements through annual reports. These reports establish each company's fleet average GHG performance and the applicable standard for both its passenger automobile and light truck fleets<sup>5</sup>. The regulations include compliance provisions, including the ability for companies to accrue emission credits or deficits, depending on their fleet performance relative to the standard. The department uses these reports to monitor emission credit balances, track transfers between companies, and assess whether the regulatory requirements have been met. There are in excess of 10,000 data elements collected each reporting cycle. ECCC reviews and validates company data and the results may be subject to change should new information become available.

Companies that submitted a report pursuant to the regulations during 2021 to 2024 model years are listed in Table 1.

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<sup>3</sup> The department has released 10 reports documenting the overall fleet performance from earlier model years.

<sup>4</sup> [The regulations, along with amendments, and the accompanying regulatory impact analysis statement](#)

<sup>5</sup> Definitions of passenger automobile and light truck can be found in the Regulations

**Table 1: model year report submission status**

Manufacturer	Common Name	2021	2022	2023	2024
Aston Martin Lagonda Ltd.	Aston Martin	LVM <sup>a</sup>	LVM <sup>a</sup>	LVM <sup>a</sup>	LVM <sup>a</sup>
BMW Canada Inc.	BMW	*	*	*	*
BYD Canada Company Limited	BYD	*	--	--	--
FCA Canada Inc.	FCA	*	*	*	*
Ferrari North America Inc.	Ferrari	LVM <sup>a</sup>	LVM <sup>a</sup>	LVM <sup>a</sup>	LVM <sup>a</sup>
Ford Motor Company of Canada Ltd.	Ford	*	*	*	*
General Motors of Canada Company	GM	*	*	*	*
Honda Canada Inc.	Honda	*	*	*	*
Hyundai Auto Canada Corp.	Hyundai	*	*	*	*
Jaguar Land Rover Canada ULC	JLR	*	*	*	*
Kia Canada Inc.	Kia	*	*	*	*
Lotus Cars Ltd.	Lotus	LVM <sup>a</sup>	LVM <sup>a</sup>	LVM <sup>a</sup>	LVM <sup>a</sup>
Lucid Motors Canada ULC	Lucid	--	*	*	*
Maserati North America Inc.	Maserati	*	*	LVM <sup>a</sup>	LVM <sup>a</sup>
Mazda Canada Inc.	Mazda	*	*	*	*
McLaren Automotive Limited	McLaren	LVM <sup>a</sup>	LVM <sup>a</sup>	LVM <sup>a</sup>	LVM <sup>a</sup>
Mercedes-Benz Canada Inc.	Mercedes	*	*	*	*
Mitsubishi Motor Sales of Canada, Inc.	Mitsubishi	*	*	*	*
Morgan Olson Canada Corp.	Morgan Olson	--	--	--	LVM <sup>a</sup>
Nissan Canada Inc.	Nissan	*	*	*	*
Pagani Automobili SPA, Italy	Pagani	LVM <sup>a</sup>	LVM <sup>a</sup>	LVM <sup>a</sup>	LVM <sup>a</sup>
Porsche Cars Canada, Ltd.	Porsche	*	*	*	*
Rivian Automotive Canada Inc.	Rivian	--	--	--	*
Subaru Canada Inc.	Subaru	*	*	*	*
Tesla Motors, Inc.	Tesla	*	*	*	*
Toyota Canada, Inc.	Toyota	*	*	*	*
VinFast Auto Canada Inc.	VinFast	--	--	--	*
Volkswagen Group Canada, Inc.	Volkswagen	*	*	*	*
Volvo Cars of Canada Corp.	Volvo	*	*	*	*

\*Indicates that a report has been submitted  
 -- Indicates that a report was not submitted  
<sup>a</sup> Beginning with the 2012 model year, low volume manufacturers (LVM) may elect to exempt themselves from CO<sub>2</sub>e standards. This exemption does not have a noticeable impact on fleet-wide performance given the small volume of vehicles.

## 2.1. CO<sub>2</sub>e emission standards

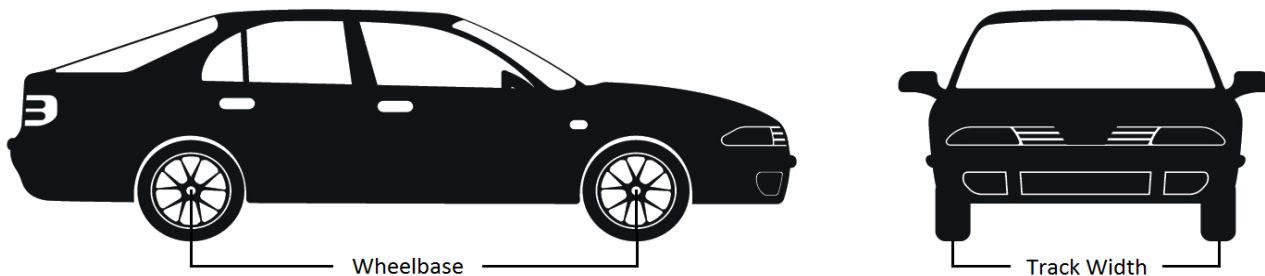
The applicable standards for a given model year are based on prescribed carbon dioxide (CO<sub>2</sub>e) emission “target values” that are a function of the “footprint” (Figure 1) and quantity of the vehicles in each company’s fleet of passenger automobiles and light trucks offered for sale<sup>6</sup> to the first retail purchaser<sup>7</sup>.

<sup>6</sup> The terms “sold”, “offered for sale” and “production volume” are used interchangeably in this report to designate the quantity of vehicles manufactured in Canada or imported in Canada for the purpose of first retail sale.

<sup>7</sup> The regulations exclude “used vehicles” imported into Canada, new vehicles exported from Canada, emergency vehicles, and vehicles imported on a temporary basis for the purposes of exhibition, demonstration, evaluation and testing.

These standards are performance-based in that they establish a maximum amount of CO<sub>2</sub>e on a gram per mile basis. This progressively more stringent approach allows companies to choose from an ever-changing array of the most cost-effective technologies to achieve compliance and reduce emissions, rather than requiring a particular technology.

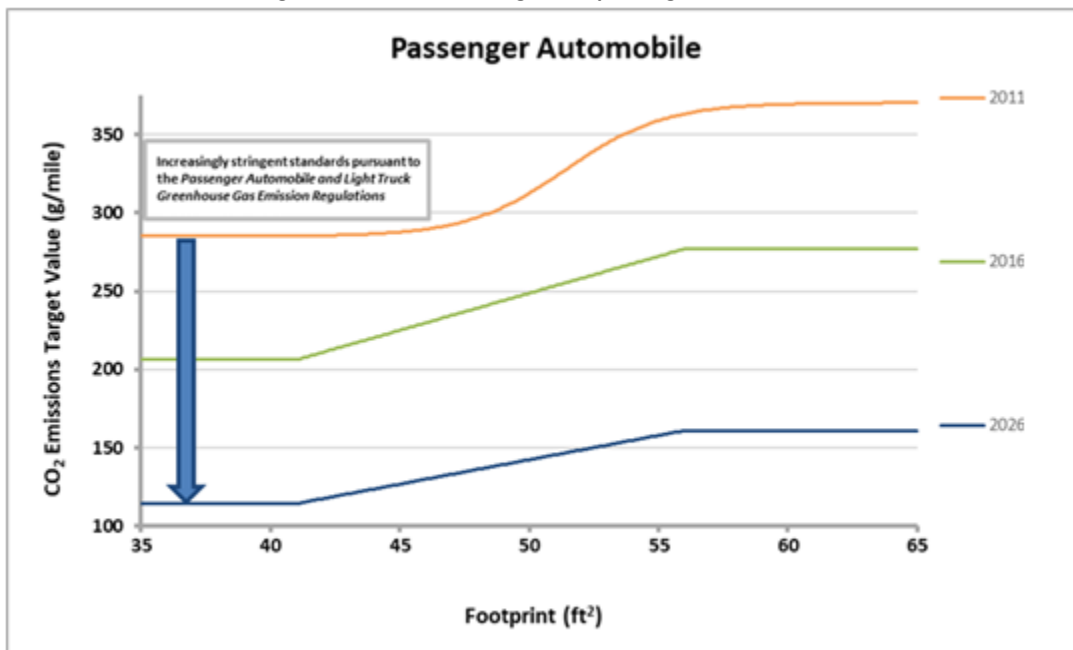
Figure 1: vehicle footprint



$$Footprint = \frac{front\ track\ width + rear\ track\ width}{2} \times wheelbase$$

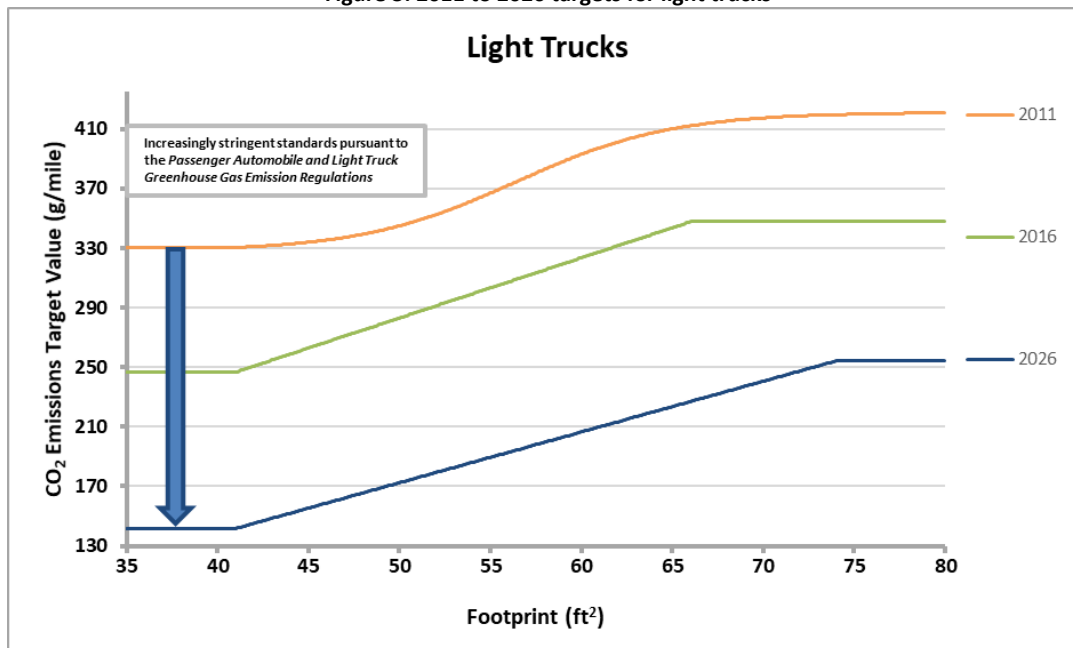
The regulations prescribe progressively more stringent target values for a given footprint size over the 2011 through 2026 model years<sup>8</sup>. Figures 2 and 3 illustrate the target values for passenger automobiles and light trucks, respectively.

Figure 2: 2011 to 2026 targets for passenger automobiles



<sup>8</sup> See footnote 2

Figure 3: 2011 to 2026 targets for light trucks



As depicted in Figures 2 and 3, the targets for the 2011 model year are unique in that they follow a smooth curve. This is because the 2011 target values were introduced 1 year prior to the U.S. Environmental Protection Agency (EPA) program and were instead based on the U.S. Corporate Average Fuel Economy (CAFE) levels. Accordingly, the regulations considered the consumption of fuel as the basis to establish reasonable approximations of GHG performance for the 2011 model year<sup>9</sup>. The CO<sub>2</sub>e standard was derived using a conversion factor of 8,887 grams of CO<sub>2</sub>/gallon of gasoline<sup>10</sup> for the 2011 model year only.

For the 2012 and later model years, the CO<sub>2</sub>e emissions target values are aligned with the U.S. EPA target values.

The overall passenger automobile and light truck fleet average standard that a company must meet is ultimately determined by calculating the sales weighted average of all the target values using the following formula:

$$\text{Fleet Average Standard} = \frac{\Sigma (A \times B)}{C}$$

where

<sup>9</sup> The fuel economy target values that apply to vehicles of the 2011 model year are calculated using the following formula:

$$T = 1 / ((1/a) + (1/b) - (1/a)) * ((e^{(x-c)/d}) / (1 + e^{(x-c)/d}))$$

Where: x is the footprint for the vehicle in question, a = 31.20, b = 24.00, c = 51.41, d = 1.91 for PA's

and a = 27.10, b = 21.10, c = 56.41, d = 4.28 for LT's

<sup>10</sup> Although the conversion factor 8,887 is specific to gasoline, it was applied fleet-wide since the proportion of vehicles using other fuel types is very low.

**A** is the CO<sub>2</sub>e emission target value for each group of passenger automobiles or light trucks having the same emission target

**B** is the number of passenger automobiles or light trucks in the group in question

**C** is the total number of passenger automobiles or light trucks in the fleet

The final company-unique fleet average CO<sub>2</sub>e standards for the 2021 to 2024 model years are presented in Table 2. These represent the regulatory values that a company’s fleets of passenger automobiles and light trucks must meet.

**Table 2: fleet average CO<sub>2</sub>e standard (g/mi)**

Manufacturer	2021 PA	2022 PA	2023 PA	2024 PA	2021 LT	2022 LT	2023 LT	2024 LT
BMW	183	182	167	159	256	251	217	210
FCA	205	203	187	152	282	291	255	227
Ford	194	190	178	165	291	281	268	243
GM	177	175	161	159	293	286	253	243
Honda	180	177	164	156	237	240	215	202
Hyundai	179	177	163	162	252	240	216	201
JLR	183	181	163	161	256	257	230	219
Kia	177	176	161	159	234	239	211	202
Lucid	--	202	189	180	--	--	--	--
Maserati	212	--	--	--	262	--	--	--
Mazda	178	173	161	155	231	228	204	200
Mercedes	192	190	178	171	255	251	226	217
Mitsubishi	171	167	150	140	219	222	199	189
Nissan	179	176	162	153	234	247	210	204
Porsche	178	173	162	145	251	248	221	210
Rivian	--	--	--	--	--	--	260	242
Subaru	174	173	158	150	225	227	202	189
Tesla	198	195	180	171	253	249	223	251
Toyota	179	176	163	155	249	246	221	210
VinFast	--	--	187	180	--	--	--	--
Volkswagen	178	176	162	152	247	240	214	200
Volvo	191	185	168	160	249	246	219	208
Fleet Average	181	179	166	158	264	264	234	217

A company’s average footprint (Table 3) is one of the factors in establishing their CO<sub>2</sub>e standards. Companies are responsible for meeting their own unique fleet average CO<sub>2</sub>e standard based on the size of vehicles they produce. However, the regulations provide additional compliance flexibilities for intermediate sized companies to make use of an alternative schedule of annual emission standards for the 2021 to 2024 model years (discussed in section 2.3.7.).

**Table 3: average footprint for the 2021 to 2024 model years (sq. ft.)**

Manufacturer	2021 PA	2022 PA	2023 PA	2024 PA	2021 LT	2022 LT	2023 LT	2024 LT
BMW	46.2	46.9	47.1	46.8	52	51.8	50	51
FCA	52.0	52.3	52.5	43.3	57.8	61.2	59.7	55.7
Ford	49.2	49.8	50.4	48.7	61	60.1	63	59.8
GM	43.3	43.9	45.4	47.0	61.8	61.3	59.3	59.9
Honda	45.7	45.8	46.1	46.1	47.8	49.5	49.5	49
Hyundai	45.3	45.7	46.0	47.9	51.2	49.4	49.7	48.6
JLR	46.4	46.8	45.8	47.7	52	53.2	53.2	53.5
Kia	44.9	45.3	45.4	46.9	47	49.2	48.6	49
Lucid	--	52.1	53.2	53.2	--	--	--	--
Maserati	53.7	--	--	--	53.4	--	--	--
Mazda	44.9	44.4	44.9	45.4	46.5	46.7	46.7	48.6
Mercedes	48.7	49.4	50.4	50.6	51.8	51.9	52.2	52.9
Mitsubishi	42.4	41.8	40.4	38.7	43.9	45.3	45.6	45.6
Nissan	45.4	45.4	45.5	45.1	47.1	50.9	48.4	49.5
Porsche	45.1	44.5	45.5	42.8	50.8	51.1	50.9	51.2
Rivian	--	--	--	--	--	--	60.7	59.5
Subaru	44.2	44.7	44.4	44.5	45.2	46.4	46.3	45.5
Tesla	50.1	50.3	50.5	50.6	51.3	51.5	51.6	61.9
Toyota	45.4	45.4	45.8	45.8	50.6	50.9	50.9	51.2
VinFast	--	--	52.7	53.6	--	--	--	--
Volkswagen	45.2	45.3	45.6	45.0	50.1	49.4	49.3	48.5
Volvo	48.3	47.6	47.3	47.3	50.5	50.7	50.6	50.7
Fleet Average	45.8	46.3	46.8	46.7	54.4	55.4	54.5	53.1

## 2.2. Carbon-related exhaust emissions

The fleet average carbon-related exhaust emission (CREE) value is the sales-weighted average performance of a company in a given model year for its passenger automobile and light truck fleets, expressed in grams of CO<sub>2</sub>e per mile. The CREE value is a single number that represents the average carbon exhaust emissions from a company’s total fleets of passenger automobiles and light trucks. The emission values to calculate a CREE value are measured using 2 emissions test procedures: the Federal Test Procedure (FTP) and the Highway Fuel Economy Test (HFET). The FTP and HFET tests are more commonly referred to as the city and highway tests. These 2 tests ensure that the CREE is measured in a manner that is consistent across the automobile industry. During these tests, manufacturers measure the carbon-related combustion products including carbon dioxide (CO<sub>2</sub>), carbon monoxide (CO), and hydrocarbons (HC). This ensures that all carbon-containing exhaust emissions that ultimately contribute to the formation of CO<sub>2</sub> are recognized.

The CREE for each vehicle model type is calculated based on actual emission constituents (such as CO<sub>2</sub>, HC, and CO) from that model over the city and highway tests. The 2 test results are then combined based on a 55% city and 45% highway driving distribution. A company’s final CREE value is based on the sales weighted average of the combined test results for each model, and the number of vehicles manufactured in Canada or imported into Canada for the purpose of sale.

The calculated fleet average CREE values achieved by companies over the 2021 to 2024 model years are presented in Table 4.

**Table 4: fleet average carbon related exhaust emissions (g/mi)**

Manufacturer	2021 PA	2022 PA	2023 PA	2024 PA	2021 LT	2022 LT	2023 LT	2024 LT
BMW	233	223	178	170	274	266	228	228
FCA	326	336	356	40	347	360	341	318
Ford	107	107	40	99	316	311	300	291
GM	206	160	101	204	351	344	331	285
Honda	213	201	209	208	252	269	259	229
Hyundai	187	178	159	95	293	242	253	239
JLR	309	342	360	333	320	332	340	319
Kia	181	174	164	96	265	271	255	245
Lucid <sup>11</sup>	--	0	0	0	--	--	--	--
Maserati	379	--	--	--	390	--	--	--
Mazda	229	197	194	221	261	262	255	242
Mercedes	278	260	170	150	316	314	280	278
Mitsubishi	183	157	200	178	261	251	189	187
Nissan	219	208	197	175	246	284	240	248
Porsche	217	263	251	312	329	335	333	293
Rivian <sup>11</sup>	--	--	--	--	--	--	0	0
Subaru	268	256	284	262	229	246	213	224
Tesla <sup>11</sup>	0	0	0	0	0	0	0	0
Toyota	187	187	166	148	248	250	221	213
VinFast <sup>11</sup>	--	--	0	0	--	--	--	--
Volkswagen	223	236	229	184	288	270	220	241
Volvo	87	43	21	17	249	245	240	218
Fleet Average	188	173	149	141	298	300	274	254

### 2.3. Compliance flexibilities

The regulations provide various compliance flexibilities that encourage the introduction of advanced technologies which reduce GHG emissions, account for innovative technologies whose impacts are not easily measured during standard emissions tests, and reduce the compliance burden on low and intermediate volume companies. The regulations also recognize the GHG reduction potential of vehicles capable of operating on fuels produced from renewable sources (such as ethanol). The aforementioned compliance flexibilities are discussed in the following sub-sections.

#### 2.3.1. Allowances for reduction in refrigerant leakage (E)

Refrigerants currently used by air conditioner (AC) systems have a global warming potential<sup>12</sup> (GWP) that is much higher than CO<sub>2</sub>. Consequently, the release of these refrigerants into the environment has a more significant impact on the formation of greenhouse gases than an equal amount of CO<sub>2</sub>. The regulations include provisions which recognize the reduced GHG emissions from improved AC systems designed to minimize refrigerant leakage into the environment. Based on the performance of the AC system components, manufacturers can calculate a total annual refrigerant leakage rate for an AC system which, in combination with the type of refrigerant, determines the CO<sub>2</sub>e leakage reduction in grams per mile (g/mi) for each of their air conditioning systems. The maximum allowance value that can be generated for

<sup>11</sup> Tesla, VinFast, Lucid, and Rivian only produce battery electric vehicles and use the 0 g/mi incentive for their CREE as described in section 2.3.5.

<sup>12</sup> Additional information relating to GWP's can be found on [Canada's action on climate change website](#).

an improved air conditioning system in a passenger automobile is 12.6 g/mi for systems using traditional HFC-134a refrigerant, and 13.8 g/mi for systems using refrigerant with a lower GWP. These maximum allowance values for air conditioning systems equipped in light trucks is 15.6 g/mi and 17.2 g/mi, respectively.

The total fleet average allowance for reduction in AC refrigerant leakage is calculated using the following formula:

$$E = \frac{\Sigma (A \times B)}{C}$$

where

**A** is the CO<sub>2</sub>e leakage reduction for each of the air conditioning systems in the fleet that incorporates those technologies;

**B** is the total number of vehicles in the fleet equipped with the air conditioning system; and

**C** is the total number of vehicles in the fleet.

Table 5 shows the leakage allowances in g/mi for the 2021 to 2024 model years.

**Table 5: allowance for reduction in AC refrigerant leakage (g/mi)**

Manufacturer	2021 PA	2022 PA	2023 PA	2024 PA	2021 LT	2022 LT	2023 LT	2024 LT
BMW	13.6	13.7	13.7	13.7	17.2	17.2	17.2	17.2
FCA	13.8	13.8	13.8	13.8	17.2	17.2	17.2	17.2
Ford	13.8	13.8	13.8	13.8	17.2	17.2	17.2	17.2
GM	13.6	13.6	13.8	13.8	17.2	17.2	17.2	17.2
Honda	13.5	12.3	12.1	12.1	17.2	16.7	15.7	15.7
Hyundai	13.7	13.6	13.6	13.7	16.9	17.1	17.1	17.1
JLR	13.7	12.3	13.7	13.7	17.2	16.7	17	17
Kia	13.5	13.5	13.6	13.7	16.9	16.6	16.9	17
Lucid	--	13.8	13.8	13.8	--	--	--	--
Maserati	13.8	--	--	--	17.2	--	--	--
Mazda	12	13.5	13.4	13.7	15.1	16.8	17	16.8
Mercedes	13.8	13.8	14.3	13.8	17.2	17.2	16.8	17.2
Mitsubishi	13.1	13.4	13.3	13.6	15.9	16.4	16.3	16.3
Nissan	13.3	13.3	12.1	13.6	16.7	16.7	16.6	16.7
Porsche	--	--	--	--	--	--	--	--
Rivian	--	--	--	--	--	--	17.2	17.2
Subaru	12.1	12	12	12	15.1	15.3	15.2	15.1
Tesla	13.6	13.5	13.6	13.6	17	16.6	16.4	16.9
Toyota	12	12	12.9	13	15.4	15.7	16.2	16.3
VinFast	--	--	13.8	11.7	--	--	--	--
Volkswagen	13.5	13.3	13.2	13.3	16.7	16.6	16.6	16.4
Volvo	13.8	13.8	13.8	13.7	17.1	17.2	17.2	16.4
Fleet Average	13.1	13.0	13.1	13.2	16.6	16.7	16.7	16.6

### 2.3.2. Allowances for improvements in air conditioning efficiency (F)

Improvements to the efficiency of vehicle air conditioning systems can result in significant reductions in CO<sub>2</sub>e emissions that are not directly measurable during standard emissions test procedures. Implementing specific technologies (for example, more efficient compressors, motors, fans etc.) can reduce the amount of engine power required to operate the air conditioning system which, in turn, reduces the quantity of fuel that is consumed and converted into CO<sub>2</sub>. The regulations contain provisions which recognize the reduced GHG emissions from AC systems with improved efficiency. Manufacturers can claim these allowances by either submitting proof of U.S. EPA approval for the efficiency-improving technology, or by selecting, during reporting, the applicable technologies from a pre-approved menu (Appendix A-2) that have an assigned value. These allowance values are aligned with those established by the U.S. EPA and may be applied cumulatively to an AC system. For the 2017 and later model years, the maximum allowance value for improvements in air conditioning efficiency is 5.0 g/mi for passenger automobiles and 7.2 g/mi for light trucks.

Once the air conditioning efficiency allowances are determined for each AC system, the overall allowance applicable to a company's fleet of vehicles is determined with the following formula:

$$F = \frac{\Sigma (A \times B)}{C}$$

where

**A** is the air conditioning efficiency allowance for each of the air conditioning systems in the fleet that incorporate those technologies

**B** is the total number of vehicles in the fleet equipped with the air conditioning system; and

**C** is the total number of vehicles in the fleet.

Table 6 shows the fleet average allowance values in g/mi for the 2021 to 2024 model years.

**Table 6: allowance for improvements in AC system efficiency (g/mi)**

Manufacturer	2021 PA	2022 PA	2023 PA	2024 PA	2021 LT	2022 LT	2023 LT	2024 LT
BMW	4.9	5	5	4.9	7.1	7.2	7.2	7.2
FCA	5.0	4.8	5.0	3.7	6.9	7	7	7
Ford	4.7	4.9	4.7	4.8	7.1	7.1	7.1	7.1
GM	3.7	3.5	4.4	4.5	7	6.8	7	7
Honda	3.6	4.5	4.2	4.2	5.3	6.5	7.2	7.2
Hyundai	3.2	3.3	3.6	3.6	4.4	4.9	5	5.2
JLR	5.0	5.0	5.0	5.0	7.2	7.2	7.2	6.3
Kia	3.3	3.2	3.4	3.6	3.6	4	4.4	4.2
Lucid	--	5.0	5.0	5.0	--	--	--	--
Maserati	5.0	--	--	--	7.2	--	--	--
Mazda	1.4	3.6	4.4	4.5	1.2	4.7	5.2	6.2
Mercedes	5.0	5.0	5.2	5.0	7.2	6.9	7	7.2
Mitsubishi	4.4	4.5	4.3	4.3	5.3	6.3	5.9	5.9
Nissan	4.1	4.3	4.2	3.9	5.4	5.2	6.3	6.6
Porsche	--	--	--	--	--	--	--	--
Rivian	--	--	--	--	--	--	6.2	6.2
Subaru	3.4	4.1	4.2	4.7	6.5	6.6	6.1	6.8
Tesla	5.0	5.0	5.0	5.0	7.2	7.2	7.2	7.2
Toyota	4.8	4.7	4.6	4.5	6.6	6.7	6.3	6.1
VinFast	--	--	5.0	4.2	--	--	--	--
Volkswagen	4.8	4.6	4.2	4.4	7	6.7	6.8	6.3
Volvo	4.0	3.7	3.5	3.5	6.3	6.5	6.2	6.5
Fleet Average	3.9	4.2	4.2	4.2	6.2	6.5	6.5	6.5

### 2.3.3. Allowances for the use of innovative technologies (G)

The regulations recognize that a variety of innovative technologies that have the potential to reduce CO<sub>2</sub>e emissions cannot be measured during standard emissions test procedures. Innovative technologies can range from advanced thermal controls that reduce operator reliance on engine driven heating/cooling systems, to solar panels which can charge the battery of an electrified vehicle. Starting with the 2014 model year, companies were given the option to select applicable technologies from a menu of pre-set allowance values. This menu includes allowances for the following systems:

- waste heat recovery
- high efficiency exterior lights
- solar panels
- active aerodynamic improvements
- engine idle start-stop
- active transmission warm-up
- active engine warm-up
- thermal control technologies

Companies can report any combination of innovative technologies from this menu; however, the total allowance value for a fleet of passenger automobiles or light trucks is capped at 10 g/mi.

The total fleet average allowance for the use of innovative technologies is calculated using the following formula:

$$G = \frac{\Sigma (A \times B)}{C}$$

where

**A** is the allowance for each of those innovative technologies incorporated into the fleet;

**B** is the total number of vehicles in the fleet equipped with the innovative technology; and

**C** is the total number of vehicles in the fleet.

Table 7 summarizes the total innovative technology allowances reported by companies for model years 2021 to 2024.

**Table 7: allowance for the use of innovative technologies (g/mi)**

Manufacturer	2021 PA	2022 PA	2023 PA	2024 PA	2021 LT	2022 LT	2023 LT	2024 LT
BMW	7.5	6.2	6	5.9	13.4	12.4	12.3	12.6
FCA	11.5	4.7	2.6	4.9	10.8	11.1	9	10.9
Ford	5.5	5.8	4.2	6	17.1	14.7	11.5	12.5
GM	6.1	6	3.8	6.6	12.2	13.3	13.2	13.1
Honda	5	7.9	6.3	7.9	12.8	16.8	12.9	14.1
Hyundai	4.5	5.2	3.6	4.4	12.8	14.1	11.8	10.8
JLR	5.9	6.1	5	5.2	13.2	15.6	15.6	13.7
Kia	4.5	4.7	3.8	4.6	9.2	9.9	10.4	10.2
Lucid	--	--	--	--	--	--	--	--
Maserati	6.7	--	--	--	13.8	--	--	--
Mazda	2.6	3.8	3.5	4.1	6.8	9.5	7	8.6
Mercedes	2.2	2.5	3.2	4.6	3.7	4.3	5.3	7.4
Mitsubishi	2.8	2.8	0.9	0.7	4.8	5.7	3.9	4
Nissan	3.1	5	2	3.3	6.5	6.5	8.9	10.6
Porsche	--	--	--	--	--	--	--	--
Rivian	--	--	--	--	--	--	3.6	3.6
Subaru	1.9	2.5	1.4	3.6	8	8.7	5.1	7
Tesla	4.7	4.7	4.7	4.8	6.8	6.9	6.9	7.8
Toyota	6	6.1	5	5.6	11.7	12	10.6	12.2
VinFast	--	--	--	--	--	--	--	--
Volkswagen	8.1	8.7	7.1	7.3	13	13.8	11.1	13.9
Volvo	4.3	4.5	4.3	4.3	8.8	11.2	11.9	12.8
Fleet Average	4.9	5.7	4.2	5.3	11.7	12.3	10.6	11.4

### 2.3.4. Allowance for certain full-size pick-up trucks (H)

The 2017 model year introduced additional allowances which companies may elect to claim in respect of their full-sized pick-up trucks. These new flexibilities recognize both the hybridization and emission reduction of vehicles that can serve some utility function in the Canadian marketplace.

### 2.3.4.1. Allowance for the use of hybrid technologies on full-size pick-up trucks

Companies may elect to calculate an allowance associated with the presence of hybrid technology on full-size pick-up trucks if that technology is present on the prescribed percentage of that company's fleet of full-size pick-up trucks for that model year. The penetration rate depends on the model year in question and whether the vehicles employ "mild" or "strong" hybrid electric technology. "Mild hybrid electric technology" means a technology that has start/stop capability and regenerative braking capability, where the recaptured braking energy is between 15% and 65% of the total braking energy. "Strong hybrid electric technology" means a technology that has start/stop capability and regenerative braking capability, where the recaptured braking energy is more than 65% of the total braking energy.

### 2.3.4.2. Allowance for full-size pick-up trucks that achieve a significant emission reduction below the applicable target

Companies may claim an allowance for the models of full-size pick-up trucks that have a CREE that is between 80% and 85% of its CO<sub>2</sub>e emission target value and comprise a prescribed percentage of the fleet. The regulations also allow companies to claim an allowance for full-size pick-up trucks that have a CREE that is less than or equal to 80% of its CO<sub>2</sub>e target value and comprise at least 10% of that company's full-size pick-up truck fleet for model years 2017 to 2025.

A company can only use one of the allowances for full-size pick-up trucks for a given vehicle.

The total fleet average allowance for certain full-size pick-up trucks is calculated using the following formula:

$$H = \frac{\Sigma (A_H \times B_H) + \Sigma (A_R \times B_R)}{C}$$

where

$A_H$  is the allowance for the use of hybrid electric technologies;

$B_H$  is the number of full-size pick-up trucks in the fleet that are equipped with hybrid electric technologies;

$A_R$  is the allowance for full-size pick-up trucks that achieve a certain carbon-related exhaust emission value;

$B_R$  is the number of full-size pick-up trucks in the fleet that achieve a certain carbon-related exhaust emission value; and

$C$  is the total number of vehicles in the fleet.

In the 2024 model year Ford and Toyota made use of the allowance for the use of hybrid technologies on full-size pick-up trucks, generating 1.1 g/mile and 0.4 g/mile respectively.

### 2.3.5. Advanced technology vehicles

The regulations offer a number of additional provisions to encourage the deployment of "advanced technology vehicles" (ATVs) which consist of battery electric vehicles (BEV), plug-in hybrid electric vehicles (PHEV), fuel cell electric vehicles (FCEV) and natural gas vehicles. BEVs are completely powered by electrical energy stored in a battery, and hence produce no tailpipe emissions. PHEVs incorporate an electrical powertrain which enables them to be charged with electricity to operate solely on electrical

power, but also contain an internal combustion engine to extend the operating range of the vehicle. FCEVs are propelled solely by an electric motor where the energy for the motor is supplied by an electrochemical cell that produces electricity without combustion. When calculating a CREE, the regulations allow companies to report 0 g/mi for electric vehicles (for example, BEVs), fuel cell vehicles, and the electric portion of plug-in hybrids (when PHEVs operate as electric vehicles). Additionally, companies may multiply the number of ATVs in their fleet by a specified factor to increase the impact that they have on a company's overall fleet average. The applicable multiplying factors and the associated model years can be found in Table 8.

**Table 8: multiplying factors for advanced technology vehicles**

Model year	BEV and FCEV multiplier	PHEV multiplier	Natural gas
2011 to 2016	1.2	1.2	1.2
2017	2.5	2.1	1.6
2018	2.5	2.1	1.6
2019	2.5	2.1	1.6
2020	2.25	1.95	1.45
2021	2.0	1.8	1.3
2022 to 2024	1.5	1.3	1.0

The production volumes of BEVs and PHEVs sold by model year are presented in Tables 9 and 10.

**Table 9: production volumes of BEVs by model year**

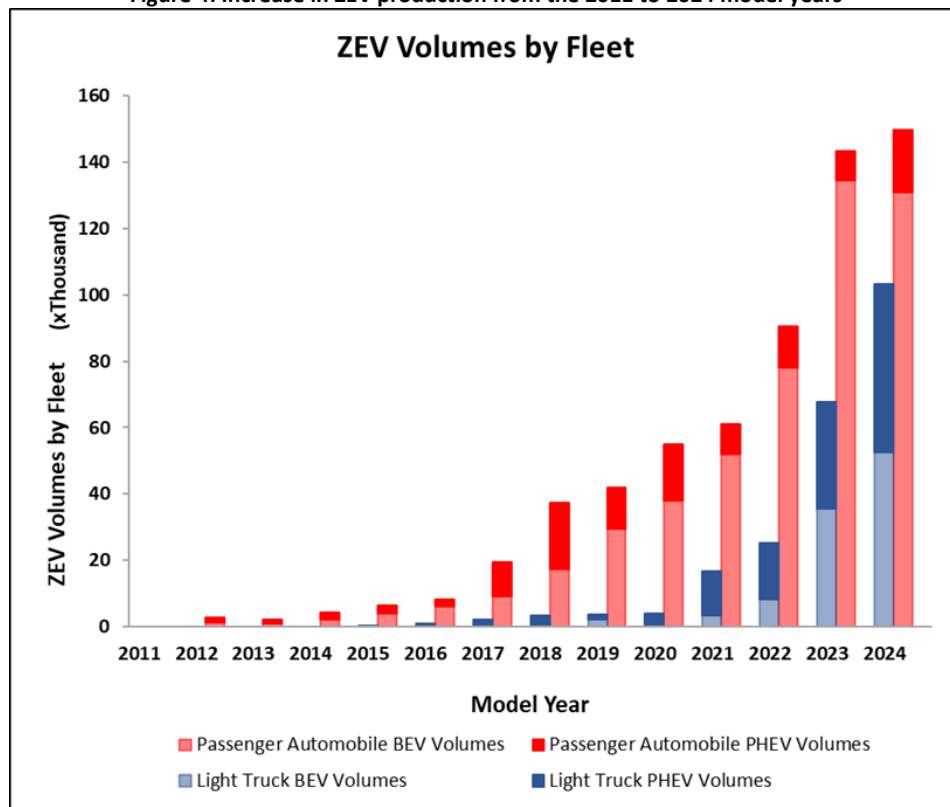
Manufacturer	2021 PA	2022 PA	2023 PA	2024 PA	2021 LT	2022 LT	2023 LT	2024 LT
BMW	391	1 013	2 743	3 613	--	406	1 792	1 683
FCA	--	--	--	4 145	--	--	--	--
Ford	5 267	6 013	10 219	7 298	--	2 122	9 507	7 518
GM	1 561	5 549	17 647	4 217	--	--	319	19 359
Honda	--	--	--	--	--	--	--	1 444
Hyundai	8 130	9 481	15 874	27 498	--	--	--	--
JLR	--	--	--	--	39	52	46	110
Kia	2 130	2 878	6 187	12 191	--	--	--	2 223
Lucid	--	99	94	140	--	--	--	--
Mazda	--	1 068	809	29	--	--	--	--
Mercedes	--	400	3 437	2 516	--	--	1 069	100
Mitsubishi	--	--	--	--	--	--	--	--
Nissan	439	916	4 650	5 409	--	--	--	--
Porsche	507	614	640	430	--	--	--	494
Rivian	--	--	--	--	--	--	883	967
Subaru	--	--	--	--	--	--	2 950	2 701
Tesla	32 414	47 711	63 824	45 074	1 450	2 811	3 359	4 108
Toyota	--	--	1 725	4 063	--	--	4 804	2 487
VinFast	--	--	801	1 764	--	--	--	--
Volkswagen	329	409	1 190	7 424	1 783	2 838	11 200	10 312
Volvo	877	1 954	4 472	5 085	--	--	--	--
Total	52 045	78 105	134 312	130 896	3 272	8 229	35 929	53 506

**Table 10: production volumes of PHEVs by model year**

Manufacturer	2021 PA	2022 PA	2023 PA	2024 PA	2021 LT	2022 LT	2023 LT	2024 LT
BMW	592	1 026	1 215	397	1 098	1 788	1 251	1 588
FCA	--	--	--	3 352	5 138	6 721	7 169	7 387
Ford	2 010	3 858	4 668	7 212	141	140	228	--
GM	--	--	--	--	--	--	--	--
Honda	172	--	--	--	--	--	--	--
Hyundai	900	381	--	--	--	3 651	2 233	3 616
JLR	--	--	--	--	140	--	37	127
Kia	488	749	351	1 231	-	674	1 914	874
Lucid	--	--	--	--	--	--	--	--
Mazda	--	--	--	285	--	--	--	4 642
Mercedes	--	--	49	--	--	--	8 624	733
Mitsubishi	300	2 105	--	--	--	--	--	13 823
Nissan	--	--	--	--	--	--	--	--
Porsche	68	53	180	--	186	291	452	626
Rivian	--	--	--	--	--	--	--	--
Subaru	--	--	--	--	259	83	174	--
Tesla	--	--	--	--	--	--	--	--
Toyota	4 254	4 175	2 100	5 961	4 939	1 904	8 103	14 412
VinFast	--	--	--	--	--	--	--	--
Volkswagen	10	20	7	67	70	121	320	268
Volvo	99	95	92	432	1 395	1 611	1 484	2 556
<b>Total</b>	<b>8 893</b>	<b>12 462</b>	<b>8 662</b>	<b>18 937</b>	<b>13 366</b>	<b>16 984</b>	<b>31 989</b>	<b>50 652</b>

Figure 4 provides a graphical representation of the overall growth in ZEV production for 2011 to 2024 model years.

**Figure 4: Increase in ZEV production from the 2011 to 2024 model years**



### 2.3.6. Provisions for small volume companies for 2012 and later model years

The regulations include provisions enabling smaller companies that may have limited product offerings to opt out of complying with the CO<sub>2</sub>e standards (non application of the standards respecting CO<sub>2</sub> equivalent emissions<sup>13</sup>) for 2012 and subsequent model years. This exemption is available to companies that:

- a. have manufactured or imported less than 750 passenger automobiles and light trucks for either the 2008 or 2009 model years
- b. have manufactured or imported for sale a running average of less than 750 vehicles for the 3 model years prior to the model year being exempted
- c. submit a small volume declaration to ECCC

A small volume company must submit an annual report to obtain credits. These companies are still required to comply with the standards for nitrous oxide and methane (refer to section 2.5 for further details).

Table 11 summarizes the production volumes reported by small volume companies. This flexibility was claimed by 6 small volume companies for the 2021 to 2024 model years.

**Table 11: production volumes for small volume manufacturers by model year**

Manufacturer	2021	2022	2023	2024
Aston Martin	132	83	219	47
Ferrari	313	493	345	348
Lotus	18	0	0	0
Maserati	474	677	1,238	448
McLaren	84	79	111	108
Morgan Olson	--	40	1 681	0
Total	1,021	1,372	2,815	951

### 2.4. Standards for nitrous oxide and methane

The regulations also limit the release of other GHG's, such as emissions of methane (CH<sub>4</sub>) and nitrous oxide (N<sub>2</sub>O). Starting with the 2012 model year, the regulations set standards for N<sub>2</sub>O and CH<sub>4</sub> at 0.01 g/mi and 0.03 g/mi respectively. These standards are intended to cap vehicle N<sub>2</sub>O and CH<sub>4</sub> emissions at levels that are attainable by existing technologies and ensure that levels do not increase with future vehicles. Companies have 3 methods by which they can meet the N<sub>2</sub>O and CH<sub>4</sub> requirements.

The first method allows companies to certify that the N<sub>2</sub>O and CH<sub>4</sub> emissions for all its vehicles of a given model year are below the cap-based standards. This method does not impact the calculation of a company's CREE.

The second method allows companies to quantify the emissions of N<sub>2</sub>O and CH<sub>4</sub> as an equivalent amount of CO<sub>2</sub> and include this in the determination of their overall CREE. Companies using this method must incorporate N<sub>2</sub>O and CH<sub>4</sub> test data into the CREE calculation, while factoring in the higher global warming

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<sup>13</sup> This exemption does not have a noticeable impact on fleet-wide performance given the small volume of vehicles.

potential of these 2 pollutants. This method is not as commonly used as it counts N<sub>2</sub>O and CH<sub>4</sub> emissions even for the portion of a company’s fleet that does not exceed the standard.

The third method allows companies to certify vehicles to alternative N<sub>2</sub>O and CH<sub>4</sub> emissions standards. This method generally offers the greatest flexibility to companies as they are left to establish alternative standards that apply only to those vehicles that would not meet the cap-based value as opposed to impacting the entire fleet. Additionally, companies using this method can comply with standards of N<sub>2</sub>O and CH<sub>4</sub> separately by setting alternative standards for either emission as needed. The g/mi difference between the alternative standard and the cap-based standard that would otherwise apply is used to determine a deficit which must be offset with conventional CO<sub>2</sub>e emissions credits. The total deficits incurred by the companies that used this method are summarized in Tables 12 and 13.

**Table 12: N<sub>2</sub>O emissions deficits by company for the 2021 to 2024 model years (Mg CO<sub>2</sub>e)**

Manufacturer	2021 PA	2022 PA	2023 PA	2024 PA	2021 LT	2022 LT	2023 LT	2024 LT
BMW	-99	-256	-271	-434	--	-83	-108	-103
FCA	--	--	--	-2 927	-9 788	-11 612	-1 158	-115
Ford	-15	-11	--	--	-5 998	-6 932	-7 149	--
GM	--	--	--	--	-105 252	-52 624	-36 969	-80 357
Hyundai	-541	-1042	-1153	-192	--	--	--	--
JLR	--	--	--	--	-797	--	--	--
Kia	-754	-1 410	-1 099	--	--	--	--	--
Mazda	-2 001	-547	-690	-1 363	-9 740	-5 330	-7 797	-14 134
Subaru	--	--	-352	-988	--	--	--	--
Toyota	-1 295	-149	-117	-185	-10 602	-5 065	-4 691	-2 706
Volkswagen	-28	-68	--	--	-149	-226	--	--
Fleet Total	-4 733	-3 483	-3 682	-6 089	-142 326	-81 872	-57 872	-97 415

**Table 13: CH<sub>4</sub> emissions deficits by company for the 2021 to 2024 model years (Mg CO<sub>2</sub>e)**

Manufacturer	2021 PA	2022 PA	2023 PA	2024 PA	2021 LT	2022 LT	2023 LT	2024 LT
FCA	--	-55	--	--	-149	-259	-74	-24
Ford	-299	-275	-81	--	-1 879	-1 829	-1 462	-319
GM	-52	--	--	--	-9	-36	-5	-4
Mazda	-194	-96	-28	-21	-20	--	--	-169
Volkswagen	-27	-36	--	-6	--	--	--	--
Fleet Total	-572	-462	-109	-27	-2 057	-2 124	-1 541	-516

## 2.5. CO<sub>2</sub>e emissions value

The fleet average CO<sub>2</sub>e emissions value, referred to as the “compliance value” is the final average CO<sub>2</sub>e performance of a company’s fleets of passenger automobiles and of light trucks, reported as CREE, after being adjusted for all available compliance flexibilities, using the following equation:

$$\text{Compliance value} = D - E - F - G - H$$

where

**D** is the fleet average carbon-related exhaust emission value for each fleet (section 2.2);

**E** is the allowance for reduction of air conditioning refrigerant leakage (section 2.3.1);

**F** is the allowance for improving air conditioning system efficiency (section 2.3.2); and

**G** is the allowance for the use of innovative technologies that have a measurable CO<sub>2</sub>e emission reduction (section 2.3.3);

**H** is the allowance for certain full-size pick-up trucks (section 2.3.4).

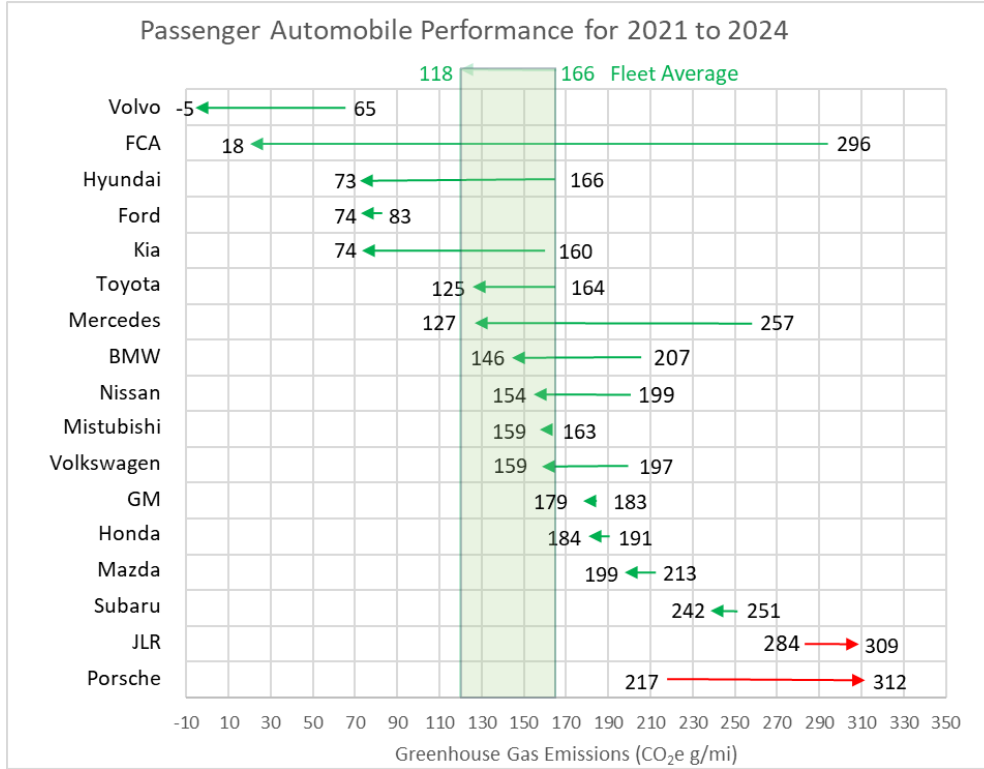
A company's compliance value for its fleet of passenger automobiles and light trucks is what is ultimately compared to its CO<sub>2</sub>e standard for both aforementioned categories to determine compliance and to establish a company's emission credit balance. Tables 14 and 15 show both the companies' compliance and standard values for the passenger automobiles and light truck fleets across the 2021 to 2024 model years. Figures 5 and 6 shows the trends in manufacturer performance over the 2021 to 2024 model years.

**Table 14: PA compliance and standard values over the 2021 to 2024 model years (g/mi)**

Manufacturer	2021 Compliance	2022 Compliance	2023 Compliance	2024 Compliance	2021 Std.	2022 Std.	2023 Std.	2024 Std.
BMW	207	198	153	146	183	182	167	159
FCA	296	313	335	18	205	203	187	152
Ford	83	83	17	74	194	190	178	165
GM	183	137	79	179	177	175	161	159
Honda	191	176	186	184	180	177	164	156
Hyundai	166	156	138	73	179	177	163	162
JLR	284	319	336	309	183	181	163	161
Kia	160	153	143	74	177	176	161	159
Lucid <sup>14</sup>	--	-19	-19	-19	--	202	189	180
Maserati	354	--	--	--	212	--	--	--
Mazda	213	176	173	199	178	173	161	155
Mercedes	257	239	147	127	192	190	178	171
Mitsubishi	163	136	182	159	171	167	150	140
Nissan	199	185	179	154	179	176	162	153
Porsche	217	263	251	312	178	173	162	145
Rivian <sup>14</sup>	--	--	--	--	--	--	--	--
Subaru	251	237	266	242	174	173	158	150
Tesla <sup>14</sup>	-23	-23	-23	-23	198	195	180	171
Toyota	164	164	144	125	179	176	163	155
VinFast <sup>14</sup>	--	--	-19	-16	--	--	187	180
Volkswagen	197	209	205	159	178	176	162	152
Volvo	65	21	-1	-5	191	185	168	160
Fleet Average	166	150	127	118	181	179	166	158

<sup>14</sup> Tesla, VinFast, Lucid and Rivian only produce electric vehicles, and are able to use the 0 g/mi incentive for its entire fleet. The compliance value may be negative once allowances have been factored in.

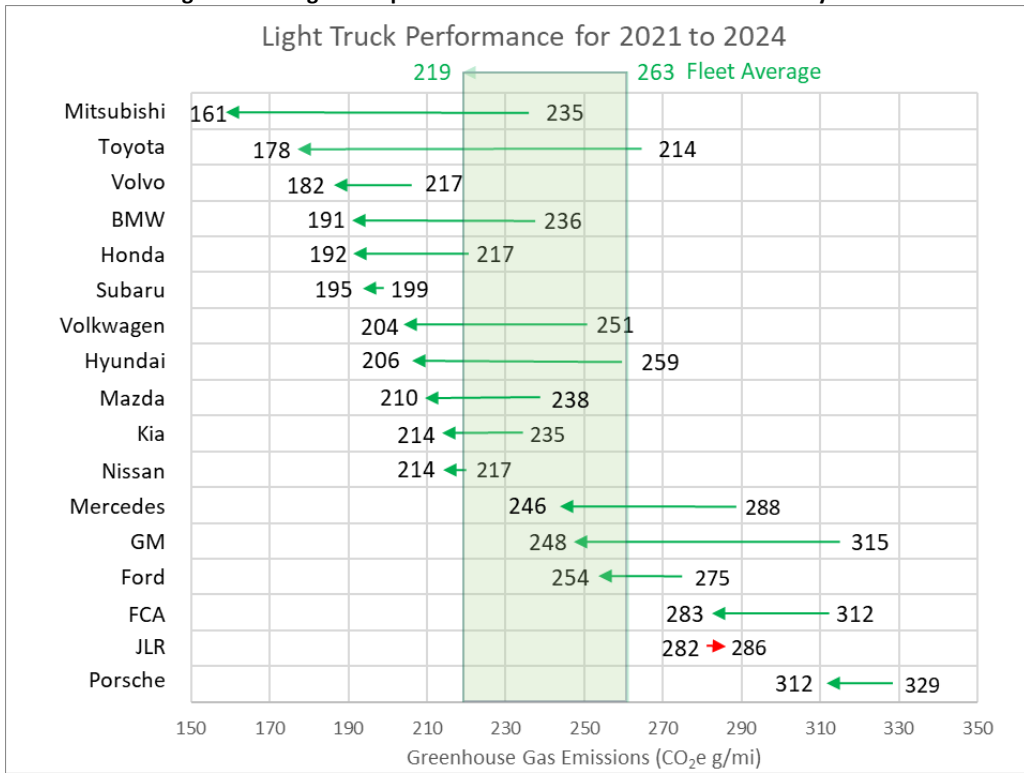
**Figure 5: Change to PA performance over the 2021 to 2024 model years**



**Table 15: LT compliance and standard values over the 2021 to 2024 model years (g/mi)**

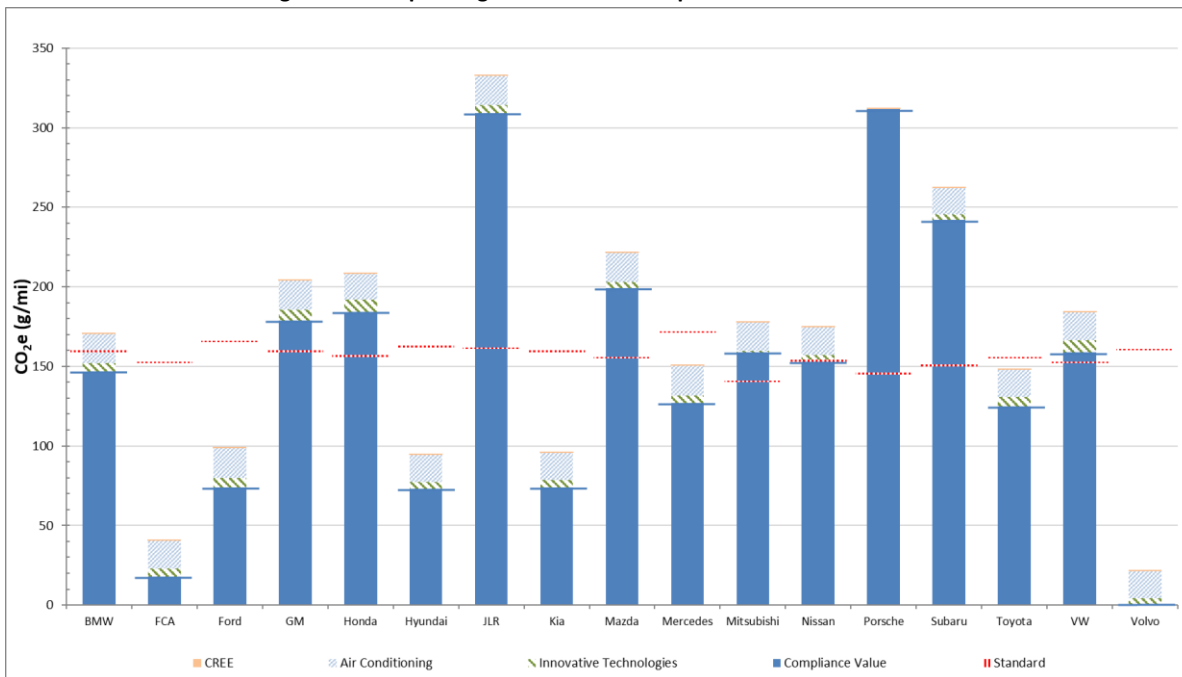
Manufacturer	2021 Compliance	2022 Compliance	2023 Compliance	2024 Compliance	2021 Std.	2022 Std.	2023 Std.	2024 Std.
BMW	236	229	191	191	256	251	217	210
FCA	312	325	308	283	282	291	255	227
Ford	275	272	264	254	291	281	268	243
GM	315	307	294	248	293	286	253	243
Honda	217	229	223	192	237	240	215	202
Hyundai	259	206	219	206	252	240	216	201
JLR	282	293	300	282	256	257	230	219
Kia	235	241	223	214	234	239	211	202
Lucid <sup>14</sup>	--	--	--	--	--	--	--	--
Maserati	352	--	--	--	262	--	--	--
Mazda	238	231	226	210	231	228	204	200
Mercedes	288	286	251	246	255	251	226	217
Mitsubishi	235	223	163	161	219	222	199	189
Nissan	217	256	208	214	234	247	210	204
Porsche	329	335	333	293	251	248	221	210
Rivian <sup>14</sup>	--	--	-27	-27	--	--	260	242
Subaru	199	215	187	195	225	227	202	189
Tesla <sup>Error! Bookmark not defined.</sup>	-31	-31	-31	-32	253	249	223	251
Toyota	214	216	188	178	249	246	221	210
VinFast <sup>14</sup>	--	--	--	--	--	--	--	--
Volkswagen	251	233	186	204	247	240	214	200
Volvo	217	210	205	182	249	246	219	208
Fleet Average	263	264	241	219	264	264	234	217

**Figure 6: Change to LT performance over the 2021 to 2024 model years**



Figures 7 and 8 provide a graphical representation of the role that compliance flexibilities play in arriving at a company’s overall compliance status for their 2024 model year passenger automobile and light truck fleets. The orange line on the top of the bar indicates a company’s fleet average CREE. The wide red line represents the fleet average standard and the wide dark blue line represents the fleet average compliance value (accounting for compliance flexibilities). The bars show the extent to which companies incorporate the previously described compliance flexibilities into their products to achieve their fleet average compliance value. Figures showing this information for prior model years are located in the appendix.

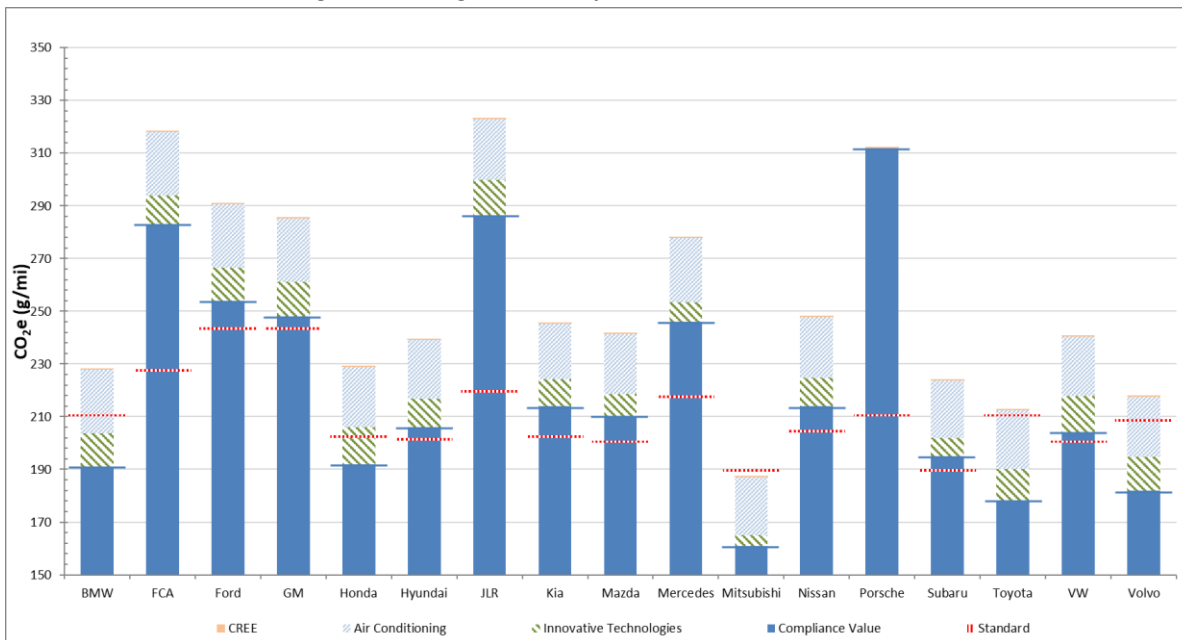
Figure 7: 2024 passenger automobile compliance status with offsets



Notes:

1. The final compliance value may be lower than the CREE through the application of compliance flexibilities
2. Tesla, Rivian, Lucid and VInFast produce electric vehicles, whose compliance values fall outside of the range of this graph.

Figure 8: 2024 light truck compliance status with offsets



Notes:

1. The final compliance value may be lower than the CREE through the application of compliance flexibilities
2. Tesla, Rivian, Lucid and VInFast produce electric vehicles, whose compliance values fall outside of the range of this graph.

## **2.6. Technological advancements and penetration rates**

As fleet average emission standards have become more stringent, automobile manufacturers have developed a variety of technologies to reduce their CO<sub>2e</sub> emissions. Some of these technologies seek to reduce or eliminate the use of conventional fuels by introducing electrical powertrain components (BEVs, PHEVs etc.). There also exists a wide range of technologies used by companies to improve the efficiency of transmissions and conventional engines and reduce emissions. Some examples include turbocharged engines, cylinder deactivation, and continuously variable transmissions.

This section, while not an exhaustive list, describes some of the commonly used technology types, along with their corresponding penetration rates in the Canadian new vehicle fleet in given model years.

### **Turbocharging**

Turbochargers improve the power and efficiency of an internal combustion engine by extracting some of the waste heat energy otherwise lost through the exhaust pipe. These exhaust gases are used to drive a turbine that is connected to a compressor which provides greater amounts of air into the combustion chamber (forced induction). This results in greater power than a naturally aspirated engine of similar displacement, and greater efficiency than a naturally aspirated engine of the same power and torque. This permits the use of smaller displacement, lighter engines that can produce the same power as larger, heavier engines without turbocharging. For this reason, it is becoming increasingly common to see turbochargers incorporated into vehicles with smaller engines in order to decrease the overall vehicle weight and improve fuel efficiency by as much as 8%.

### **Variable valve timing & lift**

Engine intake and exhaust valves are responsible for letting air into the cylinders and exhaust gases out. This is an important function since optimal engine performance requires precise “breathing” of the engine. In most conventional engines, the timing and lift of the valves is fixed, and not optimized across all engine speeds. Variable valve timing (VVT) and variable valve lift (VVL) systems adjust the timing, duration and amount that the intake and exhaust valves open based on the engine speed. This optimization of the engines ‘breathing’ improves engine efficiency resulting in reduced fuel consumption and emissions. Variable valve timing and lift technologies can result in efficiency improvements of 3-4%.

### **Higher geared transmissions (>6 speeds)**

Fuel efficiency, and by extension, CO<sub>2e</sub> emissions coming from a vehicle are dependent on the efficient operation of all the elements that make up a vehicle. An engine that is operating at speeds outside its most efficient range will result in increased fuel consumption and CO<sub>2e</sub> emissions. Transmissions with more gear ratios (or speeds), allows the engine to operate at a more efficient speed more frequently. It is becoming increasingly common for vehicles to be equipped with transmissions that have more than 6 gears to keep the engine running at its most efficient operating point and thereby reduce CO<sub>2e</sub> emissions.

### **Continuously variable transmissions**

Continuously variable transmissions (CVT) are transmissions that, unlike conventional transmission configurations, do not have a fixed number of gears. Because CVT's do not have a discrete number of shift points, they can operate variably across an infinite number of driving situations to provide the optimal speed ratio between the engine and the wheels. This ensures that the engine is able to operate as efficiently as possible and consume only as much fuel as is required, thereby lowering CO<sub>2</sub>e emissions. Typically CVT's can improve fuel efficiency by as much as 4%.

### **Cylinder deactivation system**

Cylinder deactivation systems (CDS) shut off cylinders of a 6 or 8 cylinder engine when only partial power is required (for example, travelling at constant speed, decelerating etc.). The CDS works by deactivating the intake and exhaust valves for a particular set of cylinders in the engine. A CDS can reduce CO<sub>2</sub>e emissions by improving the overall fuel consumption of the vehicle by 4 to 10%<sup>15</sup>.

### **Gasoline direct injection**

A proper air-fuel mixture is critical to the performance of any conventional internal combustion engine and has direct impacts on the resulting emissions. Over the past several decades, the most common mechanism for preparing the air-fuel mixture has been "port fuel injection". In port fuel injection systems, the air and fuel are mixed in the intake manifold and are subsequently drawn into the combustion chamber. By contrast, gasoline direct injection (GDI) systems spray fuel directly into the combustion chamber resulting in a slightly cooler air-fuel mixture allowing for higher compression ratios and improved fuel consumption. GDI systems are also better at precisely timing and metering the fuel delivered to the cylinder, which results in more efficient combustion.

### **Diesel**

Diesel engines provide greater low-end torque and fuel efficiency than a comparably sized gasoline engine. Diesel fuel contains more energy per unit volume than an equivalent amount of gasoline. As a result, diesel vehicles can travel, on average, 20 to 35% further per litre of fuel than a gasoline-based equivalent<sup>16</sup> which translates into measurable reductions in CO<sub>2</sub>e emissions.

The fleet-wide penetration rates of the above-described technologies have been provided in Table 16, while data pertaining to company specific usage can be found in Appendices A-3 to A-10.

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<sup>15</sup> [Natural Resources Canada](#)

<sup>16</sup> [US EPA website](#)

**Table 16: penetration rates of drivetrain technologies in the Canadian fleet**

Technology	2021	2022	2023	2024
Turbocharging	33.6	37.1	40.6	44.5
VVT	92.8	90.7	86.5	87.3
VVL	14.9	16.6	15.2	16.1
Higher Geared Transmission	64.4	68.7	63.9	61.6
CVT	22.7	22.5	25.7	28.3
Cylinder Deactivation	16.2	17.7	15	12.6
GDI	50.5	49.1	46.9	50.3
Diesel	1.6	1.4	1.0	1.8

### 3. Emission credits

The regulations include a system of emission credits to help meet overall environmental objectives in a manner that provides the regulated industry with compliance flexibility. A company must calculate emission credits and deficits in units of megagrams (Mg) of CO<sub>2</sub>e for each of its passenger automobile and light truck fleets of a given model year. Credits are weighted based on vehicle miles traveled (VMT) to account for the greater number of miles travelled by light trucks over their lifetime than by passenger automobiles. Using the mathematical formula below, a company will generate credits in a given model year if the result of the calculation is positive or better than the GHG emission standard. If the result of the calculation is negative or below the applicable standard, the company will incur a deficit. A company that incurs an emissions deficit must offset it with an equivalent number of emission credits from past model years or within the subsequent 3 model years.

The total credit balance is determined according to the following formula<sup>17</sup>:

$$\text{Credits} = \frac{(A - B) \times C \times D}{1,000,000}$$

Where

**A** is the fleet average standard for passenger automobiles or light trucks

**B** is the fleet average compliance value for passenger automobiles or light trucks

**C** is the total number of passenger automobiles or light trucks in the fleet

**D** is the total assumed mileage of the vehicles in question, namely:

- (a) 195,264 miles for a fleet of passenger automobiles, or
- (b) 225,865 miles for a fleet of light trucks

The credits represent the emission reductions that manufacturers have achieved in excess of those required by the regulations. The ability to accumulate credits allows manufacturers to plan and implement an orderly phase-in of emissions control technology through product cycle planning to meet future, more stringent emission standards.

<sup>17</sup> In October 2021, the Department published an [Interim Order](#) to correct the multiplier formula used to determine carbon dioxide (CO<sub>2</sub>) equivalent emission credits for advanced technology vehicles.

The regulations initially established that credits could be banked to offset a future deficit for up to 5 model years after the year in which the credits were obtained (the credits had a 5-year lifespan). The regulations were amended to extend the lifespan of credits earned during the 2010 to 2016 model years to 2021. Emission credits that can be used to offset a deficit incurred in the 2022 and later model years can only be generated beginning with the 2017 model year and have a 5-year lifespan.

### 3.1. Credit transfers

Table 17 summarizes transactions by company and the model year in which the credits were generated. There have been more than 32 million credits transferred between companies for either immediate use to offset a deficit or in anticipation of a possible future deficit, including those purchased from the Receiver General. It should be noted that the model year is not necessarily indicative of when a credit transfer occurred. For example, it is possible to transfer credits for the 2012 model year during the 2017 calendar year. As well, the total quantity transferred in or out from a company for a given model year may be the result of multiple transactions.

**Table 17: credit transactions (transferred out) by model year (Mg CO<sub>2</sub>e)**

Manufacturer	Early Action	2011 to 2020	2021	2022	2023	2024	Total
FCA	0	30 103	0	0	0	0	30 103
Honda	2 138 563	4 269 910	0	0	0	0	6 408 473
Hyundai	0	0	189 003	25 997	0	0	215 000
Lucid	0	0	0	6 381	5 721	2 898	15 000
Mazda	0	113 000	0	0	0	0	113 000
Mitsubishi	63 349	0	0	0	0	0	63 349
Nissan	822 292	402 728	0	0	0	0	1 225 020
Subaru	0	86 500	0	0	0	0	86 500
Suzuki	123 345	30 431	0	0	0	0	153 776
Tesla	2 292	5 247 606	2 987 365	3 315 527	3 928 061	2 000 000	17 480 851
Toyota	2 623 142	3 276 435	777 825	0	0	0	6 677 402
Volkswagen	0	77 000	0	0	0	0	77 000
Receiver General	--	6 906	--	--	--	--	6 906

**Table 17: credit transactions (transferred in) by model year (Mg CO<sub>2</sub>e)**

Manufacturer	Early Action	2011 to 2020	2021	2022	2023	2024	Total
Aston Martin	0	2 626	0	0	0	0	2 626
BMW	0	1 000 000	0	0	0	0	1 000 000
FCA	4 775 129	7 758 827	969 820	6 381	5 721	2 898	13 518 776
Ferrari	8 473	0	0	0	0	0	8 473
Ford	342 272	257 728	0	2 000 000	2 000 000	0	4 600 000
GM	0	1 419 718	417 545	1 015 527	1 928 061	2 000 000	6 780 851
JLR	143 369	130 162	0	0	0	0	273 531
Lotus	0	139	0	0	0	0	139
Maserati	3 740	30 103	0	0	0	0	33 843
Mazda	0	452 175	1 277 825	0	0	0	1 730 000
Mercedes	0	1 745 000	1 100 000	300 000	0	0	3 145 000
Porsche	0	444 141	189 003	25 997	0	0	659 141
Subaru	0	300 000	0	0	0	0	300 000
Volkswagen	500 000	0	0	0	0	0	500 000

### 3.2. Total credits generated and final status

Table 18 shows the credits earned (or deficits incurred) by all companies over the 2024 model year. This table also shows the total number of credits remaining in each company’s bank, taking into account the credits that have expired, been transferred, or used to offset a deficit.

Since the regulations came into force, companies have generated approximately 124.9 million emission credits (including early action credits), of which approximately 31.9 million credits remain for future use. A total of 42.4 million credits have been used to offset deficits and 50.6 million credits have expired.

**Table 18: net credits by model year and current credit balance (Mg CO<sub>2</sub>e)**

Manufacturers	Generated Credit/Deficit in 2024	Current Balance <sup>18</sup>
BMW	139 767	486 626
FCA	-813 210	1 393 745
Ford	44 649	7 406 065
GM	-523 022	6 552 509
Honda	-105 608	974 887
Hyundai	1 268 982	2 483 689
JLR	-138 705	0
Kia	494 082	1 035 553
Lucid	8 152	5 254
Mazda	-241 936	1 261 811
Mercedes	-28 917	1 057 277
Mitsubishi	282 897	648 337
Nissan	-105 034	100 050
Porsche	-293 632	0
Rivian	88 099	173 925
Subaru	-259 970	780 787
Tesla	2 960 203	1 121 050
Toyota	1 799 811	5 089 690
VinFast	101 215	149 518
Volkswagen	-158 038	137 459
Volvo	342 431	1 006 200
<b>Total</b>	<b>4 820 216</b>	<b>31 864 432</b>

### 4. Overall industry performance

The overall fleet average compliance information for passenger automobiles and light trucks is summarized in Tables 19 and 20. Additionally, Figures 9 and 10 illustrate the year over year performance for both passenger automobile and for light truck fleets. These trend lines depict the average standard applicable to the overall fleet (dotted line) and the compliance value (solid line) for each fleet.

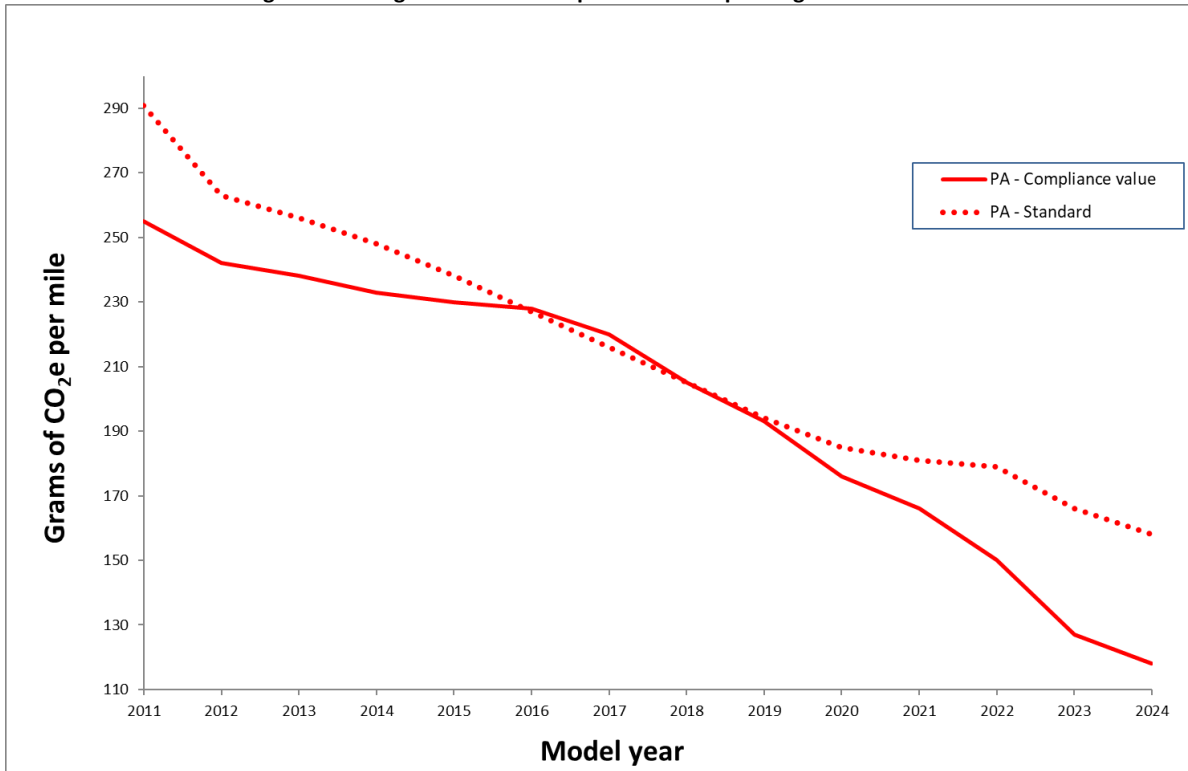
Because each manufacturer’s fleet is unique, the data presented in the tables and graphs are based on the sales weighted values for all companies and are intended to depict the average results.

<sup>18</sup> The current balance accounts for any expired credits, remaining early action credits, transactions, and offsets.

**Table 19: passenger automobile compliance summary for the 2011 to 2024 model years (g/mi)**

Model Year	CREE	Innovative Technologies	AC Refrigerant Leakage Reduction	AC Efficiency Improvements	Compliance value	Standard	Compliance margin
2011	258	0.2	2.0	1.3	255	291	36
2012	247	0.5	2.9	2.0	242	263	21
2013	244	0.4	3.0	2.4	238	256	18
2014	241	1.5	3.5	2.6	233	248	15
2015	238	1.8	4.0	2.9	230	238	8
2016	238	2.0	4.7	3.4	228	227	-1
2017	232	3.0	6.0	3.5	220	216	-4
2018	221	3.7	8.4	3.7	205	205	0
2019	211	3.7	10.3	3.8	193	194	1
2020	195	4.4	10.7	3.8	176	185	9
2021	188	4.9	13.1	3.9	166	181	15
2022	173	5.7	13.0	4.2	150	179	29
2023	149	4.2	13.1	4.2	127	166	39
2024	141	5.3	13.2	4.2	118	158	40

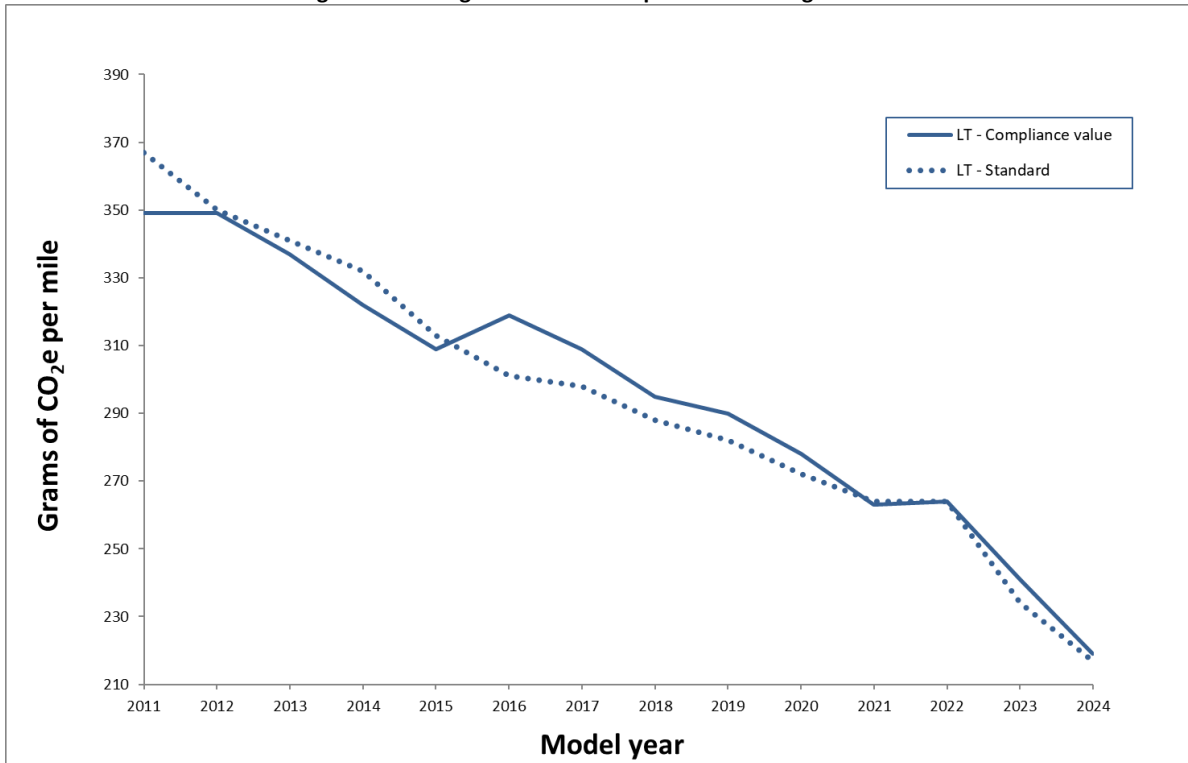
**Figure 9: average GHG emissions performance - passenger automobiles**



**Table 20: light truck compliance summary for the 2011 to 2024 model years (g/mi)**

Model Year	CREE	Innovative Technologies	AC Refrigerant Leakage Reduction	AC Efficiency Improvements	Compliance value	Standard	Compliance margin
2011	356	0.7	5.5	1.3	349	367	18
2012	357	1.2	5.8	1.5	349	350	1
2013	347	1.3	6.2	2.2	337	341	4
2014	337	4.3	6.8	3.1	322	332	10
2015	326	5.2	7.6	3.6	309	313	4
2016	337	5.9	8.5	3.7	319	301	-18
2017	334	7.5	12.0	5.7	309	298	-11
2018	323	8.5	13.3	6.1	294	288	-6
2019	320	9.7	14.2	6.0	290	282	-8
2020	309	10.7	14.7	6.0	277	272	-5
2021	298	11.7	16.6	6.2	263	264	1
2022	300	12.3	16.7	6.5	264	264	0
2023	274	10.6	16.7	6.5	241	234	-7
2024	254	11.4	16.6	6.5	219	217	-2

**Figure 10: average GHG emissions performance - light trucks**



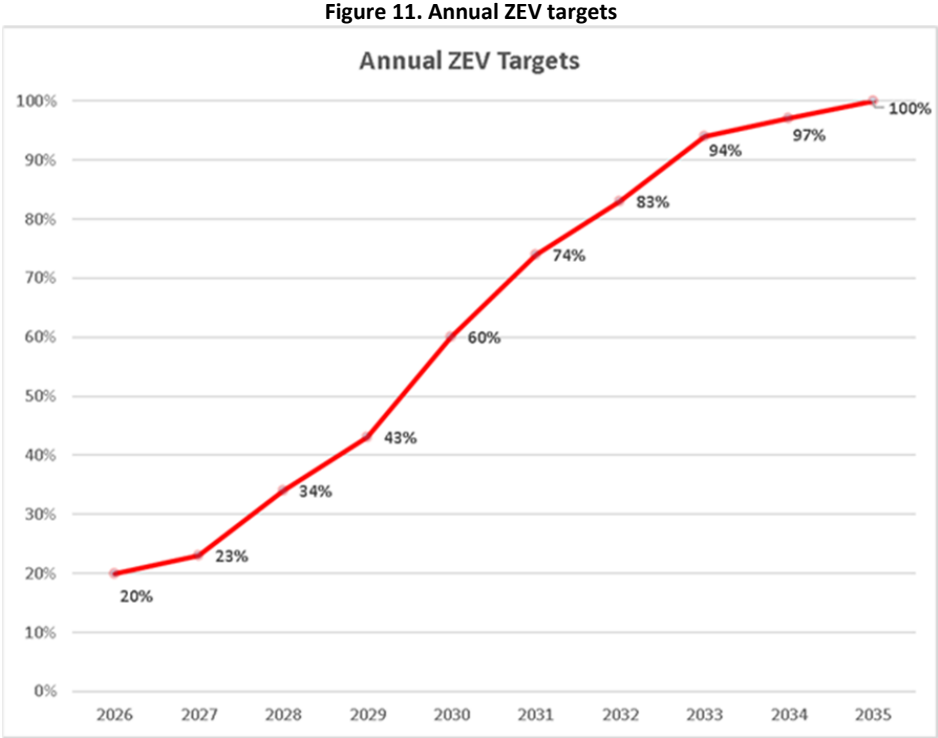
As depicted in Figures 9 and 10, the 2024 model year saw the overall compliance value for passenger automobiles decrease to 118 g/mi, and the overall compliance value for light trucks decrease to 219 g/mi. This has resulted in an overall net improvement of 53.7% and 38.3% relative to the 2011 model year for passenger automobiles and light trucks respectively.

All companies remained in compliance with the regulations through the use of their own accumulated emission credits or by purchasing credits from other companies. Results to date indicate that all companies continue to meet their vehicle GHG regulatory obligations for the 2024 model year.

### 5. Zero-Emission Vehicle Requirements

On December 20, 2023 Environment and Climate Change Canada published the [Regulations Amending the Regulations Respecting Greenhouse Gas Emissions from Passenger Automobiles and Light Trucks \(Amendments\)](#). The Amendments establish annual ZEV regulatory targets and a compliance unit system that will require manufacturers and importers to meet an annual percentage target of new light-duty ZEVs offered for sale in Canada. The Amendments apply to all companies that manufacture new passenger cars, SUVs, and pickup trucks in Canada, or import those vehicles into Canada for the purpose of selling them to the first retail purchaser. On September 5, 2025, the Prime Minister [announced](#) that the Government would remove the 2026 ZEV target from the regulations and launch a 60-day review of the overall regulations. This report does not reflect the announced removal of the 2026 target nor any potential changes which may result from the review.

Figure 11 depicts the ZEV targets published in December 2023, which require 100% of new passenger car and light truck sales in Canada to be ZEVs by 2035, with interim targets of 20% by 2026, and 60% by 2030.



The Amendments establish a methodology for determining whether the fleet offered for sale in Canada meets the ZEV target for a given model year. If a company exceeds its ZEV target, it earns compliance units for excess ZEVs offered for sale. These compliance units can be used to offset a deficit for a limited number of years in the future. If a company misses its ZEV target, it incurs a compliance deficit, which must be

satisfied by obtaining compliance units within a limited time frame. Compliance deficits can be satisfied with banked compliance units, by over-complying in future model years, by purchasing ZEV compliance units from other companies, or by creating some compliance units through financial contributions towards the construction of charging infrastructure.

**5.1. Early Compliance Units**

The Amendments allow a company to earn early compliance units for offering ZEVs for sale in model years 2024 and 2025 within a specific threshold. Manufacturers that meet the requirements to qualify for early compliance units can generate compliance units that equal up to 12 percent of their fleets of vehicles in model year 2024, and 7 percent of their fleets in model year 2025. Early compliance units may not be traded and cannot be used after model year 2027.

This flexibility provision provides an incentive for companies to offer ZEVs for sale in the short term and may serve an additional source of compliance units for some companies. Table 21 shows the early compliance units generated by companies for the 2024 model year.

**Table 21: Early compliance units**

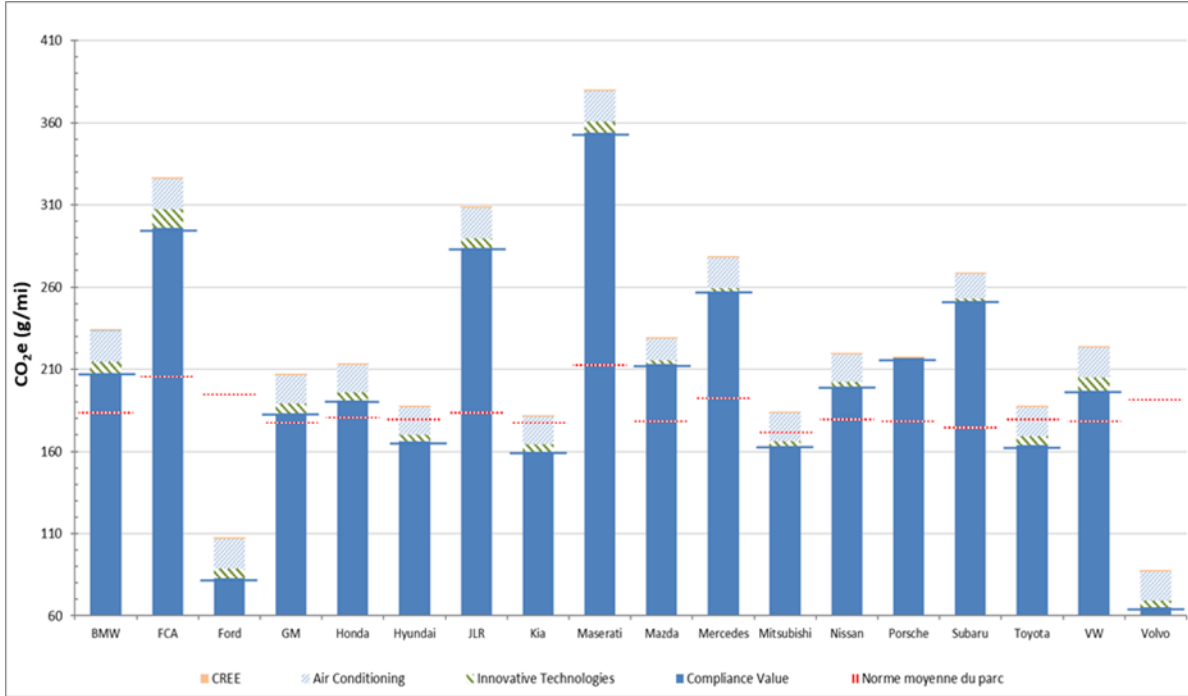
Manufacturers	Compliance Units
BMW	3 258
FCA	1 679
Ford	3 321
GM	3 171
Honda	0
Hyundai	15 008
JLR	0
Kia	9 472
Lucid	17
Mazda	0
Mercedes	1 543
Mitsubishi	6 222
Nissan	0
Porsche	75
Rivian	116
Subaru	0
Tesla	5 902
Toyota	6 378
VinFast	212
Volkswagen	6 436
Volvo	1 921
<b>Total</b>	<b>64 731</b>

## Appendix

**Table A-1: production volumes by company**

Manufacturer	2021 PA	2021 LT	2021 All	2022 PA	2022 LT	2022 All	2023 PA	2023 LT	2023 All	2024 PA	2024 LT	2024 All
Aston Martin	38	94	132	45	38	83	95	124	219	17	30	47
BMW	14 450	15 221	29 671	12 983	18 202	31 185	13 240	20 052	33 292	14 461	21 310	35 771
FCA	5 834	161 482	167 316	7 350	161 888	169 238	9 066	125 645	134 711	7 623	84 189	91 812
Ferrari	313	0	313	493	0	493	345	0	345			348
Ford	13 091	174 247	187 338	15 597	194 354	209 951	16 939	186 341	203 280	21 105	187 581	208 686
GM	18 572	172 203	190 775	23 379	164 729	188 108	32 838	178 635	211 473	38 474	216 593	255 067
Honda	39 703	64 463	104 166	60 849	58 365	119 214	37 664	63 275	100 939	47 745	67 269	115 014
Hyundai	84 131	19 949	104 080	80 506	51 671	132 177	84 984	50 157	135 141	61 927	63 142	125 069
JLR	268	7 873	8 141	92	5 111	5 203	241	10 445	10 686	332	8 980	9 312
Kia	34 294	40 668	74 962	25 897	33 646	59 543	40 783	53 798	94 581	30 472	51 032	81 504
Lotus	18	0	18	0	0	0	0	0	0	0	0	0
Lucid	0	0	0	99	0	99	94	0	94	140	0	140
Maserati	212	262	474	183	484	667	153	1 085	1 238	107	341	448
Mazda	25 103	51 399	76 502	12 026	25 552	37 578	9 238	39 814	49 052	10 880	61 387	72 267
McLaren	84	0	84	79	0	79	111	0	111	108	0	108
Mercedes	8 446	25 324	33 770	8 354	23 756	32 110	11 891	17 655	29 546	7 181	15 572	22 753
Mitsubishi	1 181	6 879	8 060	4 640	24 298	28 938	3 295	28 007	31 302	7 262	44 587	51 849
Morgan Olson	0	0	0	0	40	40	0	1 681	1 681	0	0	0
Nissan	55 002	32 241	87 243	33 663	27 340	61 003	52 483	57 152	109 635	50 808	40 546	91 354
Porsche	2 380	6 663	9 043	3 320	4 453	7 773	3 196	6 989	10 185	4 327	7 470	11 797
Rivian	0	0	0	0	0	0	0	883	883	0	967	967
Subaru	5 794	53 396	59 190	7 453	31 274	38 727	7 598	33 181	40 779	8 243	79 494	87 737
Tesla	32 414	1 450	33 864	47 711	2 811	50 522	63 824	3 359	67 183	45 074	4 108	49 182
Toyota	77 815	152 741	230 556	71 183	129 656	200 839	45 683	156 813	202 496	60 742	191 334	252 076
VinFast	0	0	0	0	0	0	801	0	801	1 764	0	1 764
Volkswagen	26 775	53 433	80 208	27 245	46 739	73 984	28 064	62 500	90 564	42 749	99 009	141 758
Volvo	1 807	8 638	10 445	2 628	8 204	10 832	5 168	8 404	13 572	5 958	10 049	16 007
Fleet Total	447 725	1 048 626	1 496 351	445 775	1 012 611	1 458 386	467 794	1 105 995	1 573 789	467 847	1 254 990	1 722 837

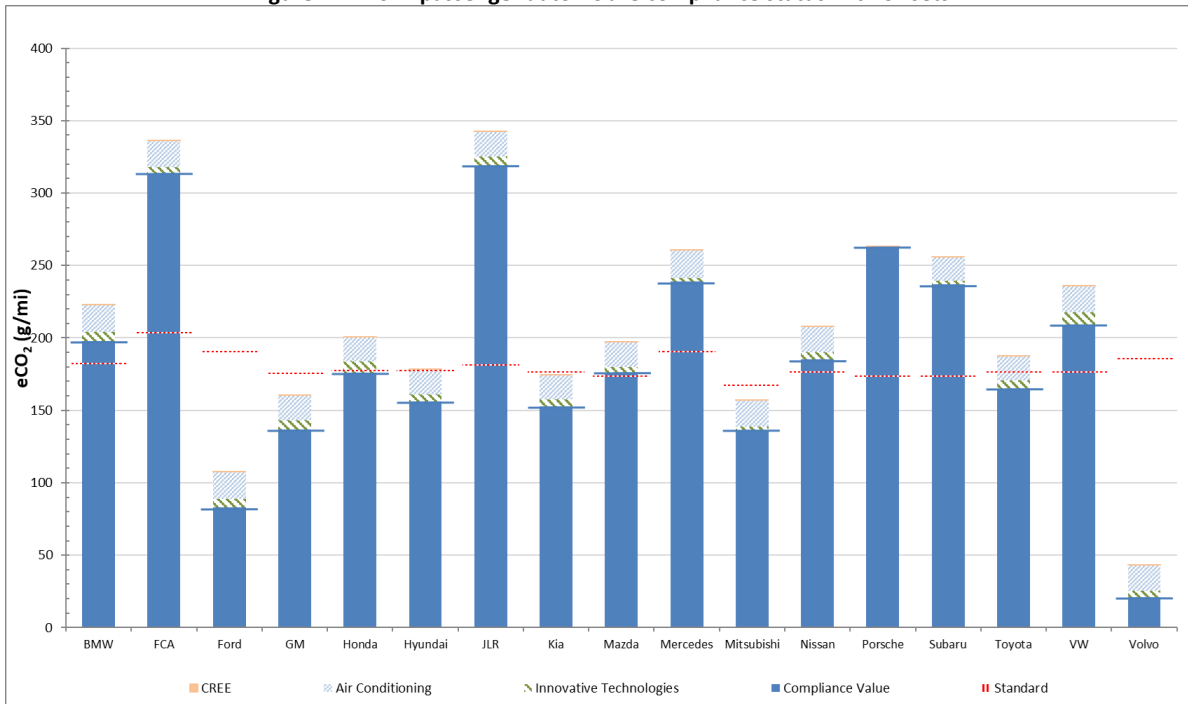
Figure A-1: 2021 passenger automobile compliance status with offsets



Notes:

1. The final compliance value may be lower than the CREE through the application of compliance flexibilities
2. Tesla, Rivian and VinFast produce electric vehicles, whose compliance values fall outside of the range of this graph.

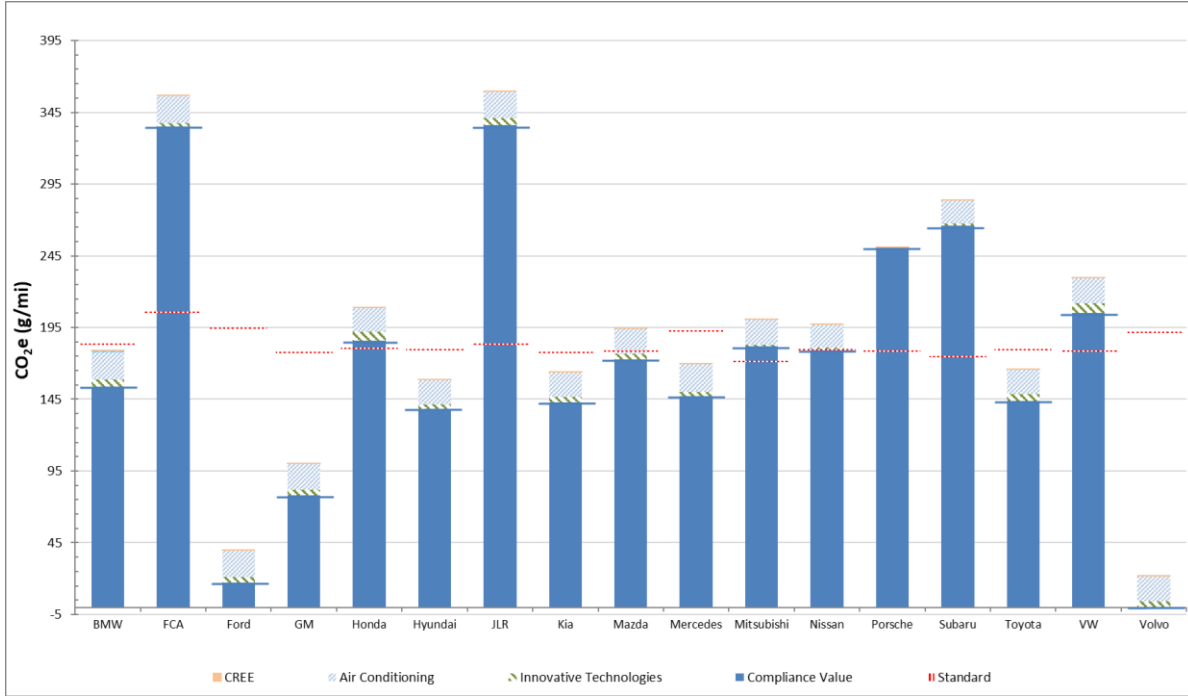
Figure A-2: 2022 passenger automobile compliance status with offsets



Notes:

1. The final compliance value may be lower than the CREE through the application of compliance flexibilities
2. Tesla, Rivian and VinFast produce electric vehicles, whose compliance values fall outside of the range of this graph.

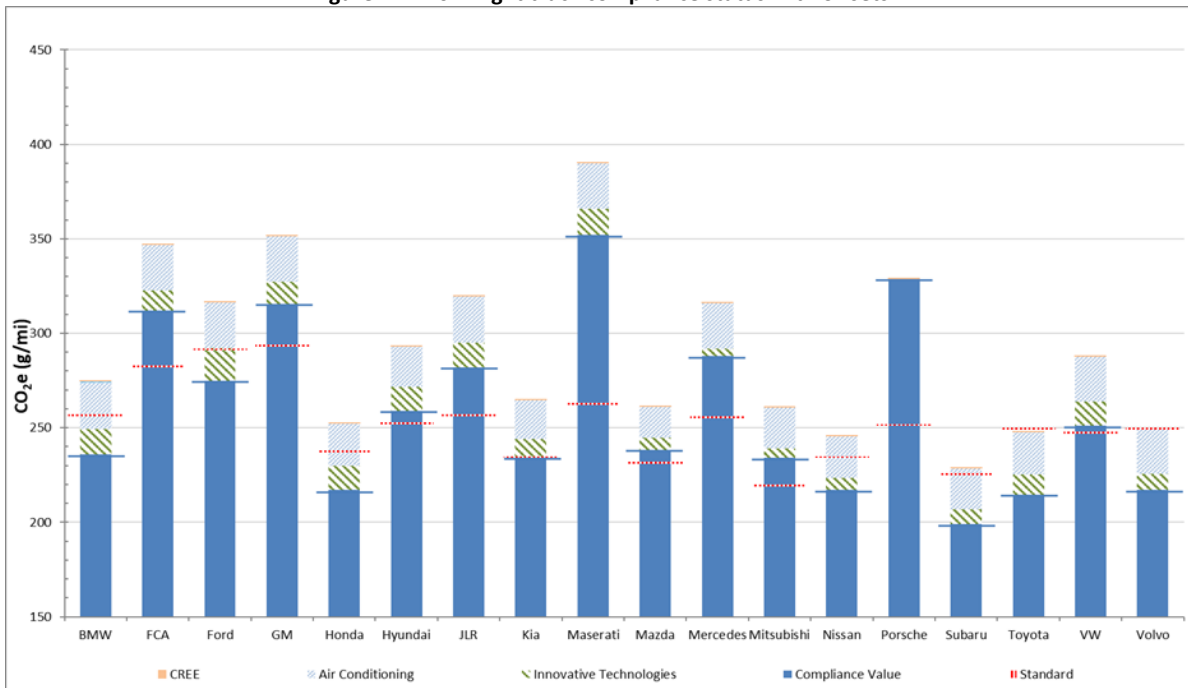
Figure A-3: 2023 passenger automobile compliance status with offsets



Notes:

1. The final compliance value may be lower than the CREE through the application of compliance flexibilities
2. Tesla, Rivian and VinFast produce electric vehicles, whose compliance values fall outside of the range of this graph.

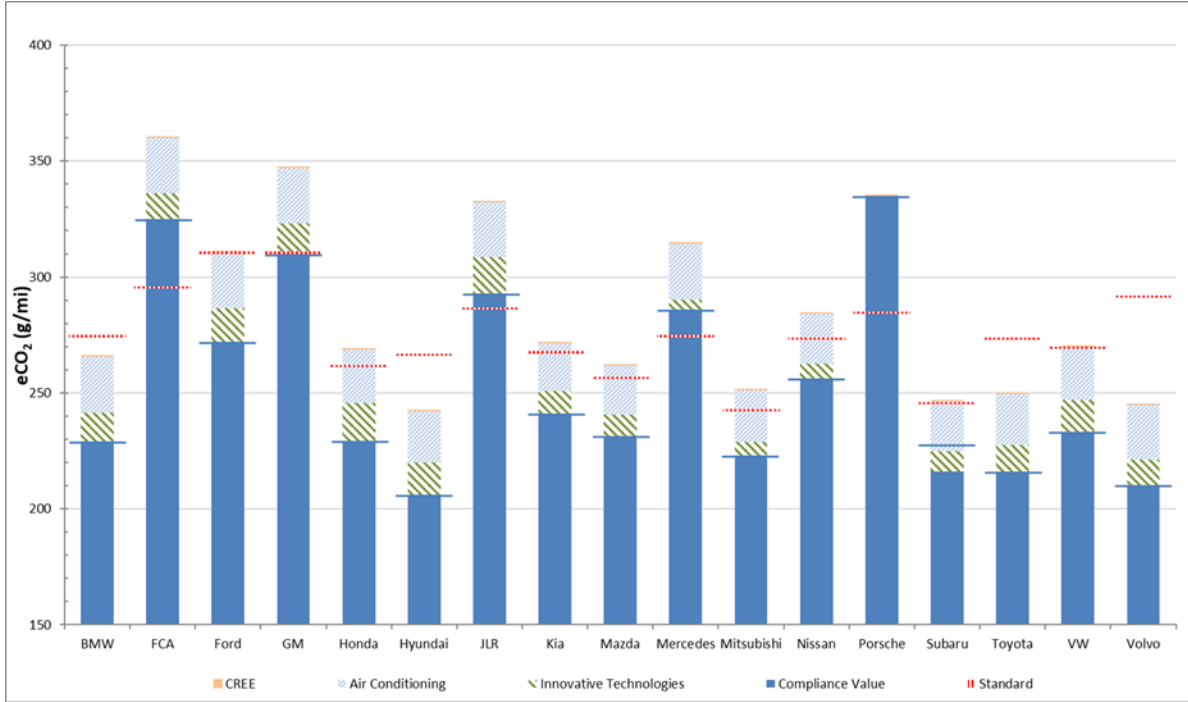
Figure A-4: 2021 light truck compliance status with offsets



Notes:

1. The final compliance value may be lower than the CREE through the application of compliance flexibilities
2. Tesla, Rivian and VinFast produce electric vehicles, whose compliance values fall outside of the range of this graph.

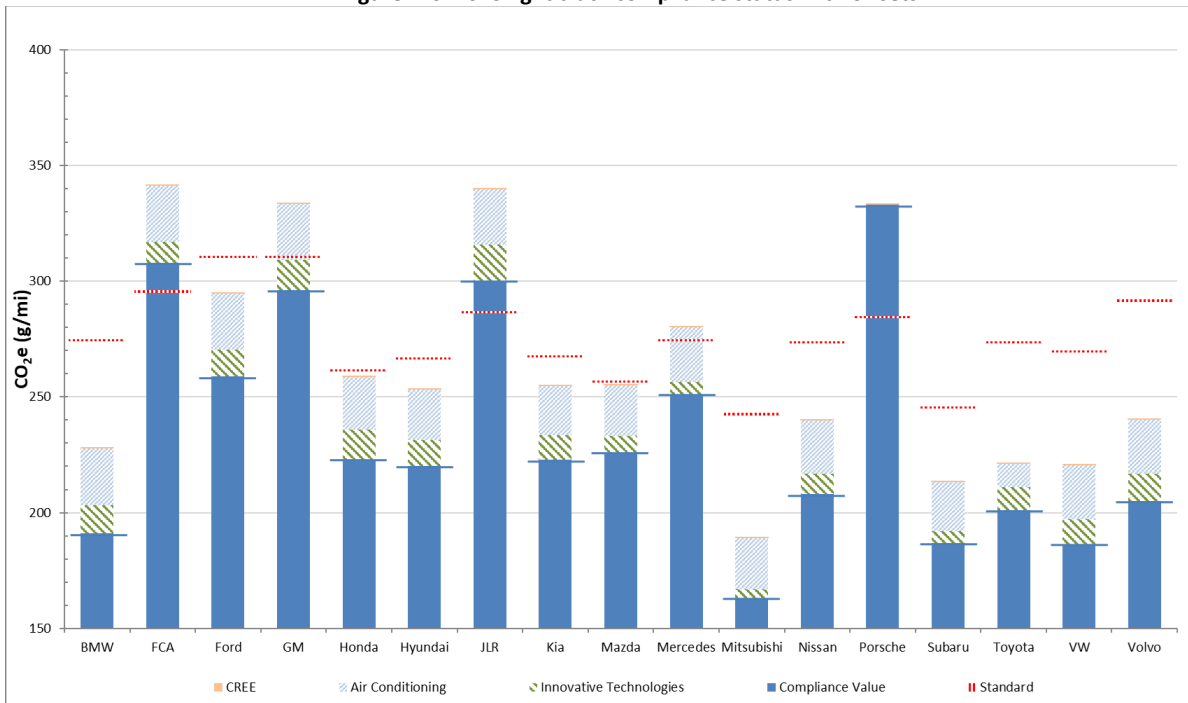
Figure A-5: 2022 light truck compliance status with offsets



Notes:

1. The final compliance value may be lower than the CREE through the application of compliance flexibilities
2. Tesla, Rivian and VinFast produce electric vehicles, whose compliance values fall outside of the range of this graph.

Figure A-6: 2023 light truck compliance status with offsets



Notes:

1. The final compliance value may be lower than the CREE through the application of compliance flexibilities
2. Tesla, Rivian and VinFast produce electric vehicles, whose compliance values fall outside of the range of this graph.

**Table A-2: preapproved menu of efficiency improving technologies for AC systems**

<b>Technology</b>	<b>Passenger automobiles (g/mi)</b>	<b>Light Trucks (g/mi)</b>
Reduced reheat, with externally-controlled, variable-displacement compressor (for example, a compressor that controls displacement based on temperature set point and/or cooling demand of the air conditioning system control settings inside the passenger compartment).	1.5	2.2
Reduced reheat, with externally-controlled, fixed-displacement or pneumatic variable displacement compressor (for example, a compressor that controls displacement based on conditions within, or internal to, the air conditioning system, such as head pressure, suction pressure, or evaporator outlet temperature).	1.1	1.4
Default to recirculated air with closed-loop control of the air supply (sensor feedback to control interior air quality) whenever the ambient temperature is 75 °F or higher: Air conditioning systems that operated with closed-loop control of the air supply at different temperatures may receive credits by submitting an engineering analysis to the Administrator for approval.	1.5	2.2
Default to recirculated air with open-loop control air supply (no sensor feedback) whenever the ambient temperature is 75 °F or higher. Air conditioning systems that operate with open-loop control of the air supply at different temperatures may receive credits by submitting an engineering analysis to the Administrator for approval.	1.0	1.4
Blower motor controls which limit wasted electrical energy (for example, pulse width modulated power controller).	0.8	1.1
Internal heat exchanger (for example, a device that transfers heat from the high-pressure, liquid-phase refrigerant entering the evaporator to the low-pressure, gas-phase refrigerant exiting the evaporator).	1.0	1.4
Improved condensers and/or evaporators with system analysis on the component(s) indicating a coefficient of performance improvement for the system of greater than 10% when compared to previous industry standard designs.	1.0	1.4
Oil separator. The manufacturer must submit an engineering analysis demonstrating the increased improvement of the system relative to the baseline design, where the baseline component for comparison is the version which a manufacturer most recently had in production on the same vehicle design or in a similar or related vehicle model. The characteristics of the baseline component shall be compared to the new component to demonstrate the improvement.	0.5	0.7
Advanced technology air conditioning compressor with improved efficiency relative to fixed-displacement compressors achieved through the addition of a variable crankcase suction valve	1.1	1.1

**Table A-3: production volume of vehicles with turbocharging**

Manufacturer	2021	2022	2023	2024
BMW	29 190	29 766	28 757	30 475
FCA	23 257	13 364	42 094	28 240
Ford	138 751	157 860	149 263	163 865
GM	65 865	85 352	99 932	156 378
Honda	64 217	52 608	57 211	52 711
Hyundai	14 721	34 665	37 689	36 718
JLR	3 248	1 533	5 576	4 531
Kia	12 627	11 437	16 165	10 390
Maserati	482	--	--	--
Mazda	17 909	8 860	12 769	23 342
Mercedes	33 770	31 710	25 040	14 767
Mitsubishi	0	6 134	5 425	8 010
Nissan	3 457	9 216	35 835	25 457
Porsche	8 145	6 373	8 894	9 574
Subaru	9 046	13 463	11 452	12 715
Toyota	8 336	13 575	31 207	56 937
Volkswagen	66 229	62 025	67 329	123 727
Volvo	3 591	3 540	4 007	9 179
Total	502 841	541 481	638 645	767 816

**Table A-4: production volume of vehicles with variable valve timing**

Manufacturer	2021	2022	2023	2024
BMW	29 190	29 766	28 757	30 475
FCA	161 489	160 477	130 049	85 812
Ford	157 435	180 099	164 765	192 822
GM	169 906	165 978	177 814	201 249
Honda	104 166	119 214	100 939	113 570
Hyundai	95 950	122 696	119 260	97 571
JLR	7 510	5 151	10 640	9 202
Kia	72 832	56 665	88 394	67 090
Maserati	482	--	--	--
Mazda	76 502	36 510	48 243	72 238
Mercedes	33 770	31 710	25 040	20 137
Mitsubishi	8 060	28 938	31 302	51 849
Nissan	86 804	60 087	104 985	85 945
Porsche	8 536	7 159	9 545	10 872
Subaru	59 190	38 727	37 829	85 036
Toyota	230 556	200 817	195 954	245 489
Volkswagen	78 027	70 596	78 167	124 022
Volvo	9 568	8 878	9 100	10 922
Total	1 389 973	1 323 468	1 360 783	1 504 301

**Table A-5: production volume of vehicles with variable valve lift**

Manufacturer	2021	2022	2023	2024
BMW	29 190	29 766	28 571	30 393
FCA	10 474	12 376	4 182	3 583
GM	13 138	24 488	38 877	44 258
Honda	57 245	76 500	84 919	82 995
JLR	7 510	5 151	10 640	9 202
Mercedes	18 800	18 197	14 570	10 843
Mitsubishi	0	0	0	1 126
Nissan	1 428	1 302	1 716	7 346
Porsche	8 536	5 186	6 654	269
Toyota	29 153	25 151	570	87 755
Volkswagen	47 582	43 944	48 779	30 393
Total	223 056	242 061	239 478	277 770

**Table A-6: production volume of vehicles with higher geared transmissions**

Manufacturer	2021	2022	2023	2024
BMW	28 489	29 248	27 992	29 777
FCA	164 272	164 822	131 799	82 153
Ford	171 375	187 707	174 418	177 974
GM	148 952	153 916	176 538	191 352
Honda	39 191	61 383	37 642	37 173
Hyundai	28 398	54 278	52 779	40 626
JLR	8 102	5 151	10 640	9 202
Kia	38 286	30 941	57 805	52 981
Maserati	482	--	--	--
Mercedes	33 770	31 710	25 040	10 627
Mitsubishi	0	18 294	13 821	20 137
Nissan	54 751	39 168	82 178	21 925
Porsche	8 280	6 640	9 244	47 339
Subaru	53 639	36 579	34 262	10 375
Toyota	102 408	105 006	91 984	82 041
Volkswagen	73 805	69 076	75 942	120 715
Volvo	9 568	8 878	9 100	116 004
Total	963 768	1 002 797	1 011 184	1 061 323

**Table A-7: production volume of vehicles with continuously variable transmissions**

Manufacturer	2021	2022	2023	2024
FCA	968	2 412	1 789	8 975
Ford	9 262	12 219	10 604	15 122
GM	10 472	16 099	7 081	6 765
Honda	74 779	83 143	71 743	88 050
Hyundai	28 991	49 661	48 951	39 487
Kia	42 490	25 806	39 090	29 246
Mitsubishi	7 735	26 648	22 517	38 026
Nissan	83 400	44 136	88 410	67 407
Subaru	53 898	36 662	34 436	82 041
Toyota	28 484	31 102	72 591	113 052
Total	340 479	327 888	397 212	488 171

**Table A-8: production volume of vehicles with cylinder deactivation**

Manufacturer	2021	2022	2023	2024
FCA	51 655	82 676	48 602	19 171
Ford	42 801	42 311	12 033	32 363
GM	103 566	92 496	120 732	114 288
Honda	14 727	26 107	20 759	15 957
Mazda	24 226	10 709	29 090	31 809
Mercedes	2 793	1 459	1 633	718
Porsche	623	546	738	906
Volkswagen	2 220	1 746	2 370	1 392
Total	242 611	258 050	235 957	216 604

**Table A-9: production volume of vehicles with gasoline direct injection**

Manufacturer	2021	2022	2023	2024
BMW	29 190	29 766	22 189	20 013
FCA	15 782	5 069	18 257	22 322
Ford	71 989	95 823	64 592	97 466
GM	161 893	160 805	177 814	201 249
Honda	79 172	78 708	76 322	81 185
Hyundai	56 674	72 712	55 371	30 589
JLR	7 510	5 151	10 640	9 202
Kia	20 887	18 527	15 495	13 364
Maserati	482	--	--	--
Mazda	76 502	36 510	48 243	72 238
Mercedes	33 770	31 707	24 978	20 099
Mitsubishi	0	12 160	8 396	13 915
Nissan	55 765	45 334	82 926	55 446
Porsche	254	7 159	9 545	10 872
Subaru	58 414	38 138	36 318	84 207
Toyota	497	355	570	269
Volkswagen	78 096	70 410	77 358	123 774
Volvo	9 568	8 878	9 100	10 922
<b>Total</b>	<b>756 445</b>	<b>717 212</b>	<b>738 114</b>	<b>867 132</b>

**Table A-10: production volume of diesel vehicles**

Manufacturer	2021	2022	2023	2024
FCA	3 305	3 921	391	0
Ford	501	0	0	0
GM	19 308	16 581	15 693	30 242
JLR	592	0	0	0
<b>Total</b>	<b>23 706</b>	<b>20 502</b>	<b>16 084</b>	<b>30 242</b>