Greenhouse Gas Emissions Performance for the 2021 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*

Environment and Climate Change Canada
Environnement et Changement climatique Canada

Canada

Cat. No.: En11-15E-PDF
ISSN: 2560-9017
EC24114

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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_2 – Carbon dioxide

CO_2e – 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_x – Oxides of nitrogen

N_2O – Nitrous oxide

PA – Passenger automobile

PM – Particulate matter

TOF – Temporary optional fleet

VKT – Vehicle kilometres travelled

ZEV – Zero emission vehicle

Table of contents

List of tables

List of figures

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_2e)[1] emissions value (referred to as the "compliance value") and the status of their emission credits.

The CO_2e 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[2]. 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 37.8% and 28.1% respectively.

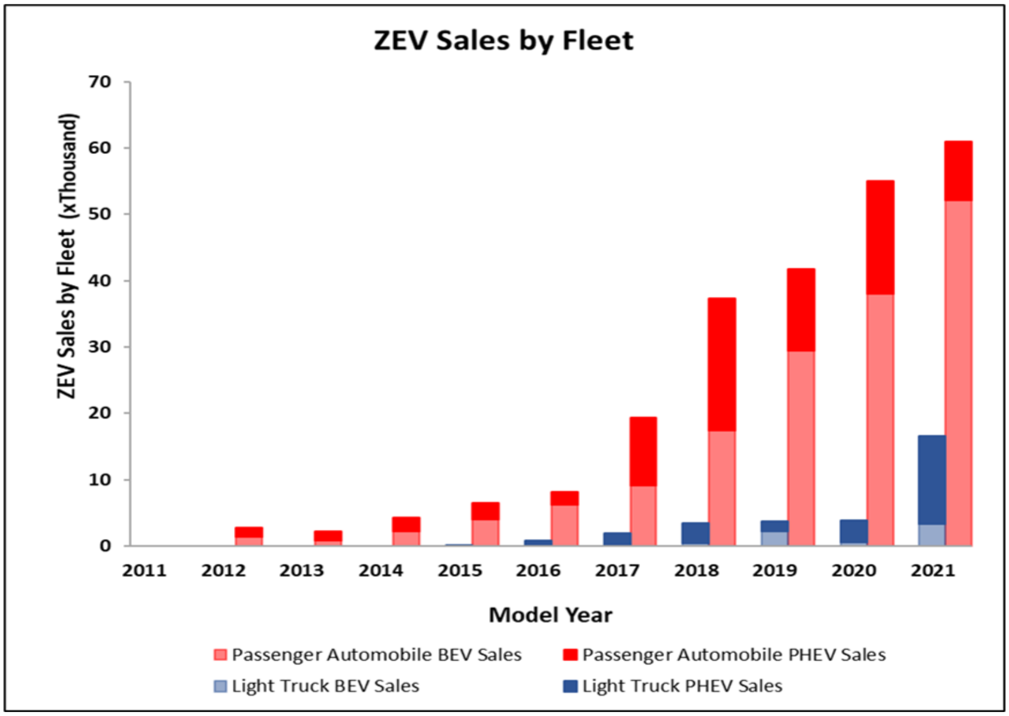
A company's performance relative to its standard is determined through its sales weighted fleet average emissions performance for the given model year for its new passenger automobile and light truck offerings, expressed in grams per mile of CO_2e based on standardized emissions tests simulating city and highway driving cycles. The emissions measured during these test procedures include CO_2 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_4) and nitrous oxide (N_2O). 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

[1] CO_2e is used throughout this report as a common unit to standardize the environmental impacts of different greenhouse gases (such as N_20 & CH_4) in terms of an equivalent amount of CO_2.

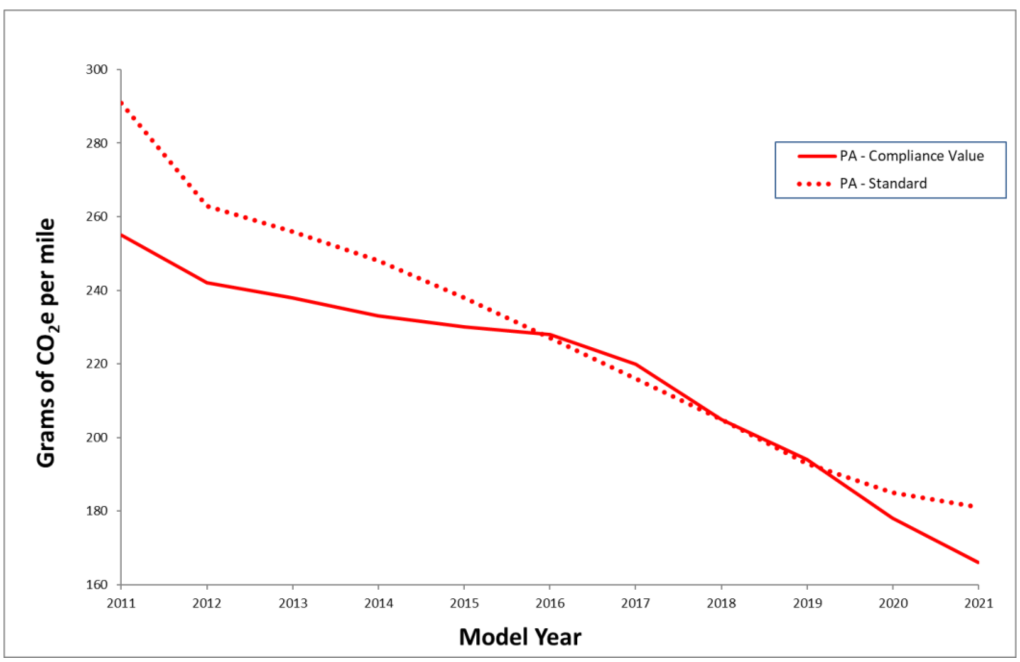
[2] In December 2021, the U.S. EPA published its Final Rule which increased the stringency of GHG standards for model years 2023 to 2026.

to 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.

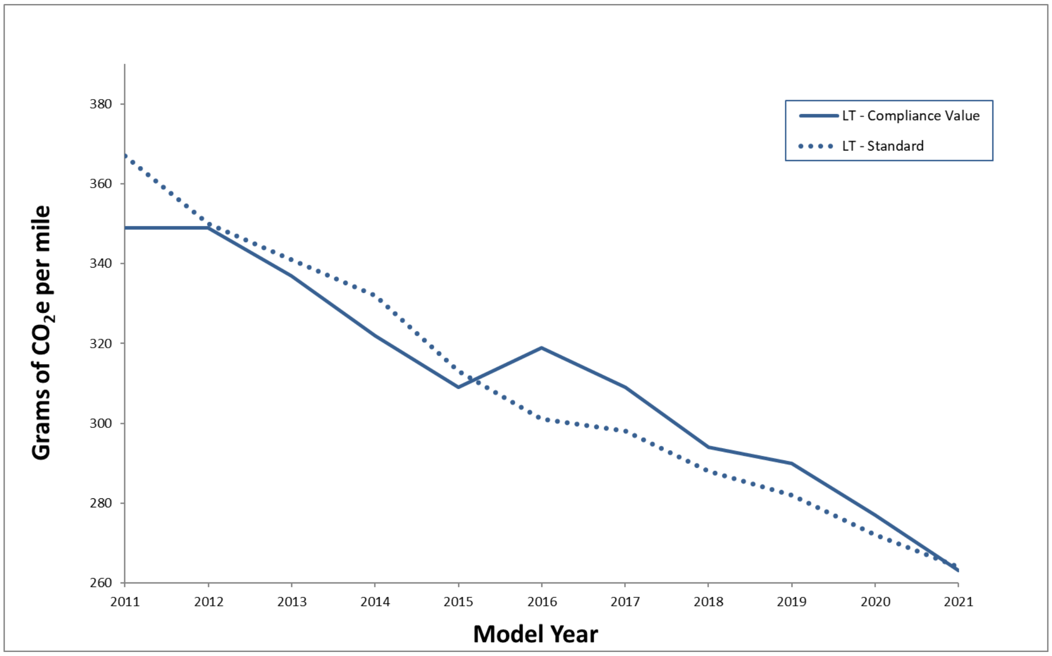
The regulations have been instrumental in influencing companies to make progressive improvements to the efficiency and GHG reductions of their new light duty vehicle fleets available in Canada since the 2011 model year. These regulations have required companies to meet progressively more stringent GHG 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 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 5.2% for the 2021 model year. More specifically, battery electric vehicles have increased from 198 to 55 314 representing 3.7% of the total fleet in 2021, and the volume of plug-in hybrid electric vehicles has increased from zero to 22 259 representing 1.5% of the total fleet in 2021. 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.



Results from annual regulatory compliance reports indicate that companies continue to be in compliance through the 2021 model year. The average compliance value for the fleet of new passenger automobiles has decreased from 255 g/mi to 166 g/mi since the introduction of the regulation, representing a 34.9% reduction.



The compliance value for light trucks decreased by 24.6%, from 349 g/mi to 263 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.



Under the regulations, companies have generated a total of approximately 100.1 million credits, of which, approximately 21.0 million are available for future use. A total of 30.8 million credits have been used to offset emission deficits by individual companies over the 2011 to 2021 model years, of which 3.5 million credits were used to offset deficits accrued in the 2021 model year. The remaining 48.4 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)[3]. Building on the previous GHG emissions performance report for the 2020 model year, this report focuses on the GHG emissions performance of the last 4 model years. 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*[4] (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[5]. 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, track, and assess whether the regulatory requirements have been met and the number of emission credit balances and transfers. 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 2018 to 2021 model years are listed in Table 1.

[3] The department has released 7 reports documenting the overall fleet performance from earlier model years.
[4] The regulations, along with amendments, and the accompanying regulatory impact analysis statement
[5] Definitions of passenger automobile and light truck can be found in the Regulations

Table 1: model year report submission status

Manufacturer	Common Name	2018	2019	2020	2021
Aston Martin Lagonda Ltd.	Aston Martin	LVM[a]	LVM[a]	LVM[a]	LVM[a]
BMW Canada Inc.	BMW	*	*	*	*
BYD Canada Company Limited	BYD	--	--	--	*
FCA Canada Inc.	FCA	*	*	*	*
Ferrari North America Inc.	Ferrari	LVM[a]	LVM[a]	LVM[a]	LVM[a]
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[a]	LVM[a]	LVM[a]	LVM[a]
Maserati North America Inc.	Maserati	LVM[a]	LVM[a]	*	*
Mazda Canada Inc.	Mazda	*	*	*	*
McLaren Automotive Limited	McLaren	LVM[a]	LVM[a]	LVM[a]	LVM[a]
Mercedes-Benz Canada Inc.	Mercedes	*	*	*	*
Mitsubishi Motor Sales of Canada, Inc.	Mitsubishi	*	*	*	*
Nissan Canada Inc.	Nissan	*	*	*	*
Pagani Automobili SPA, Italy	Pagani	LVM[a]	LVM[a]	LVM[a]	LVM[a]
Porsche Cars Canada, Ltd.	Porsche	*	*	*	*
Subaru Canada Inc.	Subaru	*	*	*	*
Tesla Motors, Inc.	Tesla	*	*	*	*
Toyota Canada, Inc.	Toyota	*	*	*	*
Volkswagen Group Canada, Inc.	Volkswagen	*	*	*	*
Volvo Cars of Canada Corp.	Volvo	*	*	*	*

*Indicates that a report has been submitted

[a] Beginning with the 2012 model year, low volume manufacturers (LVM) may elect to exempt themselves from CO_2e standards. This exemption does not have a noticeable impact on fleet-wide performance given the small volume of vehicles.

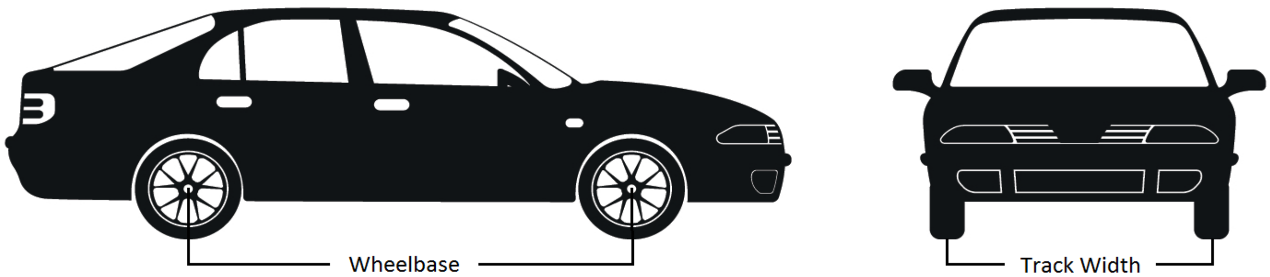
2.1. CO_2e emission standards

The applicable standards for a given model year are based on prescribed carbon dioxide (CO_2e) 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[6] to the first retail purchaser[7]. These standards are performance-based in that they establish a maximum amount of CO_2e 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.

[6] The terms "sold", "offered for sale" and "production volume" are used interchangeably in this report to designate the quantity of vehicles manufactured or imported in Canada for the purpose of first retail sale.

[7] 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.

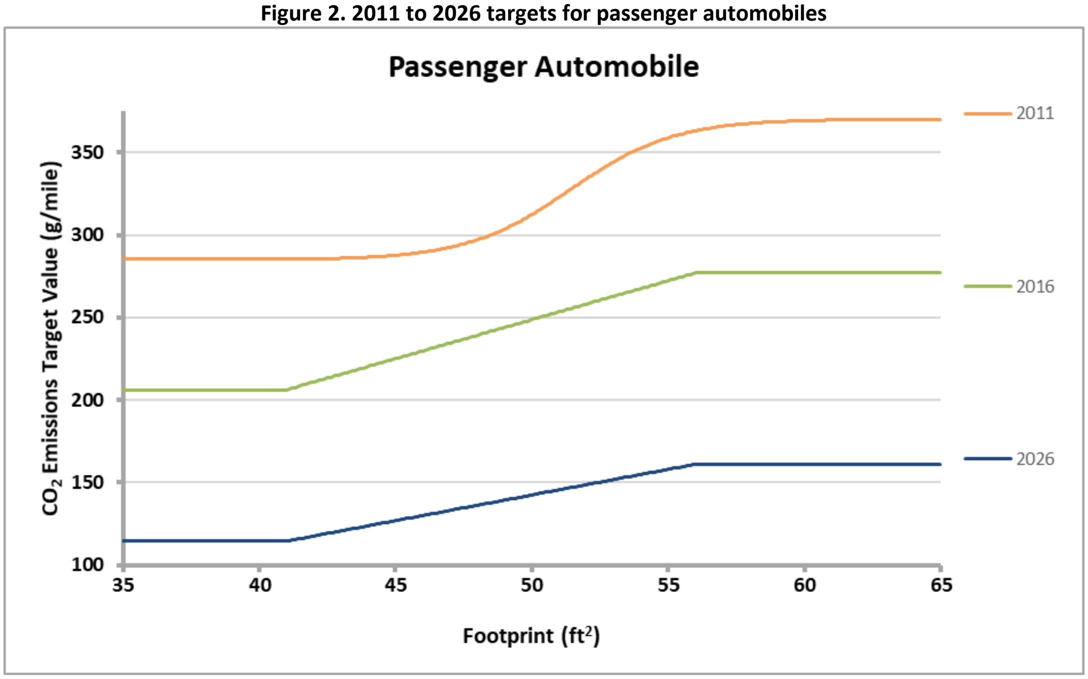
Figure 1. vehicle footprint



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

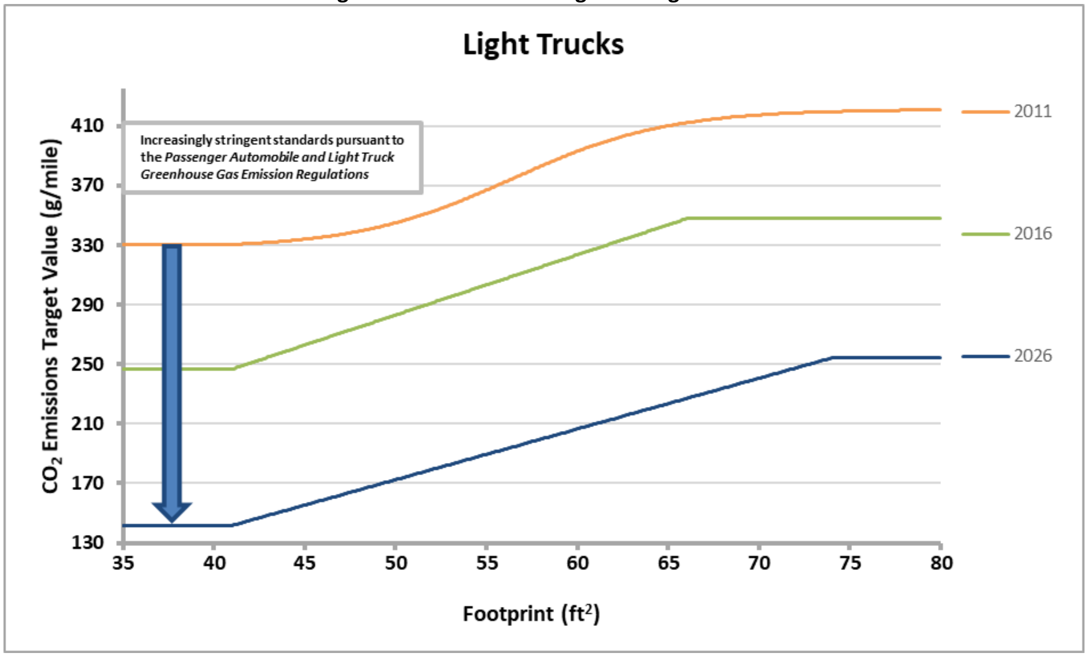
The regulations prescribe progressively more stringent target values for a given footprint size over the 2011 through 2026 model years[8]. Figures 2 and 3 illustrate the target values for passenger automobiles and light trucks, respectively.

Figure 2. 2011 to 2026 targets for passenger automobiles



[8] 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[9]. The CO_2e standard was derived using a conversion factor of 8 887 grams of CO_2/gallon of gasoline[10] for the 2011 model year only.

For the 2012 and later model years, the CO_2e 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 of the target values using the following formula:

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

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[9] 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

[10] 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.

where

A is the CO_2e 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; and

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

The final company-unique fleet average CO_2e standards for the 2018 to 2021 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_2e standard (g/mi)

Manufacturer	2018 PA	2019 PA	2020 PA	2021PA	2018 LT	2019 LT	2020 LT	2021 LT
BMW	208	196	188	183	274	270	262	256
BYD	--	--	194	--	--	--	--	--
FCA	228	218	206	205	295	301	290	282
Ford	209	202	193	194	310	303	296	291
GM	204	192	181	177	310	298	293	293
Honda	204	193	184	180	261	258	245	237
Hyundai	206	196	184	179	266	258	269	252
JLR	242	219	203	183	286	278	267	256
Kia	204	195	183	177	267	263	253	234
Maserati	--	231	218	212	--	278	269	262
Mazda	202	189	183	178	256	249	238	231
Mercedes	213	205	195	192	274	263	263	255
Mitsubishi	195	183	176	171	242	234	226	219
Nissan	205	191	190	179	273	261	245	234
Porsche	224	194	198	178	284	277	266	251
Subaru	199	189	180	174	245	241	235	225
Tesla	226	211	202	198	292	284	275	253
Toyota	201	192	183	179	273	265	261	249
Volkswagen	201	190	183	178	269	264	246	247
Volvo	245	222	212	191	291	274	263	249
Fleet Average	205	194	185	181	288	282	272	264

A company's average footprint (Table 3) is one of the factors in establishing their CO_2e standards. Companies are responsible for meeting their own unique fleet average CO_2e 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 2018 to 2021 model years (discussed in section 2.3.7.).

Table 3. average footprint for the 2018 to 2021 model years (sq. ft.)

Manufacturer	2018 PA	2019 PA	2020 PA	2021 PA	2018 LT	2019 LT	2020 LT	2021 LT
BMW	46.3	45.9	46.3	46.2	50.8	51.9	52	52
BYD	--	--	47.9	--	--	--	--	--
FCA	50.9	51.2	50.9	52	56.1	59	58.3	57.8
Ford	46.6	47.4	47.7	49.2	61.3	60.7	60.2	61.0
GM	45.2	44.3	43.5	43.3	60.2	59.7	60.1	61.8
Honda	45.4	45.2	45.2	45.7	48.2	49.2	48.3	47.8
Hyundai	45.9	45.9	45.5	45.3	49.2	49.2	53.5	51.2
JLR	48.7	48.8	47.8	46.4	50.7	51.7	51.0	52.0
Kia	45.3	45.7	45.3	44.9	49.3	50.3	50.0	47.0
Maserati	--	54.3	53.8	53.7	--	53.4	53.4	53.4
Mazda	44.8	44.2	45	44.9	47.3	47.3	46.8	46.5
Mercedes	47.2	48	48.1	48.7	50.9	50.3	52.1	51.8
Mitsubishi	42.3	41.7	42.7	42.4	44.2	44.1	44.1	43.9
Nissan	45.5	44.6	45.8	45.4	50.8	49.9	48.2	47.1
Porsche	44.4	42.8	46.6	45.1	50.3	51.6	51.0	50.8
Subaru	44.4	44.4	44.4	44.2	44.9	45.7	46.1	45.2
Tesla	50.4	49.6	49.8	50.1	54.8	54.8	54.8	51.3
Toyota	44.7	44.9	45.1	45.4	51.1	50.9	51.7	50.6
Volkswagen	44.7	44.6	45.1	45.2	50	50.4	48.5	50.1
Volvo	49.2	49.7	49.9	48.3	52.1	50.9	50.4	50.5
Fleet Average	45.5	45.3	45.6	45.8	54.8	55.1	54.5	54.4

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_2e 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_2), carbon monoxide (CO), and hydrocarbons (HC). This ensures that all carbon-containing exhaust emissions that ultimately contribute to the formation of CO_2 are recognized.

The CREE for each vehicle model type is calculated based on actual emission constituents (such as CO_2, 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 or imported into Canada for the purpose of sale.

The calculated fleet average CREE values achieved by companies over the 2018 to 2021 model years are presented in Table 4.

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

Manufacturer	2018 PA	2019 PA	2020 PA	2021 PA	2018 LT	2019 LT	2020 LT	2021 LT
BMW	259	250	249	233	300	292	295	274
BYD	--	--	0	--	--	--	--	--
FCA	314	311	324	326	360	368	357	347
Ford	241	249	204	107	347	339	324	316
GM	191	179	152	206	349	349	339	351
Honda	202	207	207	213	255	264	257	252
Hyundai	241	222	211	187	337	342	325	293
JLR	277	330	291	309	316	304	315	320
Kia	223	203	176	181	322	315	310	265
Maserati	--	376	370	379	--	421	410	390
Mazda	215	223	226	229	259	266	260	261
Mercedes	264	275	269	278	316	320	308	316
Mitsubishi	151	162	155	183	264	261	261	261
Nissan	204	202	214	219	294	288	265	246
Porsche	291	322	147	217	318	317	320	329
Subaru	254	243	250	268	242	241	235	229
Tesla[11]	0	0	0	0	0	0	0	0
Toyota	205	200	176	187	315	290	289	248
Volkswagen	255	221	193	223	296	292	300	288
Volvo	257	262	241	87	267	272	267	249
Fleet Average	221	211	195	188	323	320	309	298

2.3. Compliance flexibilities

The regulations provide various compliance flexibilities that reduce the compliance burden on low and intermediate volume companies, to encourage the introduction of advanced technologies which reduce GHG emissions, and to account for innovative technologies whose impacts are not easily measured during standard emissions tests. 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[12] (GWP) that is much higher than CO_2. 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_2. 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_2e leakage reduction in grams per mile (g/mi) for each of their air conditioning systems. The maximum allowance value that can be generated for 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

[11] Tesla and BYD only produce battery electric vehicles and use the 0 g/mi incentive for their CREE as described in section 2.3.5.

[12] Additional information relating to GWP's can be found on Canada's action on climate change website.

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:

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

where
A is the CO_2e 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 2018 to 2021 model years.

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

Manufacturer	2018 PA	2019 PA	2020 PA	2021 PA	2018 LT	2019 LT	2020 LT	2021 LT
BMW	13.6	13.5	13.6	13.6	16.9	17.2	17.2	17.2
BYD	--	--	0.0	--	--	--	--	--
FCA	13.8	13.7	13.8	13.8	15.8	15.6	15.7	17.2
Ford	12.8	12.8	13.6	13.8	15.5	16.3	17.1	17.2
GM	12.3	12.3	12.9	13.6	16.7	16.4	16.7	17.2
Honda	11.6	12.7	12.8	13.5	15.6	16.5	16.5	17.2
Hyundai	5.4	10.6	9.0	13.7	2.2	1.7	4.3	16.9
JLR	13.8	13.7	13.8	13.7	17.2	17.2	17.2	17.2
Kia	8.2	12.7	13.3	13.5	7.9	15.4	16.3	16.9
Maserati	--	5.9	13.8	13.8	--	7.7	17.2	17.2
Mazda	2.7	1.5	1.9	12.0	4.3	5.0	5.0	15.1
Mercedes	5.9	6.2	6.2	13.8	7.6	7.4	8.4	17.2
Mitsubishi	9.8	7.8	13.5	13.1	13.1	13.5	16.7	15.9
Nissan	6.2	8.6	10.1	13.3	6.9	7.4	7.2	16.7
Porsche	13.5	12.6	--	--	14.4	6.5	--	--
Subaru	1.4	1.4	7.9	12.1	4.5	9.1	14.9	15.1
Tesla	5.7	12.7	13.7	13.6	5.2	11.2	15.4	17.0
Toyota	5.2	8.1	10.8	12.7	7.5	11.1	12.8	15.9
Volkswagen	12.3	13.2	10.5	13.5	15.6	15.7	13.0	16.7
Volvo	5.1	4.9	13.2	13.8	6.9	7.4	16.6	17.1
Fleet Average	8.4	10.3	10.7	13.2	13.3	14.2	14.7	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_2e 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_2. 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:

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

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 2018 to 2021 model years.

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

Manufacturer	2018 PA	2019 PA	2020 PA	2021 PA	2018 LT	2019 LT	2020 LT	2021 LT
BMW	4.9	4.9	4.9	4.9	6.3	7.0	7.0	7.1
BYD	--	--	0.0	--	--	--	--	--
FCA	4.7	4.7	4.8	5.0	5.9	5.8	6.2	6.9
Ford	3.9	4.0	4.4	4.7	6.8	6.5	6.4	7.1
GM	4.3	4.0	3.9	3.7	6.9	6.7	6.7	7.0
Honda	3.6	3.7	3.6	3.6	5.8	6.3	5.2	5.3
Hyundai	3.4	3.5	3.1	3.2	5.2	5.4	4.0	4.4
JLR	5.0	5.0	5.0	5.0	7.2	7.2	7.2	7.2
Kia	3.2	3.6	3.3	3.3	5.2	5.4	4.2	3.6
Maserati	--	4.9	5.0	5.0	--	7.2	7.2	7.2
Mazda	0.0	0.0	1.4	1.4	0.0	0.0	1.1	1.2
Mercedes	5.0	5.0	5.0	5.0	7.1	5.8	7.1	7.2
Mitsubishi	2.2	1.9	4.6	4.4	3.0	3.0	6.0	6.0
Nissan	3.9	3.7	4.1	4.1	4.0	4.2	4.8	5.4
Porsche	5.0	5.0	--	--	7.2	7.2	--	--
Subaru	3.1	3.0	3.6	3.4	4.6	5.8	6.6	6.5
Tesla	5.0	5.0	5.0	5.0	7.2	7.2	7.2	7.2
Toyota	4.1	4.6	4.6	4.8	6.0	6.4	6.3	6.6
Volkswagen	4.8	4.9	3.8	4.8	7.1	7.1	5.5	7.0
Volvo	4.0	4.8	4.7	4.0	6.2	6.2	6.3	6.3
Fleet Average	3.7	3.8	3.8	3.9	6.1	6.0	6.0	6.2

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_2e 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:

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

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 2018 to 2021.

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

Manufacturer	2018 PA	2019 PA	2020 PA	2021 PA	2018 LT	2019 LT	2020 LT	2021 LT
BMW	3.6	4.4	7.3	7.5	8.1	10.8	13.3	13.4
BYD	--	--	0.0	--	--	--	--	--
FCA	4.3	4.8	5.2	11.5	10.4	11.6	10.6	10.8
Ford	5.5	6.3	7.1	5.5	13.4	14.8	16.1	17.1
GM	7.1	6.0	6.0	6.1	8.9	10.0	12.1	12.2
Honda	4.1	4.1	4.4	5.0	8.5	9.4	12.7	12.8
Hyundai	2.4	2.1	4.0	4.4	5.7	5.3	8.5	12.8
JLR	6.9	5.5	6.8	5.9	12.4	12.2	12.9	13.2
Kia	2.0	2.9	4.7	4.5	4.5	4.7	7.5	9.2
Maserati	--	6.0	7.0	6.7	--	13.1	13.8	13.8
Mazda	1.4	1.9	2.4	2.6	4.6	5.1	6.6	6.8
Mercedes	3.9	1.5	1.4	2.2	3.3	2.5	2.9	3.7
Mitsubishi	2.4	1.7	3.2	2.9	1.4	1.4	4.9	5.1
Nissan	2.2	2.2	3.0	3.1	6.0	5.9	6.2	6.5
Porsche	3.2	2.0	--	--	3.1	9.8	--	--
Subaru	2.0	2.1	2.3	1.9	4.9	6.2	8.5	8.0
Tesla	4.8	4.6	4.6	4.7	8.3	8.3	8.3	6.8
Toyota	4.2	4.6	5.1	5.5	7.0	8.7	8.8	11.2
Volkswagen	4.7	5.1	5.6	8.1	10.6	11.6	11.9	13.0
Volvo	6.7	4.7	5.0	4.3	11.4	8.4	8.5	8.8
Fleet Average	3.7	3.7	4.4	4.8	9.2	10.2	11.0	11.6

2.3.4. Allowance for certain full-size pick-up trucks

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_2e 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_2e 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:

$$\boldsymbol{H} = \frac{\boldsymbol{\Sigma}\,(\mathbf{A}_{\mathrm{H}} \times \mathbf{B}_{\mathrm{H}}) + \boldsymbol{\Sigma}\,(\mathbf{A}_{\mathrm{R}} \times \mathbf{B}_{\mathrm{R}})}{\mathbf{C}}$$

where
$\boldsymbol{A_H}$ is the allowance for the use of hybrid electric technologies;
$\boldsymbol{B_H}$ is the number of full-size pick-up trucks in the fleet that are equipped with hybrid electric technologies;
$\boldsymbol{A_R}$ is the allowance for full-size pick-up trucks that achieve a certain carbon-related exhaust emission value;
$\boldsymbol{B_R}$ is the number of full-size pick-up trucks in the fleet that achieve a certain carbon-related exhaust emission value; and
$\boldsymbol{C}$ is the total number of vehicles in the fleet.

As of the 2021 model year no companies made use of the allowance for certain full-size pick-up trucks.

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 2025	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

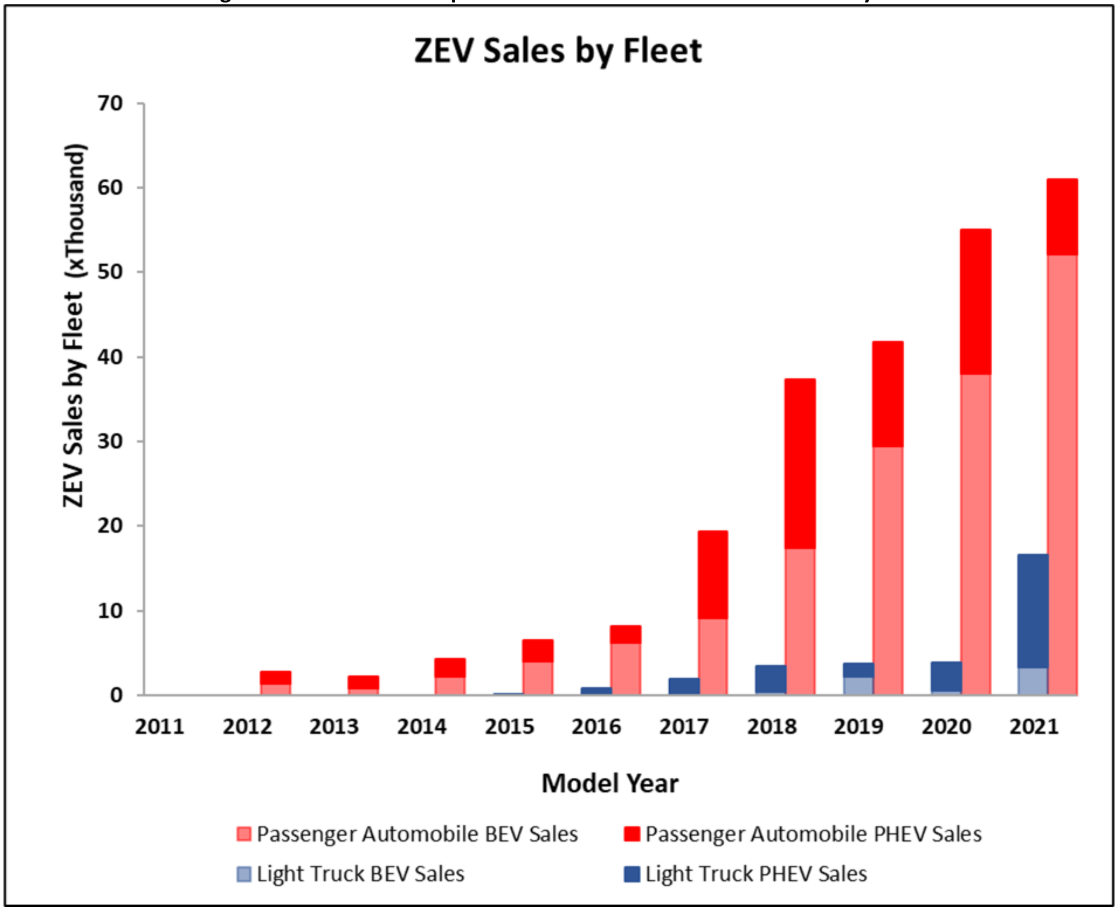
Manufacturer	2018 PA	2019 PA	2020 PA	2021 PA	2018 LT	2019 LT	2020 LT	2021 LT
BMW	70	69	158	391	--	--	--	--
BYD	--	--	25	--	--	--	--	--
FCA	--	--	--	--	--	--	--	--
Ford	682	--	--	5 267	--	--	--	--
GM	1 474	5 445	5 236	1 561	--	--	--	--
Honda	--	--	--	--	--	--	--	--
Hyundai	394	4 584	5 573	8 130	--	--	--	--
JLR	--	365	--	--	--	365	139	39
Kia	964	1 186	3 677	2 130	--	--	--	--
Mazda	--	--	--	--	--	--	--	--
Mercedes	442	141	--	--	--	--	--	--
Mitsubishi	--	--	--	--	--	--	--	--
Nissan	4 440	4 340	1 848	439	--	--	--	--
Porsche	--	--	1 039	507	--	--	--	--
Subaru	--	--	--	--	--	--	--	--
Tesla	8 511	12 502	18 483	32 414	450	862	328	1 450
Toyota	50	196	22	--	--	--	--	--
Volkswagen	808	1 024	1 929	329	--	918	23	1 783
Volvo	--	--	--	877	--	--	--	--
Total	17 835	29 487	37 990	52 045	450	2145	490	3 272

Table 10. production volumes of PHEVs by model year

Manufacturer	2018 PA	2019 PA	2020 PA	2021 PA	2018 LT	2019 LT	2020 LT	2021 LT
BMW	481	656	277	592	566	--	46	1 098
BYD	--	--	--	--	--	--	--	--
FCA	--	--	--	--	1 578	600	1 026	5 138
Ford	2 106	1 513	1 906	2 010	--	--	208	141
GM	5 400	2 675	--	--	--	--	--	--
Honda	850	910	747	172	--	--	--	--
Hyundai	1 024	1 622	1 396	900	--	--	--	--
JLR	--	--	--	--	--	--	207	140
Kia	45	1 150	1 361	488	--	--	--	--
Mazda	--	--	--	--	--	--	--	--
Mercedes	330	--	9	--	--	147	59	--
Mitsubishi	5 380	2 088	2 456	300	--	--	--	--
Nissan	--	--	--	--	--	--	--	--
Porsche	344	90	73	68	348	325	320	186
Subaru	--	--	413	--	--	--	--	259
Tesla	--	--	--	--	--	--	--	--
Toyota	3 606	1 600	8 659	4 254	--	--	--	4 939
Volkswagen	609	--	--	10	--	--	444	70
Volvo	41	3	86	99	497	541	688	1 395
Total	20 216	12 317	16 970	8 893	2 989	1 613	3 411	13 366

Figure 4 provides a graphical representation of the overall growth in ZEV production for 2011 to 2021 model years.

Figure 4. Increase in ZEV production from the 2011 to 2021 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_2e standards (non application of the standards respecting CO_2 equivalent emissions[13]) 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).

[13] This exemption does not have a noticeable impact on fleet-wide performance given the small volume of vehicles.

Table 11 summarizes the production volumes reported by small volume companies. This flexibility was claimed by 6 small volume companies for the 2012 and later model years.

Table 11. production volumes for small volume manufacturers by model year

Manufacturer	2018	2019	2020	2021
Aston Martin	44	148	741	826
Ferrari	247	364	370	313
Lotus	12	0	15	18
Maserati	1 000	--	--	474
McLaren	220	195	157	84
Total	1 523	707	1 283	1 715

2.4. Standards for nitrous oxide and methane

The regulations also limit the release of other GHG's, such as emissions of methane (CH_4) and nitrous oxide (N_2O). Starting with the 2012 model year, the regulations set standards for N_2O and CH_4 at 0.01 g/mi and 0.03 g/mi respectively. These standards are intended to cap vehicle N_2O and CH_4 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_2O and CH_4 requirements.

The first method allows companies to certify that the N_2O and CH_4 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_2O and CH_4 as an equivalent amount of CO_2 and include this in the determination of their overall CREE. Companies using this method must incorporate N_2O and CH_4 test data into the CREE calculation, while factoring in the higher global warming potential of these 2 pollutants. This method is not as commonly used as it counts N_2O and CH_4 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_2O and CH_4 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_2O and CH_4 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_2e emissions credits. The total deficits incurred by the companies that used this method are summarized in Tables 12 and 13.

Table 12. N_2O emissions deficits by company for the 2018 to 2021 model years (Mg CO_2e)

Manufacturer	2018 PA	2019 PA	2020 PA	2021 PA	2018 LT	2019 LT	2020 LT	2021 LT
BMW	-2 284	--	--	-99	-3 920	--	--	--
FCA	--	--	-49	--	-23 275	-6 269	-10 333	-9 788
Ford	-715	-847	-10	-15	-1 7047	-10 562	-713	-5 998
GM	-1 166	-236	--	--	-6 146	-4 501	-35 225	-105 252
Hyundai	-331	-999	-917	-541	--	--	--	--
JLR	-1 999	-62	--	--	-9 638	-3 935	-1 322	-797
Kia	-2 211	-1 447	-1 104	-754	--	--	--	--
Mazda	-1 449	-360	-179	-2 001	-4 324	-12 750	-3 439	-9 740
Nissan	-414	--	--	--	--	--	--	--
Toyota	-1 306	-1 466	-1267	-1 295	-2 289	-3 490	-8 913	-10 602
Volkswagen	--	--	--	-28	--	-300	-120	-149
Fleet Total	-11 875	-5 417	-3 526	-4 733	-66 639	-41 807	-60 065	-142 326

Table 13. CH_4 emissions deficits by company for the 2018 to 2021 model years (Mg CO_2e)

Manufacturer	2018 PA	2019 PA	2020 PA	2021 PA	2018 LT	2019 LT	2020 LT	2021 LT
BMW	-288	--	--	--	-493	--	--	--
FCA	-3	-3	-37	--	-3 215	-3 001	-186	-149
Ford	-152	-155	-240	-299	-18 801	-13 041	-10 361	-1 879
GM	-357	-137	-64	-52	-1 969	-762	-310	-9
Mazda	-340	-474	-122	-194	-121	-401	0	-20
Volkswagen	-74	-15	-51	-27	--	--	--	--
Fleet Total	-1 214	-784	-514	-572	-24 599	-17 205	-10 857	-2 057

2.5. CO_2e emissions value

The fleet average CO_2e emissions value, referred to as the “compliance value” is the final average CO_2e 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_2e emission reduction (section 2.3.3);

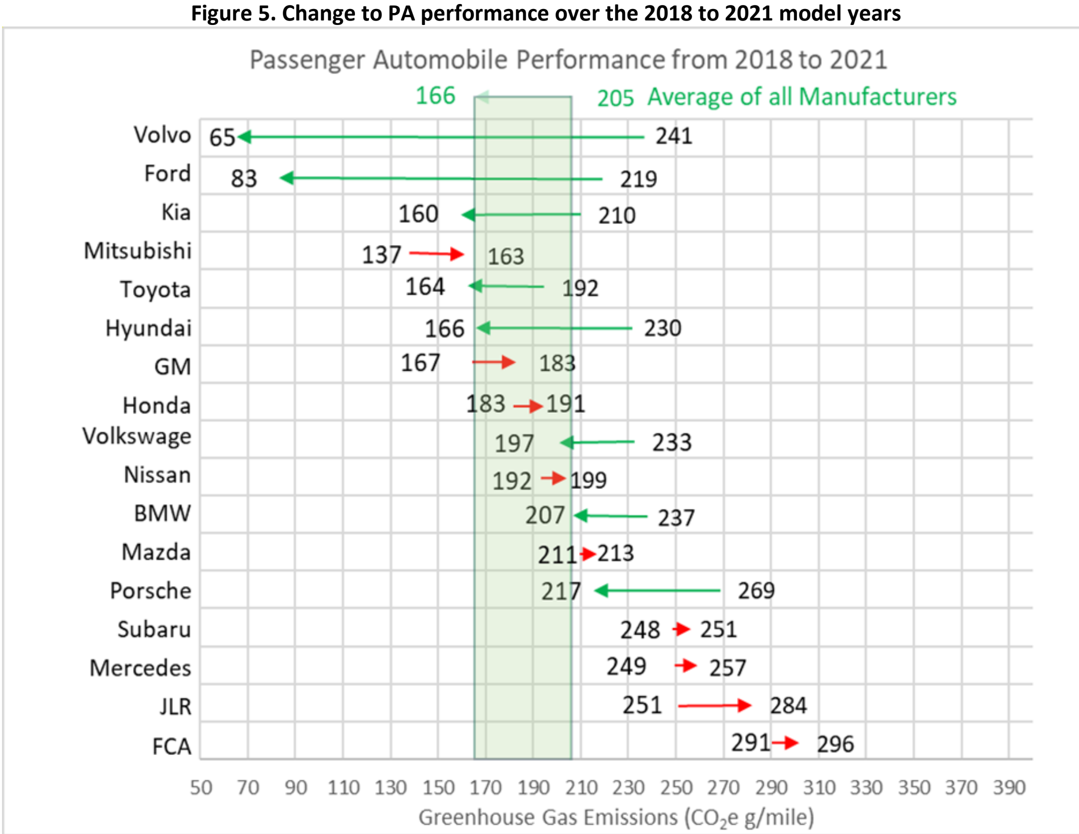
H is the allowance for certain full-size pick-up trucks (section 2.3.4).

A company’s compliance value for its fleet of passenger automobiles and light trucks is what is ultimately compared to its CO_2e 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 2018 to 2021 model years. Figures 5 and 6 shows the trends in manufacturer performance over the 2018 to 2021 model years.

Table 14. PA compliance and standard values over the 2018 to 2021 model years (g/mi)

Manufacturer	2018 Compliance	2019 Compliance	2020 Compliance	2021 Compliance	2018 Std.	2019 Std.	2020 Std.	2021 Std.
BMW	237	227	223	207	208	196	188	183
BYD	--	--	0	--	--	--	194	--
FCA	291	288	300	296	228	218	206	205
Ford	219	226	179	83	209	202	193	194
GM	167	157	129	183	204	192	181	177
Honda	183	187	186	191	204	193	184	180
Hyundai	230	206	195	166	206	196	184	179
JLR	251	306	265	284	242	219	203	183
Kia	210	184	155	160	204	195	183	177
Maserati	--	359	344	354	--	231	218	212
Mazda	211	220	220	213	202	189	183	178
Mercedes	249	262	256	257	213	205	195	192
Mitsubishi	137	151	134	163	195	183	176	171
Nissan	192	188	197	199	205	191	190	179
Porsche	269	302	147	217	224	194	198	178
Subaru	248	237	236	251	199	189	180	174
Tesla[14]	-16	-22	-23	-23	226	211	202	198
Toyota	192	183	156	164	201	192	183	179
Volkswagen	233	198	173	197	201	190	183	178
Volvo	241	248	218	65	245	222	212	191
Fleet Average	205	193	176	166	205	194	185	181

Figure 5. Change to PA performance over the 2018 to 2021 model years

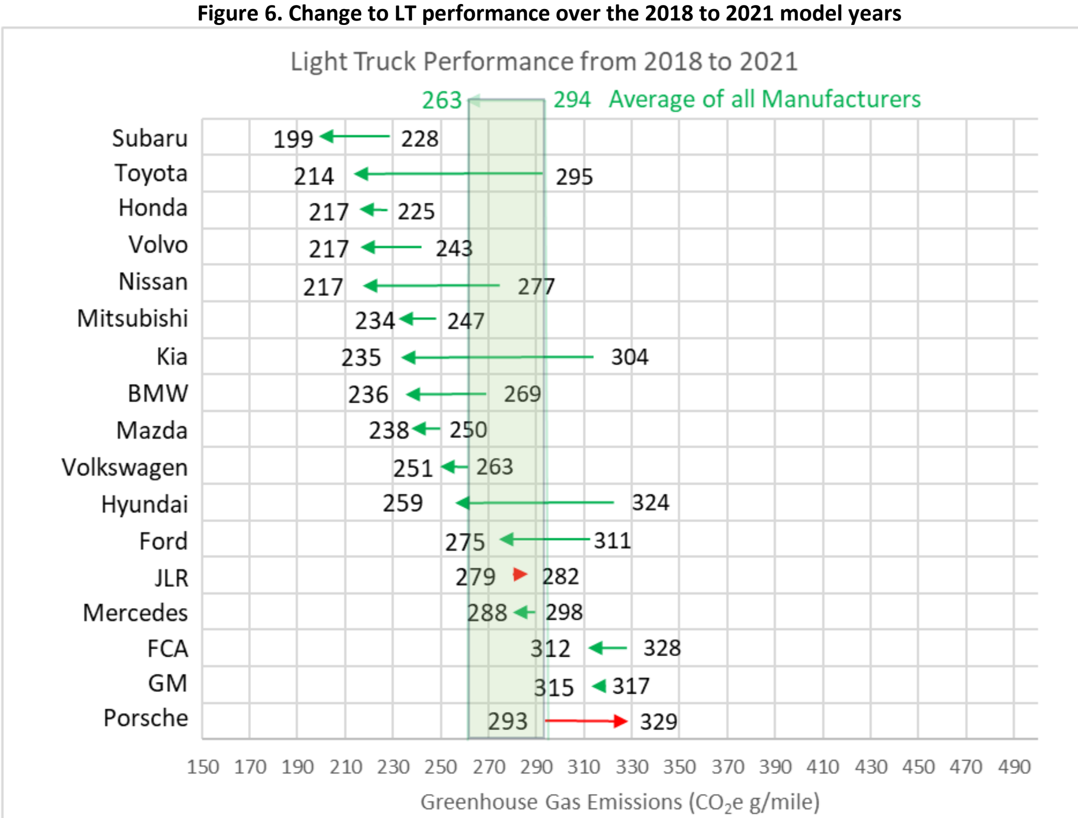


[14] Tesla only produces electric vehicles, and is able to use the 0 g/mi incentive for its entire fleet. The compliance value is negative once its AC allowances have been factored in.

Table 15. LT compliance and standard values over the 2018 to 2021 model years (g/mi)

Manufacturer	2018 Compliance	2019 Compliance	2020 Compliance	2021 Compliance	2018 Std.	2019 Std.	2020 Std.	2021 Std.
BMW	269	257	258	236	274	270	262	256
BYD	--	--	--	--	--	--	--	--
FCA	328	335	325	312	295	301	290	282
Ford	311	301	284	275	310	303	296	291
GM	317	316	304	315	310	298	293	293
Honda	225	232	223	217	261	258	245	237
Hyundai	324	330	308	259	266	258	269	252
JLR	279	267	278	282	286	278	267	256
Kia	304	290	282	235	267	263	253	234
Maserati	--	393	372	352	--	278	269	262
Mazda	250	256	247	238	256	249	238	231
Mercedes	298	304	290	288	274	263	263	255
Mitsubishi	247	243	233	234	242	234	226	219
Nissan	277	271	247	217	273	261	245	234
Porsche	293	294	320	329	284	277	266	251
Subaru	228	220	205	199	245	241	235	225
Tesla[14]	-21	-27	-31	-31	292	284	275	253
Toyota	295	264	261	214	273	265	261	249
Volkswagen	263	258	270	251	269	264	246	247
Volvo	243	250	236	217	291	274	263	249
Fleet Average	294	290	277	263	288	282	272	264

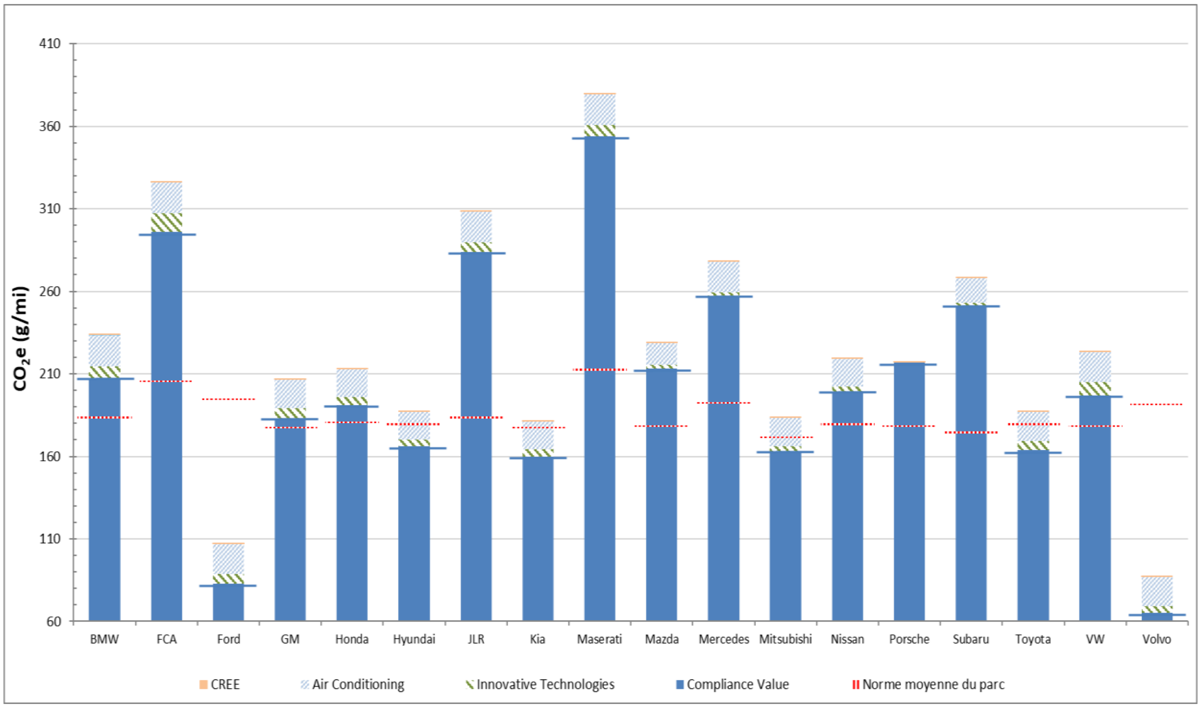
Figure 6. Change to LT performance over the 2018 to 2021 model years



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 2021 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.

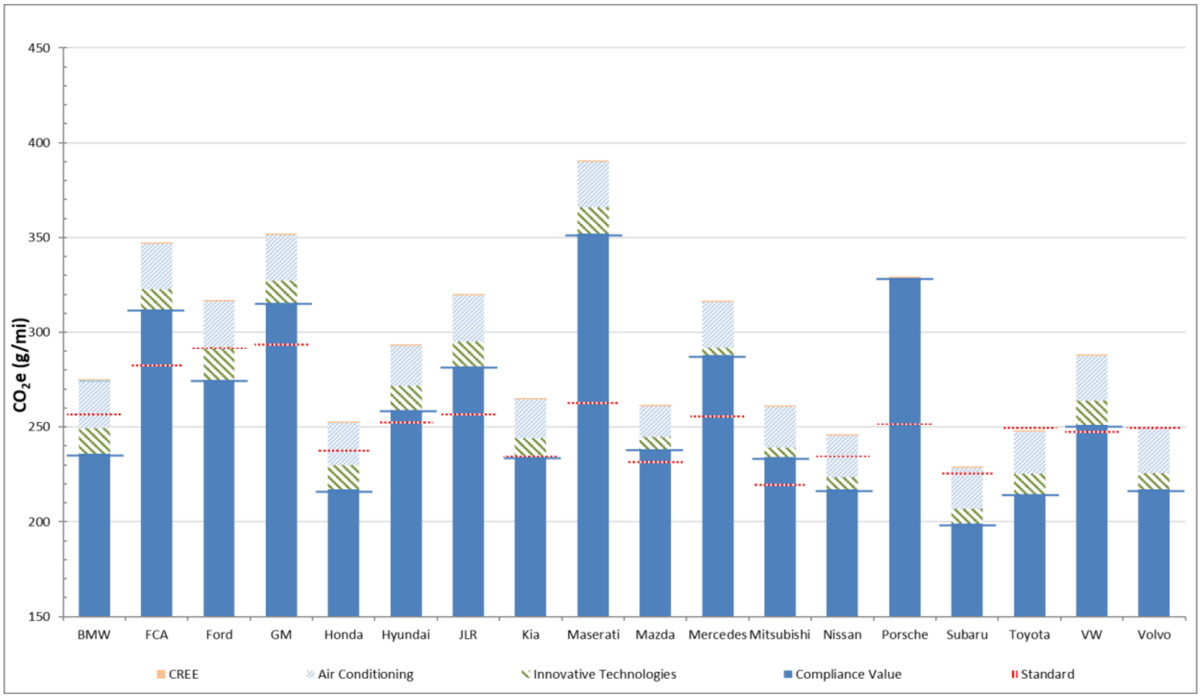
Figure 7. 2021 passenger automobile compliance status with offsets



Notes:

1. The final compliance value may be lower than the CREE through the application of compliance flexibilities
2. Tesla has a fleet average standard of 198 g/mi and fleet average compliance value of -23 g/mi. Tesla's compliance value falls outside of the range of this graph.

Figure 8. 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 has a fleet average standard of 253 g/mi and fleet average compliance value of -31 g/mi. Tesla's compliance value falls 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_2e 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_2e emissions coming from a vehicle are dependent on the efficient operation of all of 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_2e 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_2e 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 discreet 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_2e 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_2e emissions by improving the overall fuel consumption of the vehicle by 4 to 10%[15].

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

[15] Natural Resources Canada

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 – 35% further per litre of fuel then a gasoline based equivalent[16] which translates into measurable reductions in CO_2e 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.

Table 16. penetration rates of drivetrain technologies in the Canadian fleet

Technology	2018	2019	2020	2021
Turbocharging	33.8	33.2	32.7	33.6
VVT	94.7	95.4	94.2	92.8
VVL	17.9	18.2	18	14.9
Higher Geared Transmission	39.4	54.9	57.4	64.4
CVT	20.9	21	28.4	22.7
Cylinder Deactivation	12.5	16.3	13.7	16.2
GDI	45.6	42	48	50.5
Diesel	1.2	0.5	0.7	1.6

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_2e for each of its passenger automobile and light truck fleets of a given model year. Credits are weighted based on VKT to account for the greater number of kilometres 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[17]:

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

[16] US EPA website

[17] In October 2021, the Department published an Interim Order to correct the multiplier formula used to determine carbon dioxide (CO2) equivalent emission credits for advanced technology vehicles.

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; and
D is the 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.

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 15 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_2e)

Manufacturer	Early Action	2011 to 2016	2017	2018	2019	2020	2021	Total
FCA	0	30 103	0	0	0	0	0	30 103
Honda	2 138 563	3 069 910	0	0	0	0	0	5 208 473
Mazda	0	113 000	0	0	0	0	0	113 000
Mitsubishi	63 349	0	0	0	0	0	0	63 349
Nissan	822 292	402 728	0	0	0	0	0	1 225 020
Suzuki	123 345	30 431	0	0	0	0	0	153 776
Tesla	2 292	352 079	435 776	1 041 029	1 450 234	1 748 770	1 169 820	6 200 000
Toyota	2 623 142	2 780 598	0	0	0	0	0	2 623 142
Receiver General	--	6 906	--	--	--	--	--	6 906

Table 17. credit transactions (transferred in) by model year (Mg CO_2e)

Manufacturer	Early Action	2011 to 2016	2017	2018	2019	2020	2021	Total
Aston Martin	0	2 626	0	0	0	0	0	2 626
BMW	0	1 000 000	0	0	0	0	0	1 000 000
FCA	4 775 129	3 333 018	435 776	1 041 029	1 300 234	1 648 770	969 820	13 503 776
Ferrari	8 473	0	0	0	0	0	0	8 473
Ford	342 272	257 728	0	0	0	0	0	600 000
GM	0	0	0	0	0	0	200 000	200 000
JLR	143 369	0	0	0	0	0	0	143 369
Lotus	0	139	0	0	0	0	0	139
Maserati	3 740	30 103	0	0	0	0	0	33 843
Mercedes	0	1 745 000	0	0	0	0	0	1 745 000
Porsche	0	117 141	0	0	150 000	100 000	0	367 141
Subaru	0	300 000	0	0	0	0	0	300 000
Volkswagen	500 000	0	0	0	0	0	0	500 000

4.2. Total credits generated and final status

Table 18 shows the credits earned (or deficits incurred) by all companies over the 2021 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 100.1 million emission credits (including early action credits), of which approximately 21 million credits remain for future use. A total of 30.8 million credits have been used to offset deficits and 48.4 million credits have expired.

Table 18. net credits by model year and current credit balance (Mg CO_2e)

Manufacturers	Generated Credit/Deficit in 2021	Current Balance[18]
BMW	3 816	164 995
BYD	0	2 121
FCA	-1 211 101	5 395 629
Ford	1 078 217	1 618 599
GM	-965 745	2 154 402
Honda	211 064	3 734 898
Hyundai	191 686	222 776
JLR	-53 048	0
Kia	111 665	419 114
Maserati	-10 658	0
Mazda	-263 619	31 218
Mercedes	-295 380	0
Mitsubishi	-20 975	280 305
Nissan	-88 545	476 306
Porsche	-135 509	61 914
Subaru	223 278	1 122 876
Tesla	2 987 365	2 083 698
Toyota	1 454 063	2 596 602
Volkswagen	-149 343	211 869
Volvo	140 096	393 457
Total	3 207 327	20 970 779

[18] The current balance accounts for any expired credits, remaining early action credits, transactions, and offsets.

5. Overall industry performance

The overall fleet average compliance information for passenger automobiles and light trucks is summarized in Tables 19 and 20. Additionally, Figures 6 and 7 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.

Table 19. passenger automobile compliance summary for the 2011 to 2021 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	4.8	13.2	3.9	166	181	15

Figure 9. average GHG emissions performance - passenger automobiles

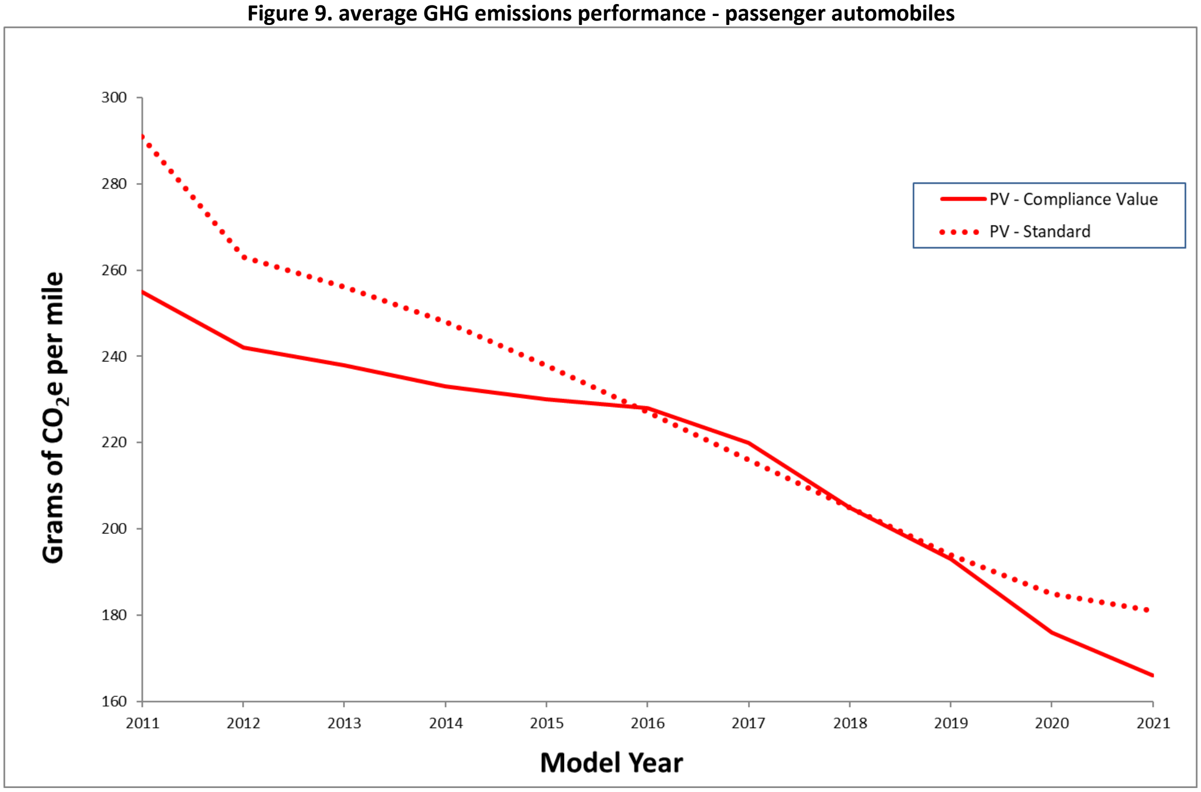
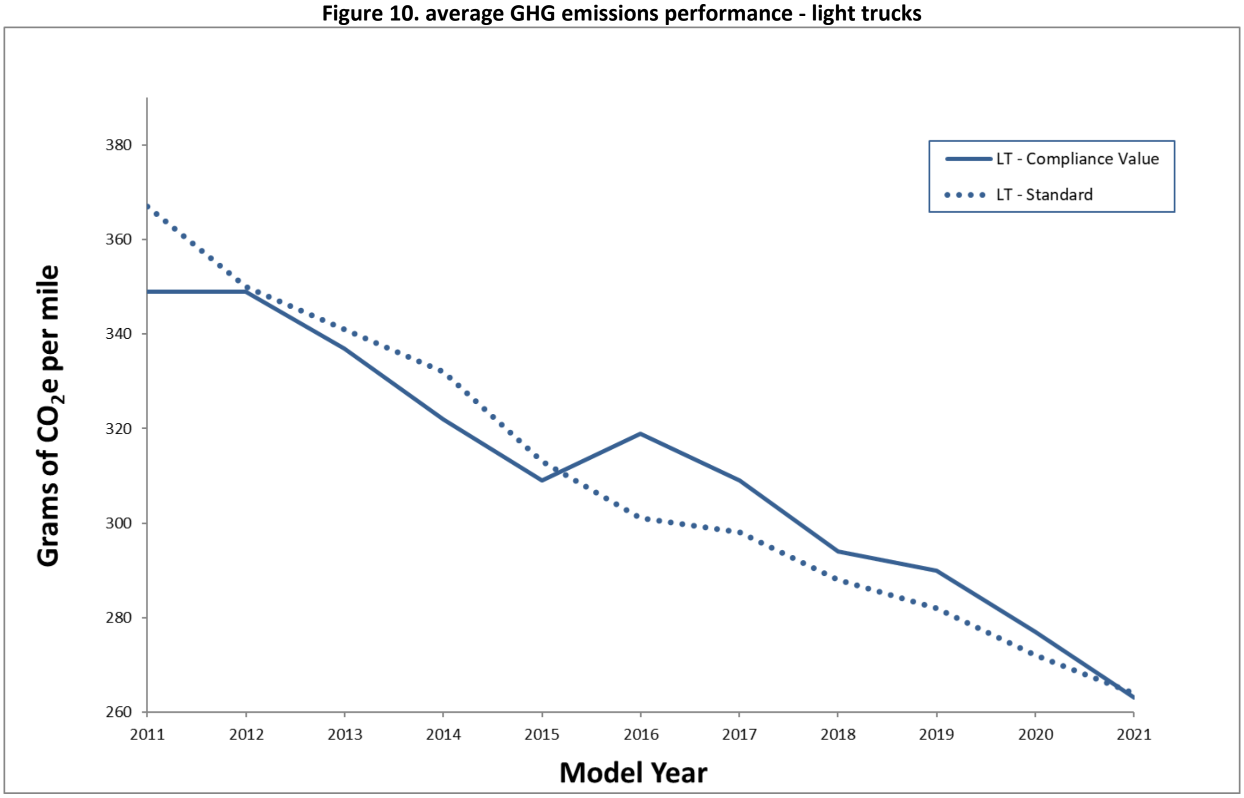


Table 20. light truck compliance summary for the 2011 to 2021 model years (g/mi)

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	-6
2021	298	11.6	16.6	6.2	263	264	1

Figure 10. average GHG emissions performance - light trucks



As depicted in Figures 9 and 10, the 2021 model year saw the overall compliance value for passenger automobiles decrease to 166 g/mi, and the overall compliance value for light trucks decrease to 263 g/mi. This has resulted in an overall net improvement of 34.9% and 24.6% relative to the 2011 model year for passenger automobiles and light trucks respectively.

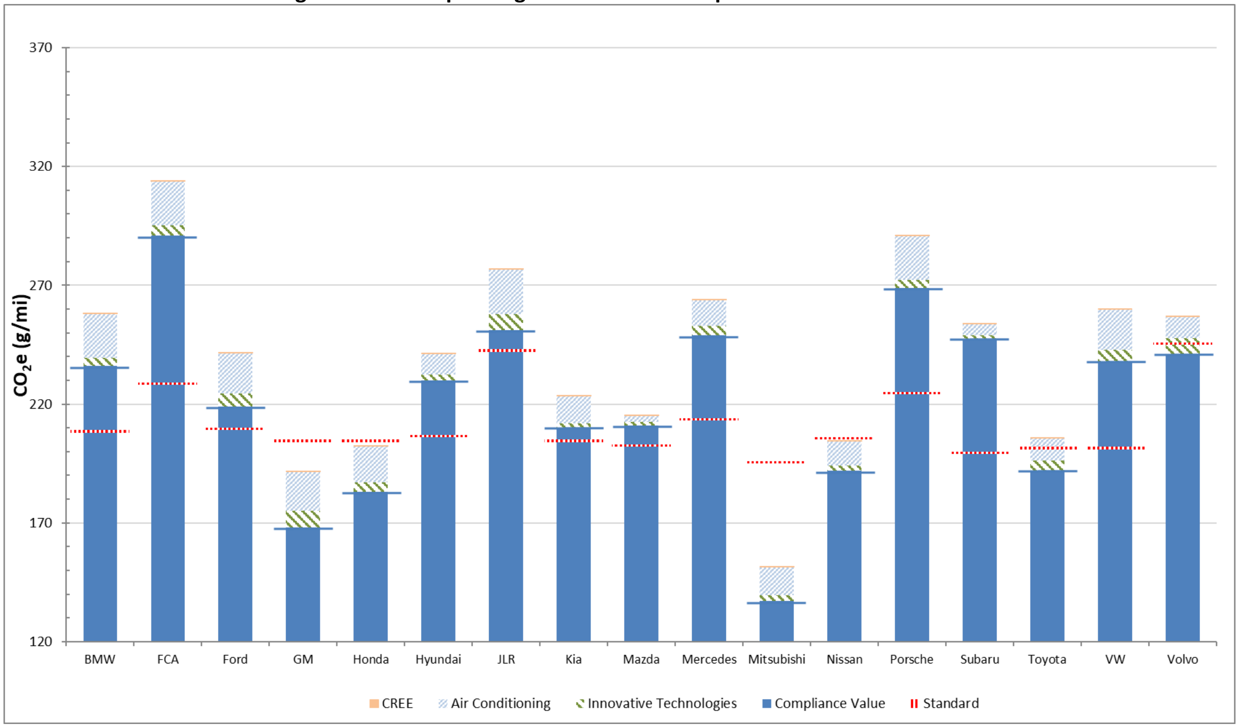
All companies remained in compliance with the regulations through the use of their own accumulated emission credits or by purchasing credits from other companies. Results to date indicate that all companies continue to meet their vehicle GHG regulatory obligations for the 2021 model year.

Appendix

Table A-1. production volumes by company

Manufacturer	2018 PA	2018 LT	2018 All	2019 PA	2019 LT	2019 All	2020 PA	2020 LT	2020 All	2021 PA	2021 LT	2021 All
Aston Martin	44	0	44	148	0	148	741	0	741	826	0	826
BMW	34 831	17 207	52 038	23 245	18 585	41 830	18 188	13 506	31 694	14 450	15 221	29 671
BYD	--	--	--	--	--	--	25	0	25	0	0	0
FCA	15 144	170 242	185 386	11 522	221 797	233 319	2 936	137 799	140 735	5 834	161 482	167 316
Ferrari	247	0	247	364	0	364	370	0	370	313	0	313
Ford	41 855	233 897	275 752	27 203	200 523	227 726	15 349	172 413	187 762	13 091	174 247	187 338
GM	81 077	188 187	269 264	60 593	186 381	246 974	24 622	128 565	153 187	18 572	172 203	190 775
Honda	110 320	81 930	192 250	102 062	102 252	204 314	80 531	73 611	154 142	39 703	64 463	104 166
Hyundai	117 473	6 050	123 523	111 853	3 900	115 753	122 929	8 298	131 227	84 131	19 949	104 080
JLR	1 654	11 646	13 300	567	11 678	12 245	423	14 985	15 408	268	7 873	8 141
Kia	55 202	22 719	77 921	42 547	28 680	71 227	47 977	33 467	81 444	34 294	40 668	74 962
Lotus	12	0	12	0	0	0	15	0	15	18	0	18
Maserati	172	291	463	77	191	268	120	362	482	212	262	474
Mazda	55 953	26 762	82 715	39 613	30 779	70 392	18 368	21 827	40 195	25 103	51 399	76 502
McLaren	220	0	220	195	0	195	157	0	157	84	0	84
Mercedes	25 562	29 596	55 158	17 214	19 918	37 132	13 543	26 523	40 066	8 446	25 324	33 770
Mitsubishi	9 004	15 434	24 438	5 158	13 252	18 410	4 151	14 435	18 586	1 181	6 879	8 060
Nissan	82 124	57 229	139 353	88 662	52 623	141 285	56 966	43 810	100 776	55 002	32 241	87 243
Porsche	3 589	7 837	11 426	2 130	5 723	7 853	2 944	4 856	7 800	2 380	6 663	9 043
Subaru	16 574	42 019	58 593	16 350	49 803	66 153	12 845	38 408	51 253	5 794	53 396	59 190
Tesla	8 511	450	8 961	13 101	263	13 364	18 483	328	18 811	32 414	1 450	33 864
Toyota	112 328	121 236	233 564	90 548	113 360	203 908	99 295	118 030	217 325	77 815	152 741	230 556
Volkswagen	61 658	68 060	129 718	78 118	50 314	128 432	22 059	32 233	54 292	26 775	53 433	80 208
Volvo	1 256	6 691	7 947	1 762	10 116	11 878	953	9 061	10 014	1 807	8 638	10 445
Fleet Total	834 638	1 107 192	1 941 830	733 127	1 120 238	1 853 365	563 947	892 346	1 456 293	448 633	1 048 894	1 497 527

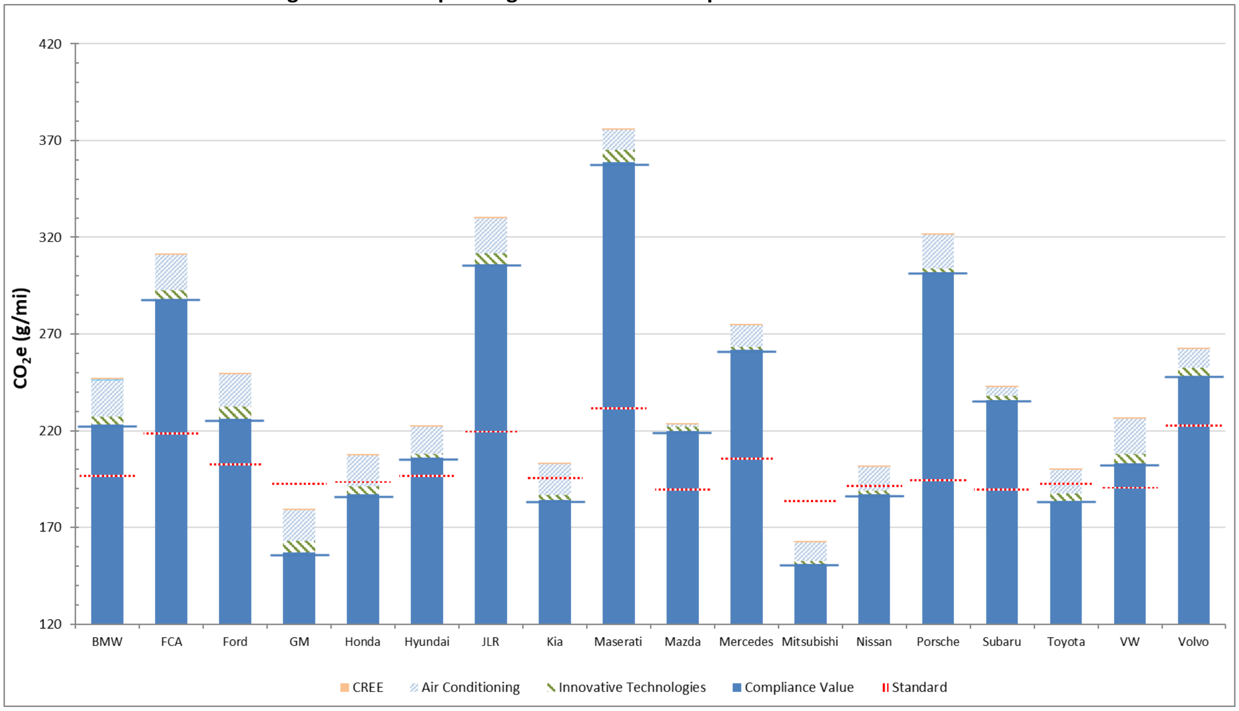
Figure A-1. 2018 passenger automobile compliance status with offsets



Notes:

1. The final compliance value may be lower than the CREE through the application of compliance flexibilities
2. Tesla has a fleet average standard of 226 g/mi and fleet average compliance value of -16 g/mi. Tesla's compliance value falls outside of the range of this graph.

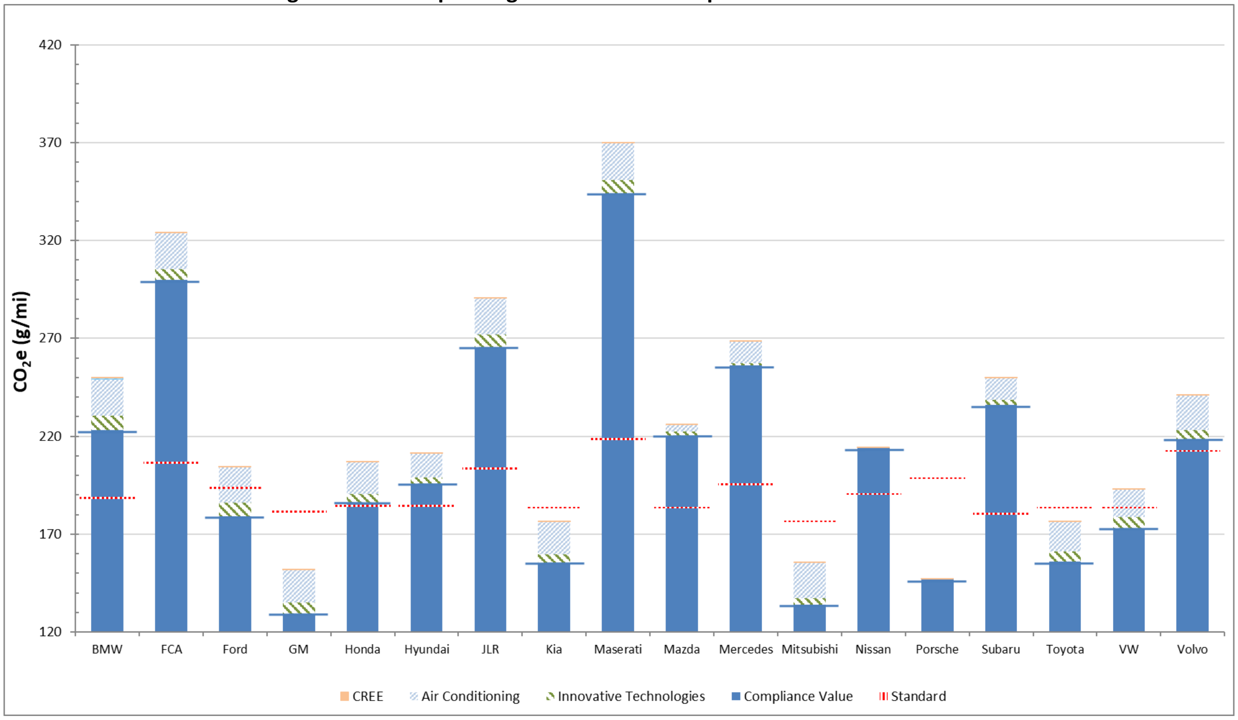
Figure A-2. 2019 passenger automobile compliance status with offsets



Notes:

1. The final compliance value may be lower than the CREE through the application of compliance flexibilities
2. Tesla has a fleet average standard of 211 g/mi and fleet average compliance value of -22 g/mi. Tesla's compliance value falls outside of the range of this graph.

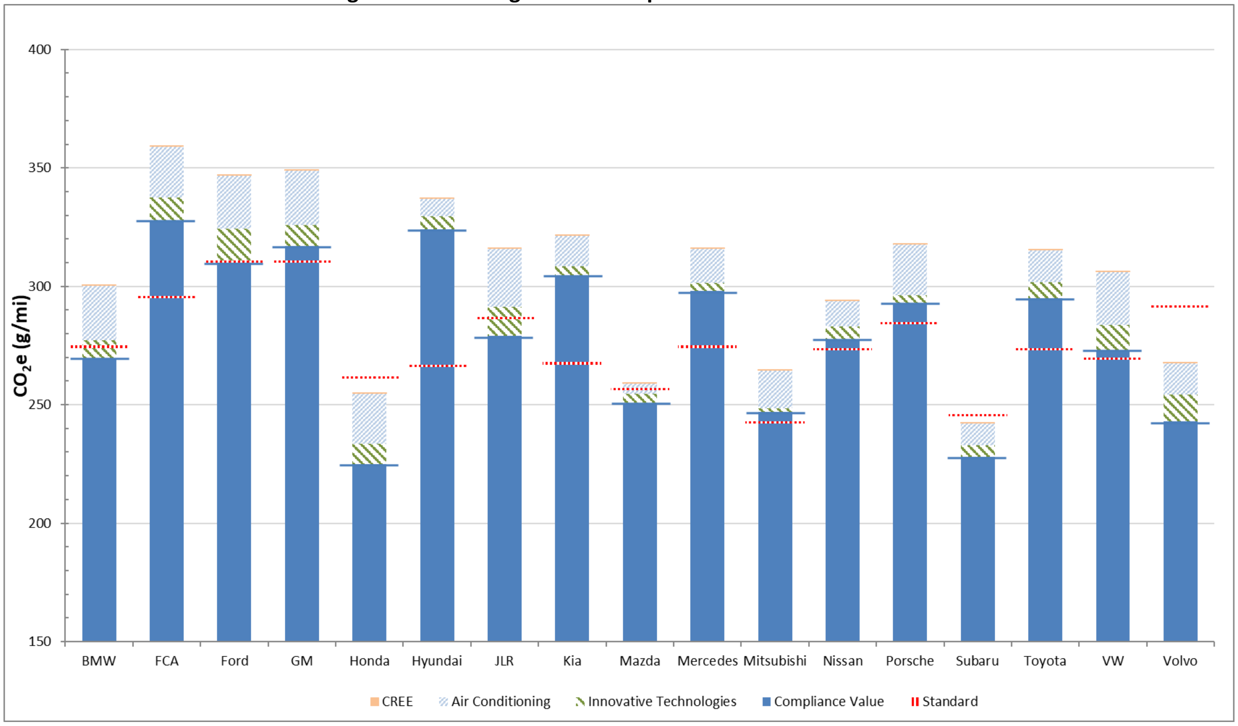
Figure A-3. 2020 passenger automobile compliance status with offsets



Notes:

3. The final compliance value may be lower than the CREE through the application of compliance flexibilities
4. Tesla has a fleet average standard of 202 g/mi and fleet average compliance value of -23 g/mi. Tesla's compliance value falls outside of the range of this graph.
5. BYD has a fleet average standard of 194 g/mi and fleet average compliance value of 0 g/mi. BYD's compliance value falls outside of the range of this graph.

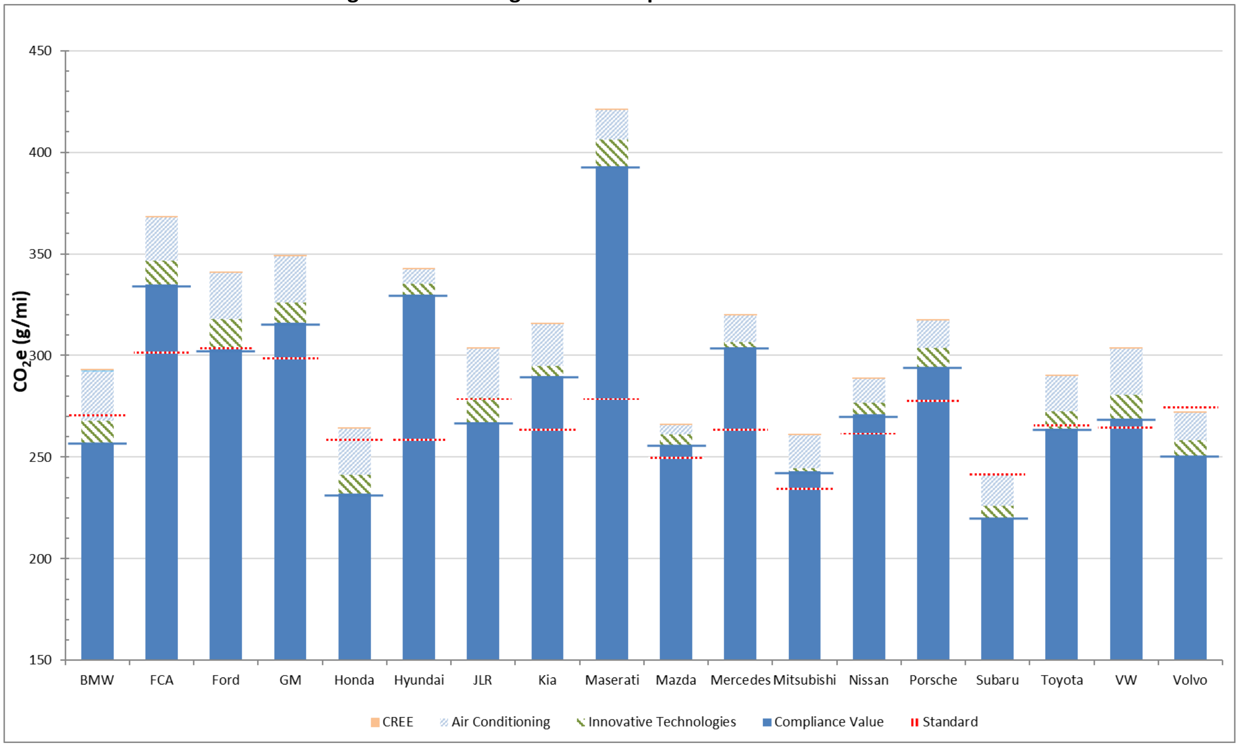
Figure A-4. 2018 light truck compliance status with offsets



Notes:

1. The final compliance value may be lower than the CREE through the application of compliance flexibilities
2. Tesla has a fleet average standard of 292 g/mi and fleet average compliance value of -21 g/mi. Tesla's compliance value falls outside of the range of this graph.

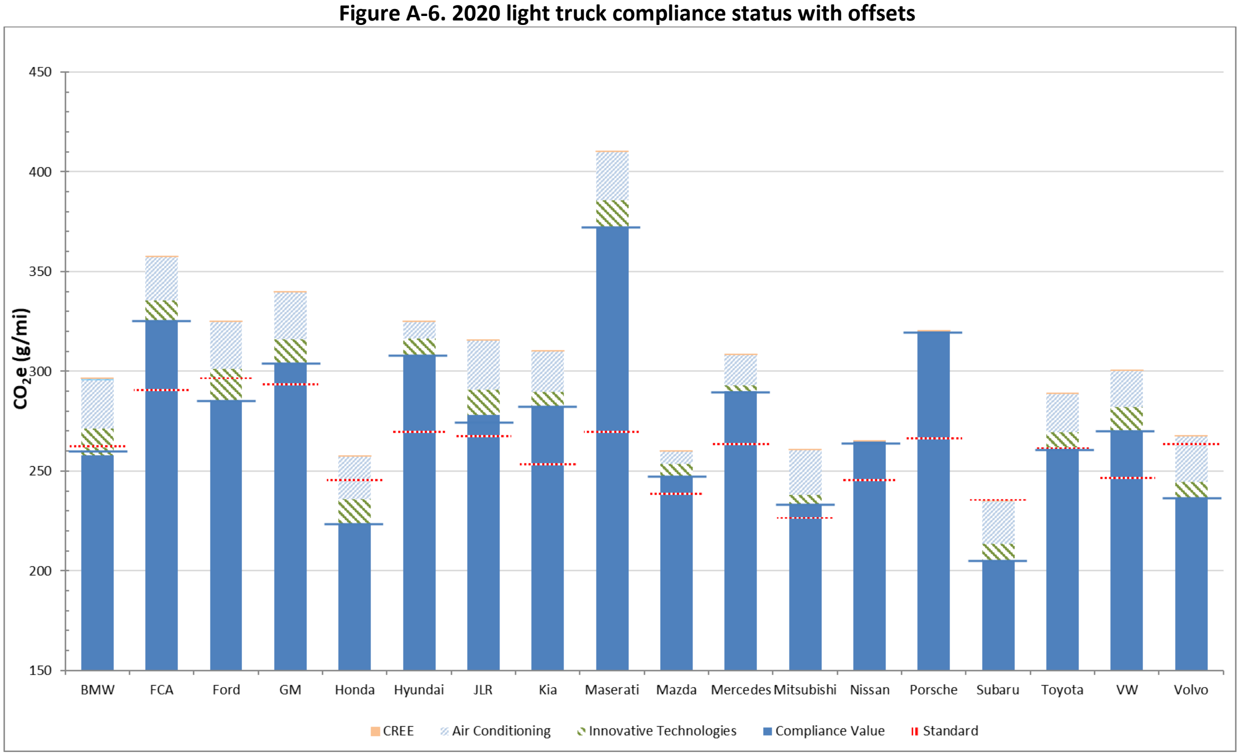
Figure A-5. 2019 light truck compliance status with offsets



Notes:

1. The final compliance value may be lower than the CREE through the application of compliance flexibilities
2. Tesla has a fleet average standard of 284 g/mi and fleet average compliance value of -27 g/mi. Tesla's compliance value falls outside of the range of this graph.

Figure A-6. 2020 light truck compliance status with offsets



Notes:

3. The final compliance value may be lower than the CREE through the application of compliance flexibilities
4. Tesla has a fleet average standard of 275 g/mi and fleet average compliance value of -31 g/mi. Tesla's compliance value falls outside of the range of this graph.

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

Technology	Allowance value (g/mi)
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).	1.7
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
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.	1.7
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.	1.1
Blower motor controls which limit wasted electrical energy (for example, pulse width modulated power controller).	0.9
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).	1.1
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).	1.1
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.	0.6

Table A-3. production volume of vehicles with turbocharging

Manufacturer	2018	2019	2020	2021
BMW	51 729	41 633	31 481	29 190
BYD	--	--	0	--
FCA	13 340	10 693	14 687	23 257
Ford	164 992	161 201	132 368	138 751
GM	102 272	82 820	56 807	65 865
Honda	92 935	92 538	76 355	64 217
Hyundai	15 002	17 376	16 152	14 721
JLR	7 665	6 080	12 771	3 248
Kia	6 740	2 301	2 675	12 627
Maserati	--	452	268	482
Mazda	5 943	12 735	5 416	17 909
Mercedes	54 716	36 991	40 066	33 770
Mitsubishi	3 051	3 848	4 173	0
Nissan	4 013	8 486	3 365	3 457
Porsche	102 06	7 401	6 354	8 145
Subaru	7 540	8 696	12 249	9 046
Toyota	4 969	6 884	7 444	8 336
Volkswagen	108 768	111 198	50 140	66 229
Volvo	2 088	3 192	3 549	3 591
Total	655 969	614 525	476 320	502 841

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

Manufacturer	2018	2019	2020	2021
BMW	49 292	41 633	31 481	29 190
BYD	--	--	0	--
FCA	174 949	222 283	135 261	161 489
Ford	216 872	191 796	159 409	157 435
GM	262 223	238 873	142 300	169 906
Honda	189 280	204 314	154 142	104 166
Hyundai	123 129	111 169	125 654	95 950
JLR	10 833	9 817	14 287	7 510
Kia	76 957	70 041	77 767	72 832
Maserati	--	463	268	482
Mazda	82 715	70 208	40 195	76 502
Mercedes	54 716	36 991	40 066	33 770
Mitsubishi	24 438	18 410	18 586	8 060
Nissan	134 913	136 945	98 928	86 804
Porsche	11 426	7 853	6 761	8 536
Subaru	58 593	66 153	51 253	59 190
Toyota	233 514	203 712	217 303	230 556
Volkswagen	128 910	126 490	49 087	78 027
Volvo	7 947	11 878	10 014	9 568
Total	1 840 707	1 769 029	1 372 762	1 389 973

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

Manufacturer	2018	2019	2020	2021
BMW	49 292	41 633	31 481	29 190
FCA	20 691	12 547	8 156	10 474
GM	3 940	62	4 933	13 138
Honda	132 525	131 803	95 409	57 245
JLR	10 833	9 817	14 287	7 510
Mercedes	0	9 587	18 149	18 800
Mitsubishi	6 425	4 862	5 545	0
Nissan	8 325	4 394	1 903	1 428

Porsche	11 426	7 853	6 761	8 536
Toyota	13 514	9 804	39 288	29 153
Volkswagen	91 365	105 248	36 835	47 582
Total	348 336	337 610	262 747	223 056

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

Manufacturer	2018	2019	2020	2021
BMW	48 365	36 184	30 975	28 489
FCA	124 854	184 880	116 342	164 272
Ford	142 121	153 389	165 213	171 375
GM	79 811	124 530	101 414	148 952
Honda	45 711	77 951	60 188	39 191
Hyundai	8 757	25 507	33 571	28 398
JLR	13 294	11 873	15 269	8 102
Kia	2 440	20 537	21 058	38 286
Maserati	--	452	268	482
Mercedes	54 716	36 991	40 066	33 770
Mitsubishi	3 051	3 848	4 173	54 751
Nissan	30 409	47 354	30 762	8 280
Porsche	10 935	7 607	6 317	53 639
Subaru	33 738	56 211	45 076	102 408
Toyota	68 806	115 112	106 374	73 805
Volkswagen	90 782	104 054	49 028	9 568
Volvo	7 947	11 878	10 014	28 489
Total	765 737	1 018 358	836 108	963 768

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

Manufacturer	2018	2019	2020	2021
FCA	0	600	1 026	968
Ford	2 860	5 390	11 772	9 262
GM	10 944	22 050	12 178	10 472
Honda	141 280	137 294	109 601	74 779
Hyundai	0	0	46 969	28 991
Kia	0	12 300	31 660	42 490
Mitsubishi	15 846	14 497	14 333	7 735
Nissan	112 790	114 857	95 193	83 400
Subaru	49 919	59 598	45 489	53 898
Toyota	73 312	23 416	45 664	28 484
Total	406 951	390 002	413 885	340 479

Table A-8. production volume of vehicles with cylinder deactivation

Manufacturer	2018	2019	2020	2021
FCA	48 374	96 115	52 737	51 655
Ford	0	0	16 696	42 801
GM	137 688	131 428	83 485	103 566
Honda	33 245	42 749	23 086	14 727
Mazda	23 102	28 751	20 472	24 226
Mercedes	0	2 142	1 817	2 793
Porsche	0	0	0	623
Volkswagen	1 044	569	778	2 220
Total	243 453	301 754	199 071	242 611

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

Manufacturer	2018	2019	2020	2021

BMW	49 292	41 633	31 481	29 190
FCA	3257	7 744	11 126	15 782
Ford	102 948	22 051	77 783	71 989
GM	240 931	211 556	129 927	161 893
Honda	125 220	142 381	103 952	79 172
Hyundai	73 000	74 035	58 513	56 674
JLR	10 833	9 817	14 287	7 510
Kia	65 121	56 952	44 780	20 887
Maserati	--	452	268	482
Mazda	82 715	70 208	40 195	76 502
Mercedes	54 687	36 966	40 059	33 770
Nissan	41 087	40 129	32 920	55 765
Porsche	0	0	0	254
Subaru	29 505	52 667	49 459	58 414
Toyota	434	317	2 655	497
Volkswagen	0	0	52 340	78 096
Volvo	7 947	11 878	10 014	9 568
Total	886 977	778 786	699 759	756 445

Table A-10. production volume of diesel vehicles

Manufacturer	2018	2019	2020	2021
BMW	2 437	0	0	0
FCA	9 880	2 661	3 489	3 305
Ford	3 030	1 913	265	501
GM	5 567	2 656	5 651	19 308
JLR	2 467	2 063	982	592
Mazda	0	184	0	0
Total	23 381	9 477	10 387	23 706