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Assessing Canada's 2025 passenger vehicle greenhouse gas standards: Characteristics of the Canadian fleet

Authors: Francisco Posada, Aaron Isenstadt, Ben Sharpe, & John German

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Background

This paper is part of a series that reports on an analysis done by the ICCT of Canada-specific technology pathways, costs, and benefits of Canada's 2025 passenger vehicle greenhouse gas standards, as finalized in 2014 (Regulations Amending the Passenger Automobile and Light Truck Greenhouse Gas Emission Regulations, 2014). The analysis compares that scenario—that is, the standards in force—to the alternative of following the Trump Administration's proposal to roll back the 2025 U.S. fuel economy and greenhouse gas emissions standards.

The analysis is relevant because Canada's passenger vehicle fuel efficiency regulation is structured in such a way as to tie Canada's standards directly to the U.S. regulation. If Canada rests with the regulatory status quo, its greenhouse gas standards will automatically retreat to whatever level is the final outcome of the U.S. rulemaking process initiated in August 2018.

The ICCT analysis used the U.S. Environmental Protection Agency's Optimization Model for Reducing Emissions of Greenhouse Gases from Automobiles (OMEGA) version 1.4.56, updated most recently to support the technical assessment for the midterm review (U.S. Environmental Protection Agency [EPA], 2017a). OMEGA was developed by EPA to evaluate technology costs and benefits and help set an appropriate stringency for greenhouse gas (GHG) standards for light-duty vehicles (LDV). The model evaluates the relative costs and effectiveness (CO_2 emission reduction) of vehicle technologies and applies them to a defined baseline vehicle fleet to meet a specified CO_2 emissions target. The ICCT adapted OMEGA for use with Canada's fleet and applied the model to evaluate the impacts of Canada remaining aligned with a weakened US regulation versus developing stand-alone standards that retain the current GHG targets out to 2025.

Canada's baseline fleet

Evaluating the costs and consumer benefits of future GHG standards in the Canadian LDV market requires an understanding of the baseline vehicle fleet. The first step in ICCT's analysis was to fully develop the Canadian LDV baseline fleet characteristics with all the inputs required to run the OMEGA model.

The development of the OMEGA database for the baseline Canadian fleet starts with sales and basic vehicle information from a vehicle market analysis company, then adds technology details from the EPA fuel economy guides, dimensions data from the U.S. Department of Transportation (DOT) database, and various additions from online sources. The data is then summarized in this report to assess the main characteristics of the Canadian LDV fleet, as well as to provide a sense of the similarities and differences between the Canadian and the U.S. LDV fleets. Summary and comparisons are done across the entire fleet, by vehicle type (car and truck) and by manufacturer. The end result, the baseline fleet, is subsequently used as an input to estimate technology pathways and costs to meet the LDV GHG 2025 targets as proposed by Canadian authorities in 2012 (Regulations Amending the Passenger Automobile and Light Truck Greenhouse Gas Emission Regulations, 2012).

DATABASE CONSTRUCTION

The construction of the Canadian baseline fleet began with a dataset purchased from DesRosiers Automotive Consultants Inc. (DAC). This dataset contains calendar year (CY) 2016 sales of all new vehicles, which includes sales of models from MY 2014–2017. Furthermore, the DAC dataset includes vehicle classes up through class 2b/3 trucks. These heavy-duty vehicles consist of all vehicles with gross vehicle weight rating (GVWR) greater than 10,000 lbs (class 3), as well as pickups and cargo vans with GVWR greater than 8,500 lbs (class 2b). Examples of such vehicles are Ford F250 and F350, Mercedes Sprinter, RAM 2500 and Promaster 1500-3500, and some variants of GMC Express, and Chevy Savana. Since Canada's GHG standards apply strictly to LDVs, these heavy-duty entries in the DAC dataset were excluded. These heavy-duty sales amount to only 3.2% of all sales in the DAC dataset. In addition to the heavy-duty vehicles, vehicle sales from the low-volume manufacturers—Aston Martin, Ferrari, and McLaren—were also excluded. These low-volume manufacturers make up less than 0.02% of all CY 2016 (CY16) sales in Canada.

Besides sales, make, model, and model year, the DAC dataset also contains other information about each vehicle. For example, all models include information on type of fuel, injection type, engine size, and configuration (V6, I4, etc.), induction type (turbocharged, naturally aspirated, etc.), drive configuration (AWD, FWD, etc.), and, for most vehicles, some performance characteristics (power, torque, and label CO_2 values).

In order to fill in the numerous other vehicle characteristics required to run OMEGA, the information in the DAC dataset was used to match each DAC vehicle to the exact model in EPA's MY 2015–2017 fuel economy guides (EPA, 2017b). Specific characteristics available in the fuel economy guides include: transmission type and number of gear ratios, unadjusted (i.e. laboratory) CO_2, exhaust gas recirculation (EGR), variable valve timing (VVT) and variable valve lift (VVL), cylinder deactivation, hybridization and stop-start, type of lubrication and friction reduction, and carline class.

The DAC dataset provided label—or adjusted—CO_2 values by model, but the GHG compliance determination and the OMEGA model require vehicle two-cycle unadjusted CO_2 values to be used. We replaced the adjusted CO_2 values with unadjusted values from the EPA guide by matching the vehicle model information (model, engine displacement, transmission and other criteria). The reason for taking this step is that adjusted CO_2 closely represents real world CO_2-emissions, while unadjusted CO_2 values only account for the results of the two-cycle (city and highway) tests conducted in the laboratory. Unadjusted CO_2 emissions and fuel consumption are much lower than in the real world, so adjustments are made to the unadjusted values in order to better reflect average real-world CO_2 emissions for the label or window sticker. However, for the purposes of GHG emission standards, the unadjusted (two-cycle) CO_2 emissions value is used to determine compliance.

After combining the information for each matched vehicle in the DAC and fuel economy datasets, several important vehicle characteristics remained outstanding: vehicle dimensions (track width[s], wheelbase, curb weight), valve actuation type (dual overhead cam, overhead valve, etc.), and power steering type. Using the additional characteristics of the combined dataset, each vehicle was again matched to its corresponding entry in the market database compiled and maintained by the U.S. National Highway Traffic Safety Administration (NHTSA, 2016).

NHTSA's market database only contains information for MY 2016 vehicles. For most models, much of the required missing information (dimensions, valve actuation, and power steering) is the same for MY 2016 and MY 2017. Nevertheless, since about 21% of sales (45% of models) in the fully combined Canadian CY 2016 database were MY 2017 vehicles, data for MY 2017 vehicles were double-checked and filled-in using information publicly available on the internet from *Car and Driver*, *The Car Connection*, and *Auto123*, which is Canada-specific.

CANADIAN FLEET OVERVIEW

The complete database was used to evaluate the Canadian baseline fleet characteristics. Canada had 1,878,470 new vehicle sales in CY 2016. The top 10 selling automakers cover 93% of the Canadian market; all of them are also present in the United States. Table 1 summarizes the CY 2016 sales shares of all manufacturers.

Only three models sold in Canada in CY 2016 were not offered in the United States: Nissan Micra, Kia Rondo, and Mitsubishi Mirage. Together they make up nearly 15,000 sales, or just under 0.8% of the fleet.

Table 1 Canadian fleet sales data, calendar year 2016

Make	CY16 Sales	Sales Share	Cumulative Share
Ford	278,099	14.8%	14.8%
FCA	266,658	14.2%	29.0%
GM	238,455	12.7%	41.7%
Toyota	217,659	11.6%	53.3%
Hyundai/Kia	209,839	11.2%	64.5%
Honda	186,668	9.9%	74.4%
Nissan	132,363	7.0%	81.4%
Volkswagen	97,962	5.2%	86.7%
Mazda	69,210	3.7%	90.3%
Subaru	50,190	2.7%	93.0%
BMW	44,714	2.4%	95.4%
Mercedes	43,642	2.3%	97.7%
Mitsubishi	22,292	1.2%	98.9%
JLR	12,174	0.6%	99.5%
Volvo	6,103	0.3%	99.9%
Total	**1,878,470**	**100%**	**100.0%**

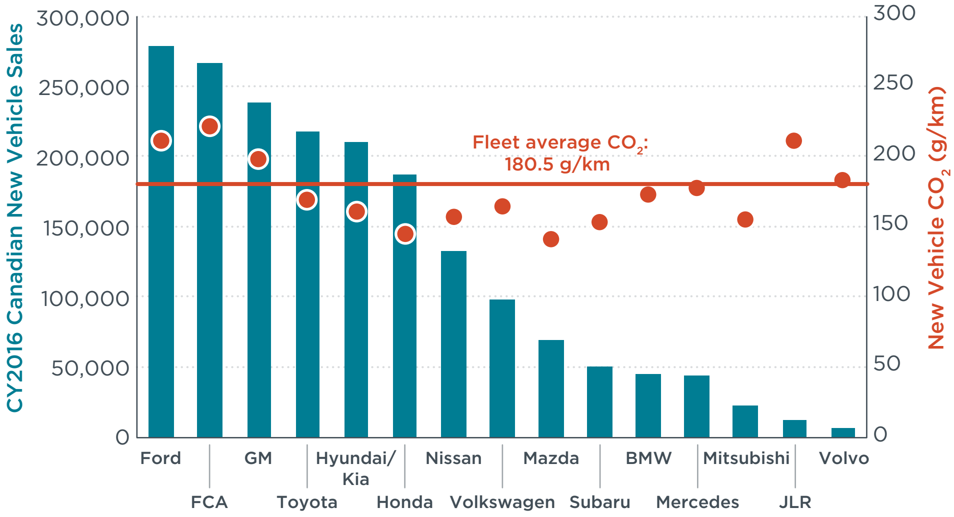

Figure 1. Fleet-average CO$_2$ emissions and sales by manufacturer in Canada in CY16. Sorted by manufacturer market share.

Figure 1 illustrates the CO$_2$ emissions of Canadian new vehicles in CY 2016. In that year, the entire fleet averaged 180.5 gCO$_2$/km. Each manufacturer's sales-weighted average CO$_2$ emissions is shown as a red circle. The three largest manufacturers—which make up nearly 42% of new sales in Canada—averaged about 210 gCO$_2$/km. In comparison, the remainder of the fleet averaged just 160 gCO$_2$/km. The Canadian fleet is comprised of 47.7% cars and 52.3% trucks.

COMPARISON OF CANADIAN AND U.S. LIGHT-DUTY FLEETS

Given that one of the objectives of this project is to assess the costs and benefits of harmonizing the second phase of the Canadian vehicle GHG regulation with the EPA vehicle GHG standards, a comparison between the fleet performances and efficiency technology uptake is relevant. This section compares the fuel economy for both fleets by manufacturer, the relative shares of cars and trucks in both markets, and basic fleet-average vehicle characteristics.

Table 2 compares the CY 2016 Canadian fleet to the MY 2015 U.S. fleet, based on several characteristics. Since the Canadian fleet comprises MY 2016 and MY 2017 vehicles, it represents slightly updated vehicles and technology. Although the U.S. fleet's average CO$_2$ emissions are lower than Canada's fleet, separate car and truck emissions are higher. This outcome arises due to a higher market share of trucks in Canada than in the United States. Five out of every ten light vehicles sold in Canada in CY 2016 were trucks, compared to four out of ten vehicles sold in the United States in MY 2015. Since virtually all vehicles sold in Canada are also available in the United States, part of the increased efficiency of the Canadian fleet is due to newer technologies present on newer vehicles. However, the differences in car weight and power also suggest that Canadian consumers tend to buy slightly smaller and lighter cars than U.S. consumers, leading to the greater difference in efficiency for cars compared with trucks.

The following figures explore the data in Table 2 more deeply. Figure 2 splits the market share of cars and trucks by 15 manufacturers. All makes, except

Subaru, sell a higher proportion of trucks in Canada than in the United States. Seven manufacturers in Canada have truck market shares that are at least 20% higher than those in the United States. Of these, five have at least a 40% greater truck share.

Seven manufacturers have higher car CO_2 emissions in Canada than in the United States, but only five manufacturers have higher truck CO_2 emissions in Canada (Figure 3). However, the top-selling car producers are, in order of most to least sales, Hyundai/Kia, Toyota, Honda, and GM. They represent more than 57% of the car market. The seven manufacturers whose cars are higher-emitting than in the United States represent less than 27% of the overall car market. The comparatively low share of higher-emitting cars in Canada leads to an overall fleet of cars that emits less than in the United States. For trucks, the top sellers are FCA, Ford, GM, and Toyota (representing more than 69% of trucks). The five manufacturers with higher-emitting trucks represent more than 60% of the truck market. Seven manufacturers have lower CO_2 emissions in Canada for both their cars and trucks.

Car and truck CO_2 performance for the Canadian CY2016 fleet are 149.9

Table 2. Canada CY 2016 and U.S. MY 2015 light-duty fleet characteristics.

Fleet	Market Share	Footprint (sq. m)	Weight (kg)	Power (HP)	Power-to-Weight (HP/kg)	CO_2 emissions (g/km)
Canada cars	47.7%	4.2	1480	190	0.126	149.9
US cars	57.3%	4.3	1520	195	0.126	151.0
Difference		**-2.3%**	**-2.6%**	**-2.6%**	**0.0%**	**-0.7%**
Canada trucks	52.3%	5.1	2010	277	0.136	208.4
US trucks	42.7%	5.0	2026	271	0.132	208.5
Difference		**2.0%**	**-0.8%**	**1.0%**	**3.0%**	**0.0%**
Canada fleet		4.7	1757	235	0.131	180.5
US fleet		4.6	1736	228	0.129	175.5
Difference		**2.2%**	**1.2%**	**3.1%**	**1.6%**	**2.8%**

NB: US data for MY 2015 is from the EPA OMEGA baseline (EPA 2017a).

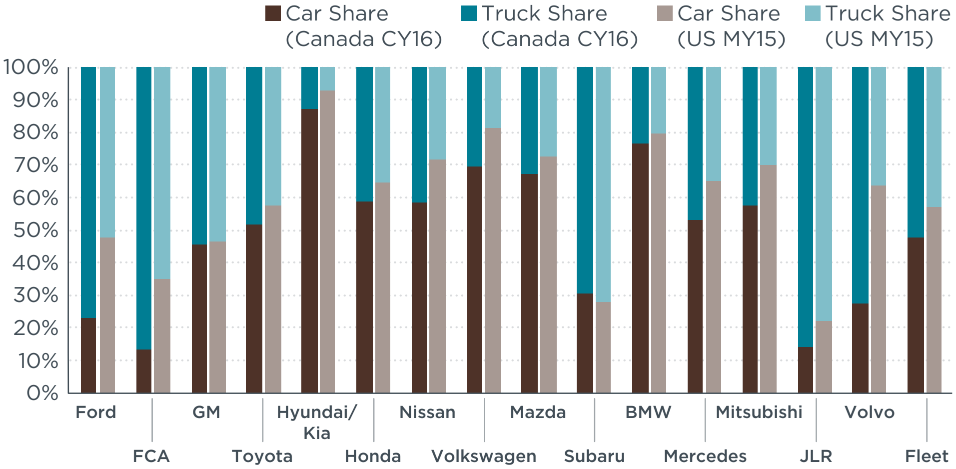

Figure 2. Car and truck share by manufacturer in Canada (CY 2016) and in the United States (MY 2015). Sorted by total market share of manufacturer in Canada.

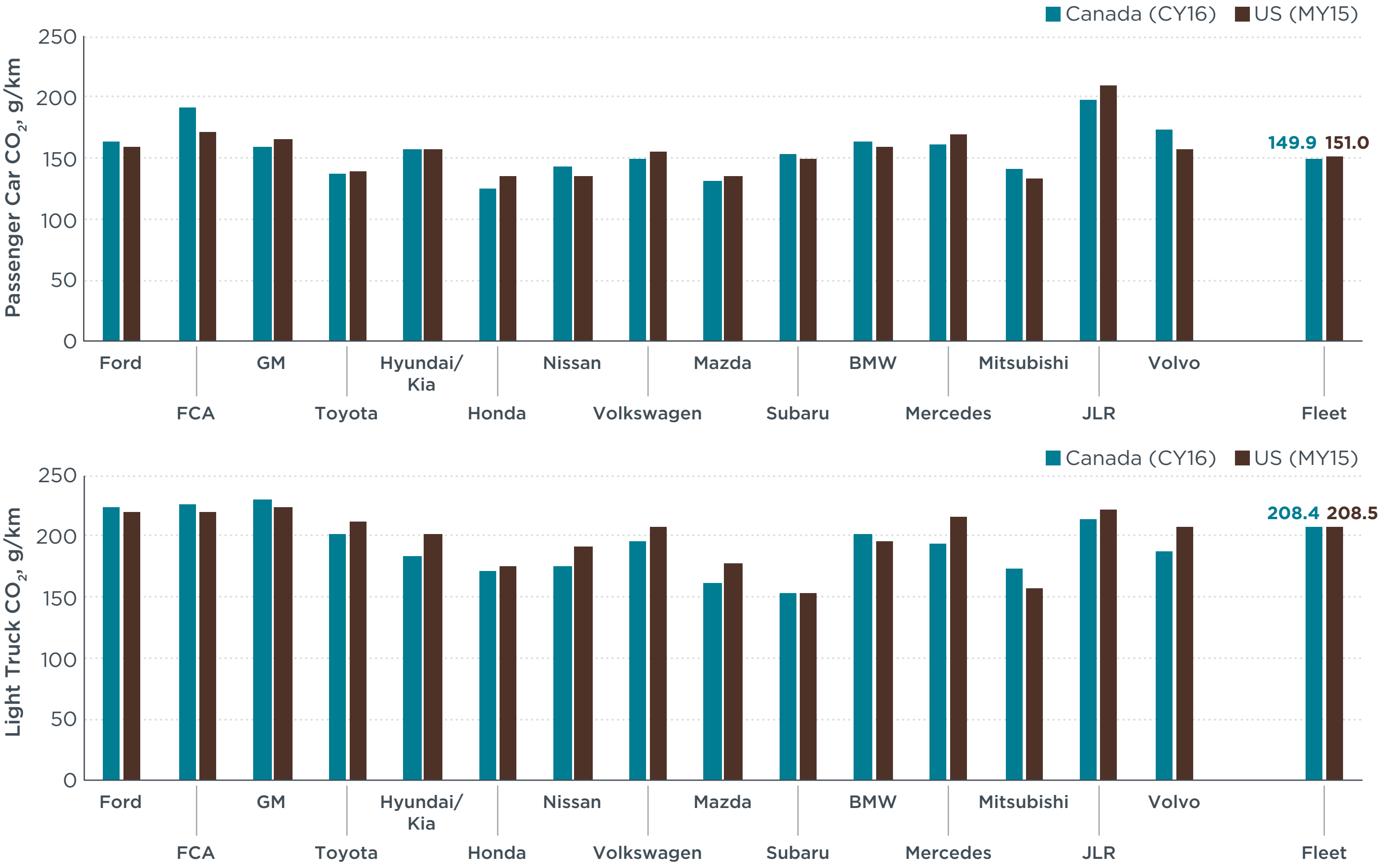

Figure 3. Car and truck CO_2 emissions by manufacturer in Canada (CY 2016) and in the United States (MY 2015). Sorted by total market share of each manufacturer in Canada.

g/km and 208.4 g/km. Despite lower car and truck average emissions in Canada for most manufacturers, the CY 2016 Canadian fleet averages 180.5 gCO_2/km compared to the MY 2015 U.S. fleet average of 175.5 gCO_2/km. The large market share of trucks in Canada explains why, even if half the manufacturers in Canada are more efficient than those in the United States, the overall fleet average is still slightly less efficient in Canada.

The car and truck emissions values presented here for CY2016 match very closely to the MY 2016 values presented by ECCC in August of 2018 (Environment and Climate Change Canada [ECCC], 2018). The ECCC reports 147 and 209 gCO_2/km for their MY 2016 car and light truck vehicles, placing CY2016 values within 1.8% of the official number. This is consistent with the CY 2016 values being composed of a mix of MY 2016 and more efficient MY 2017 vehicles.

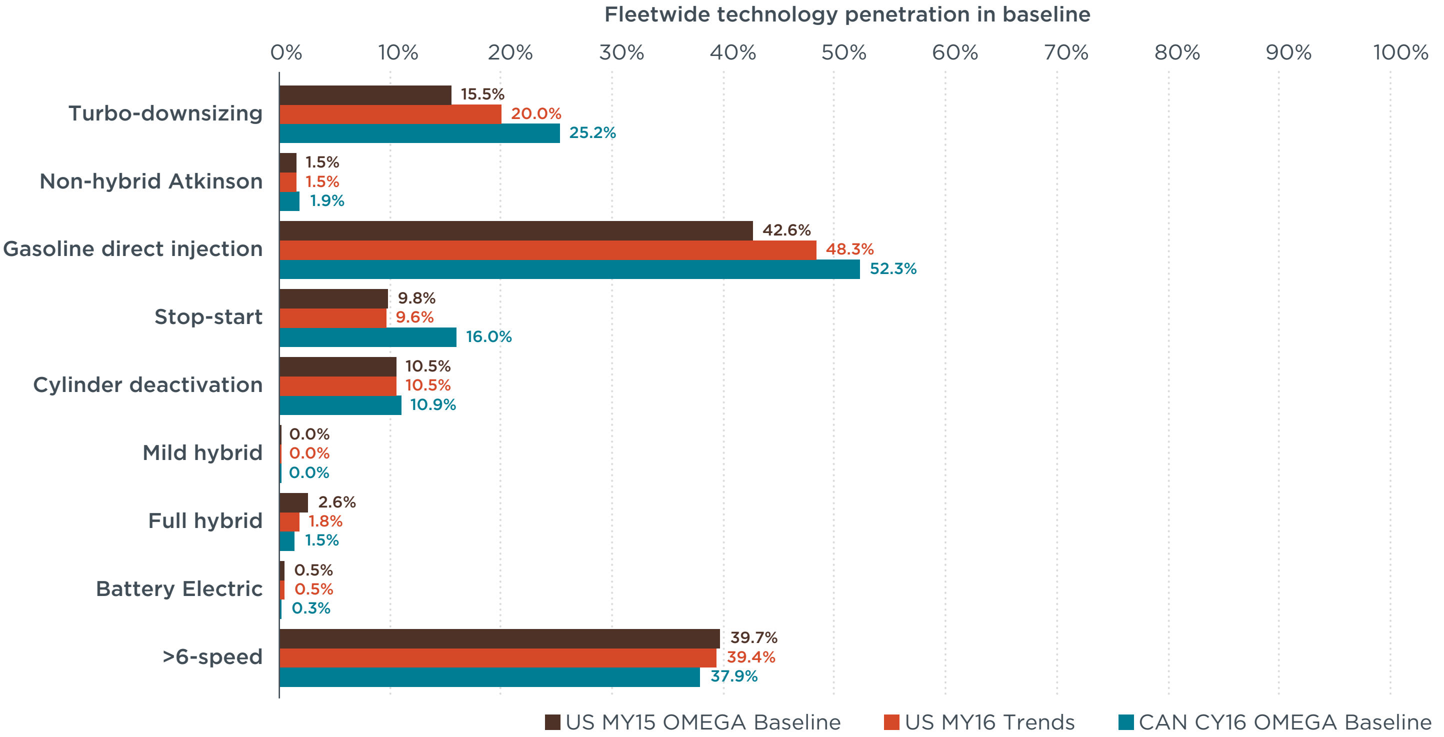

Figure 4. Market penetration of select efficiency technology

DISCUSSION ON TECHNOLOGY ADOPTION AND EARLY COMPLIANCE TRENDS

The two countries' fleets are extremely similar in terms of the level of technology applied in the LDV sector, and the rate of adoption for some of these technologies is very fast in the North American market. A comparison of key efficiency technologies between the Canadian CY 2016 vehicles and the U.S. vehicles from the MY 2015 OMEGA baseline, and MY 2016 EPA trends report (EPA, 2018b) helps illustrate this behavior (Figure 4).

The Canadian baseline fleet (CY 2016) enjoys about 10 percentage points higher market share of turbocharged engines and gasoline direct injection (GDI) systems than U.S. MY 2015 fleet. Many of these turbocharged engines have GDI. Although stop-start is more widely used in the Canadian baseline than in the U.S. baseline, some of this difference results from newer, CY 2016 vehicles comprising the Canadian baseline.

Most of the gaps between Canada and the United States disappear when comparing the U.S. MY 2016 data to the Canadian baseline from CY 2016. Data from the EPA's light-duty technology and CO_2 trends report (EPA, 2018b) show that GDI was available in 48.3% of MY 2016 LDVs in the United States and very close to the 52.3% uptake seen in Canada for CY 2016. Turbochargers are also a close match between the fleets when looking at the U.S. MY 2016 adoption rates (20.0%) and the Canadian CY 2016 adoption rates (25.2%). From these data points, it can be concluded that the Canadian fleet has adopted fuel-efficient technologies at the same rate as the U.S. fleet, suggesting a unified North American LDV technology market.

The technology comparisons presented here are key to understanding the projected costs of meeting the standards in the future. The technologies listed in Figure 4 were selected for comparison and illustration, as they offer the main sources of efficiency improvements. Estimated changes in the market share of these technologies is one of the primary outputs of the OMEGA model. The changes from the baseline indicate one of numerous possible pathways to comply with the standards.

Moreover, some vehicles in the Canadian baseline fleet already meet future CO_2 emissions targets, especially when including air-conditioning leakage and efficiency credits, as well as 6 gCO_2/mi in off-cycle credits.[1] Sales of these vehicles are plotted in Figure 5. Approximately 35% of conventional vehicles (non-hybrid, non-plug-in) already meet their 2020 targets. In fact, more than one out of every three conventional gasoline vehicles meets its 2020 target. Manufacturers use sales of these vehicles to accumulate compliance credits. According to official CO_2 emissions levels which were used to construct the OMEGA baseline database, the 2022 targets are met with hybrids, plug-in vehicles, about 16% of gasoline vehicles, and 58% of diesel vehicles. Only plug-ins, most hybrids, and some MY 2015 Ford F150s already meet the GHG 2025 targets, when air conditioning and off-cycle credits are included. For reference, the 2020-compliant sales plotted in Figure 5 correspond to about 22% of CY 2016 models; 2022-compliant sales represent 11% of CY 20116 models; and 2025-compliant sales are about 5% of all CY 2016 models.

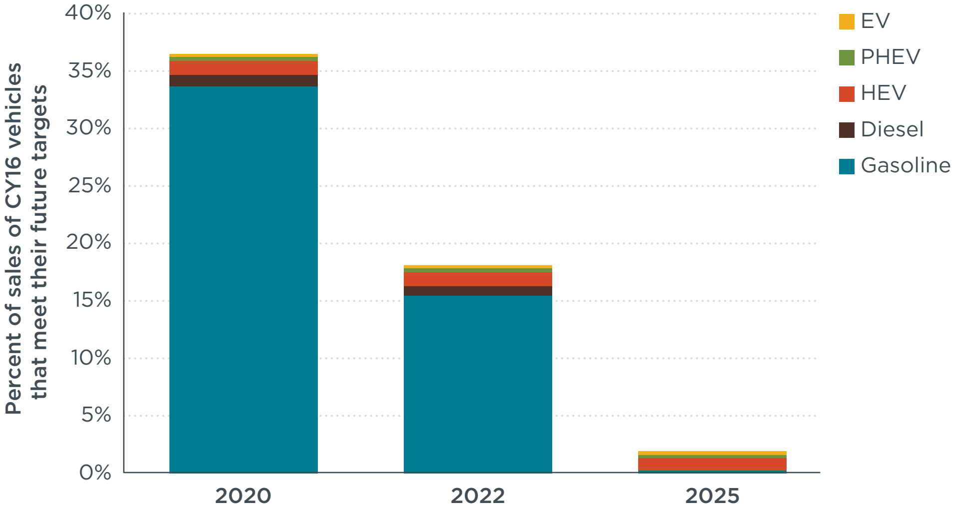

Figure 5. Share of CY 2016 sales that meet future targets, air conditioning efficiency, and off-cycle credits of 6 gCO_2/mi included.

Though it may be surprising, the fact that some F150s—one of the most popular vehicles in Canada—already meet their 2025 targets is the result of important efficiency technology as well as significantly less stringent CO_2 targets for trucks. The MY 2025-compliant trucks are 2WD, have stop-start, and turbo-downsized engines. These particular models are the SuperCab 8' box, which have the largest footprint of all F150 variants: over 76 sq ft. Consequently, the targets for these vehicles extend to the least stringent portion of the standards. These large F150s must meet a 2025 target of 294gCO_2/mi. Their baseline CO_2 value, at 315gCO_2/mi is only 7% greater, and 21 grams higher, than their 2025 target. Thus, minimal improvement is necessary, especially when adding in air conditioning and off-cycle credits.

It is worth reiterating that Figure 5 shows the share of CY 2016 vehicles that meet their future targets assuming they take full advantage of credits for air-conditioning (AC) efficiency and reduced refrigerant leakage (a total of 18.8 gCO_2/mi for cars and 24.4 gCO_2/mi for trucks) as well as 6 gCO_2/mi in off-cycle credits. This use of credits to meet the targets is the same methodology used by EPA when evaluating technology uptake and costs to meet 2025 targets with the OMEGA model (EPA, 2018a & 2018b). Judging by the higher-than-expected usage of off-cycle credits in MY 2016, in the 2020–2025 time frame, the industry on the whole is expected to deploy credits at least equivalent to the level of credits of industry leaders in 2016 (EPA, 2018b; Lutsey & Isenstadt, 2018). The 6 gCO_2/mi used by industry leaders in 2016 could easily rise to 10–25 gCO_2/mi fleet-wide by 2025. At 17.5 gCO_2/mi in average off-cycle credits, more than half of conventional, non-hybrid CY 2016 vehicles would meet their 2020 targets, nearly 30% of all vehicles would meet their 2022 targets, and more than 6% would meet 2025 targets. Thus, off-cycle credits offer major flexibility in the standards (Lutsey & Isenstadt, 2018). Though high levels of off-cycle credits are likely, ICCT has not included them at such high levels in the OMEGA modeling due to uncertainties at this time.

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[1] Off-cycle credits are one of the multiple flexibility compliance tools under the current U.S. GHG regulation. These credits account for CO_2 reduction benefits from technologies that provide those under real driving conditions and that are not accounted for during the two-cycle tests. Off-cycle credits are provided to manufacturers as incentives to install efficient technologies that provide benefits beyond what is measured in the laboratory.

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