COMPARISON OF GREENHOUSE GAS REDUCTIONS FOR THE UNITED STATES AND CANADA UNDER U.S. CAFE STANDARDS AND CALIFORNIA AIR RESOURCES BOARD GREENHOUSE GAS REGULATIONS

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AN ENHANCED TECHNICAL ASSESSMENT
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EXECUTIVE SUMMARY

This document provides quantification of the greenhouse gas (GHG) emission reductions resulting from adoption of California emission standards by states and Canadian provinces and builds upon reports issued by the staff of the California Air Resources Board (ARB) on January 2 and January 23, 2008. This report also addresses a number of comments received regarding the original January 2 assessment and corrects several minor computational errors in the original analysis.

California adopted greenhouse gas emissions standards for new passenger vehicles, effective with 2009 models. Manufacturers have flexibility in meeting these standards through a combination of reducing tailpipe emissions of carbon dioxide (CO_2), nitrous oxide (N_2O), and methane (CH_4) and receiving credit for systems demonstrated to mitigate fugitive emissions of hydrofluorocarbons (HFCs) from vehicle air conditioning systems. The emission standards become increasingly more stringent through the 2016 model year[1] (Pavley regulation). California is also committed to further strengthening these standards beginning in 2017 to obtain a 45 percent greenhouse gas reduction from 2020 model year vehicles. As allowed by the federal Clean Air Act, 12 additional states have adopted California's standards and other states, as well as Canadian provinces, have also expressed interest in doing so.

In public comments explaining his denial of a waiver under Sec. 209(b) of the Clean Air Act for California to enforce its greenhouse gas standards, United States Environmental Protection Agency (U.S. EPA) Administrator Stephen Johnson makes the claim, without supporting documentation, that California's motor vehicle GHG emissions standards are less effective in reducing global warming pollution than the recently enacted Corporate Average Fuel Economy (CAFE) standards. The California Air Resources Board's staff analyzed this claim and prepared and documented its own technical evaluation.

California standards regulate GHG emissions; federal CAFE standards are aimed at reducing the nation's fuel consumption. In this study the two programs are evaluated so that the reductions in GHG gases under the California rules can be compared to those expected from implementation of the CAFE portion of the 2007 Energy Bill. The results show that the Administrator's claim that the federal CAFE program is better than California's program at reducing GHG emissions from motor vehicles is wrong, whether in California, those states that adopt the California standards, or the nation as a whole (See Table ES-1).

The apples-to-apples comparison of total tons of GHG emissions reduced under the new federal CAFE standards versus those that would occur with full implementation of the California rules also reveal the following results:

- ***California's Rules Are More Stringent Earlier****.* In calendar year 2016, our state standards (referred to as the California standards or the Pavley rules) will reduce California's GHG emissions by 16.4 million metric tons (MMT) of carbon dioxide equivalents (CO_2E). This is more than double the 7.5 MMT reduction produced by the federal rules.

- ***California's Rules Are More Stringent Later****.* By 2020, California is committed to implement revised, more stringent GHG emission limits (the Pavley Phase 2 rules). California's requirements would reduce California GHG emissions by 31.7 $MMTCO_2E$ in 2020, 69 percent more than the 18.8 MMTs reductions under the federal rules in that year.

[1] The regulations were adopted by the California Air Resources Board in their final form on August 4, 2005 pursuant to AB1493 (Pavley) signed into law in 2002. The baseline year for all reduction calculations is 2002.

- ***There Are Greater Fuel Savings Under California Rules**.* Our analysis estimates the effects of the federal CAFE standards on GHG emission rates. This also allows a comparison of the impact of the two programs on vehicle efficiency. Since the California rules are significantly more effective at reducing GHGs than the federal CAFE program, they also result in better fuel efficiency – roughly 43 miles per gallon (mpg) in 2020 for the California vehicle fleet as compared to the new CAFE standard of 35 mpg.

- ***The Cumulative Greenhouse Gas Benefit Is Greater under California Rules.*** The cumulative GHG emission reductions of our standards have also been estimated (see Table ES-1). Between 2009 and 2016, the California standards will prevent emissions of 55 $MMTCO_2E$ in California. This is more than twice the 22 MMTs prevented if only the new federal CAFE standards were implemented. By 2020, the California rules would prevent 158 $MMTCO_2E$ emissions, double the 79 MMTs reductions of CO_2E expected if only the federal standards were implemented in California.

- ***Other States Magnify the Superiority of California Rules.*** There are also significant benefits for other states that adopt the California standards. Twelve states have done so to date. By 2020, California's more stringent limits will reduce cumulative GHG emissions in California and those 12 states by 434 $MMTCO_2E$, an 89 percent improvement over the federal standards.

Table ES-1. Summary of Cumulative Benefits of the California Program for California, Other States, and Canada

		Cumulative GHGs Reduced			% Benefit
Region	**Year**	**Fed. Std[b]**	**CA Std**	**CA over Fed Std**	**CA over Fed Std**
California	2016	22	55	33	150%
	2020[c]	79	158	79	100%
California and 12 Other States[d]	2016	66	145	79	120%
	2020[c]	230	434	204	89%
All 50 States	2016	207	434	226	109%
	2020[c]	716	1323	608	85%
Canada	2016	12	29	17	139%
	2020[c]	44	87	43	99%
United States and Canada	2016	219	462	243	111%
	2020[c]	759	1411	651	86%

[a] Million metric tons.
[b] Based on CAFE standard.
[c] Based on current and planned standards.
[d] Includes states that have adopted California's standards (Connecticut, Maine, Maryland, Massachusetts, New Jersey, New Mexico, New York, Oregon, Pennsylvania, Rhode Island, Vermont, and Washington).

- ***California's Rules Would Be a Better "National Solution**."* If the Pavley rules are implemented in all 50 states, by 2016 a cumulative total of 434 $MMTCO_2E$ will have been prevented from being emitted into the air as compared to 207 $MMTCO_2E$ if only the new federal fuel economy standards were implemented. By 2020, the combination of the Pavley 1 and 2 rules will have prevented 1,323 $MMTCO_2E$ from being emitted as compared to 716 $MMTCO_2E$ if only the federal fuel economy standards were implemented (see Table ES-1 and Figures ES-1 and ES-2).

- ***There Are Additional Benefits if Canada Adopts California Standards**.* If the Pavley rules are implemented in Canada, by 2016 a cumulative total of 29 $MMTCO_2E$ will have been reduced as compared to 12 $MMTCO_2E$ if only the new federal fuel economy standards were implemented. By 2020, the Pavley rules will have prevented a total of 87 $MMTCO_2E$ from being emitted as compared to 44 $MMTCO_2E$ if only the federal fuel economy standards were implemented.

- ***The Bottom Line: California's Rules Provide Superior Greenhouse Gas Benefits**.* If the Pavley rules were implemented in the United States and Canada, by 2016 a cumulative total of 462 $MMTCO_2E$ will have been reduced as compared to 219 $MMTCO_2E$ if only the new federal fuel economy standards were implemented. By 2020, the Pavley rules will have prevented 1,411 $MMTCO_2E$ from being emitted as compared to 759 $MMTCO_2E$ if only the federal fuel economy standards were implemented.

Figure ES-1. Comparison of Cumulative Nationwide GHG Benefits of Pavley Regulation and New Federal Fuel Economy Standards

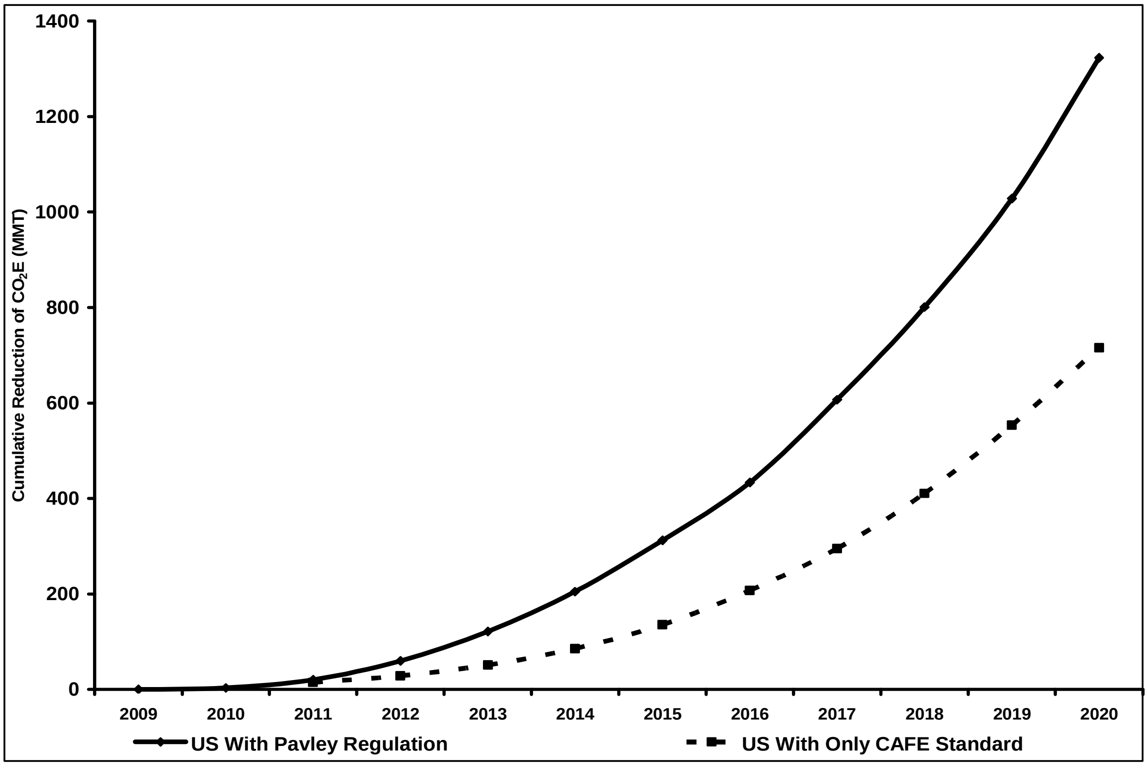
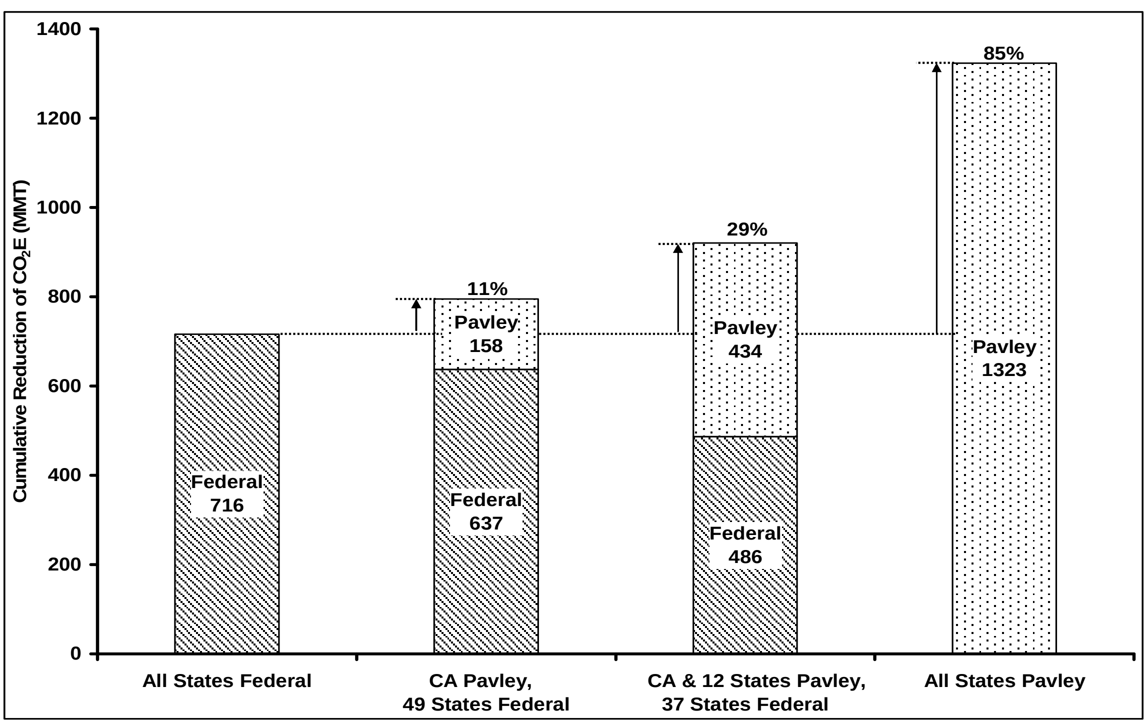


Figure ES-2. Comparison of Nationwide Cumulative GHG Benefits Achieved by Pavley Regulation and New Federal Fuel Economy Standards by 2020 under Different Scenarios



INTRODUCTION

Background

On December 19, 2007, Unites States Environmental Protection Agency (U.S. EPA) Administrator Stephen Johnson announced his agency's decision denying the California Air Resources Board's (ARB) request for a waiver to allow California to enforce the state's motor vehicle greenhouse gas emissions rules approved in 2004 pursuant to state legislation, AB 1493, passed in 2002 (also known as the Pavley Bill).

Administrator Johnson's letter (www.epa.gov/otaq/climate/20071219-slj.pdf) referenced HR6, the 2007 Energy Bill[2] that mandates improved national standards for fuel economy (Corporate Average Fuel Economy [CAFE] standards). These standards require a fleetwide average of 35 miles per gallon (mpg) for light duty vehicles sold in 2020 and beyond. The Administrator's letter claimed that California's AB 1493 standards[3] (also known as the Pavley rules) would result in an equivalent fuel economy measurement of 33.8 mpg[4].

ARB staff had never seen this figure before and it was not clear how the U.S.EPA had arrived at this estimate. What was clear, however, was the importance of this number: Administrator Johnson's letter strongly suggested that because U.S. EPA had concluded that California's GHG rules indirectly produced a lower miles per gallon result than the newly enacted CAFE 2020 standard of 35 mpg, the federal CAFE program mandated by the 2007 Energy Bill would therefore be a more effective approach to reducing greenhouse gas emissions.

In order to ensure a fair comparison of California's program to the 2007 Energy Bill, and to assess U.S. EPA's unsupported claims concerning the relative effectiveness of the California program and the new federal CAFE requirements in reducing GHG emissions, ARB staff prepared a technical study that was released to the public on January 2, 2008[5]. Following release of the January 2 technical assessment, ARB staff received a number of comments related to the original analysis. There was widespread interest in knowing the benefit of the California standards not just for California and the 12 other states that have adopted the California program, but also for the remaining 37 states as well, many of which are committed to or considering adopting California's standards. ARB staff subsequently released an addendum on January 23, 2008, that included estimated emissions benefits for all 50 states.

[2] Full text of HR6 is at http://energy.senate.gov/public/_files/HR6BillText.pdf

[3] California requires reductions in greenhouse gas emissions from vehicles weighing less than 10,000 pounds. The standards start in model year 2009, and ramp up to a 30 percent reduction in greenhouse gas emissions for vehicles sold in model year 2016 and beyond. To date, these rules have been adopted by 12 additional states that, with California, represent about one-third of the nation's registered automobiles.

[4] California's standards are stated as grams of greenhouse gases per mile and do not directly equate to miles per gallon. They require greenhouse gas emissions to be reduced and do not regulate fuel economy. Moreover, these rules constitute only one element of a comprehensive approach to reduce greenhouse gases in the mobile sector. This approach includes a Low Carbon Fuel Standard that is being designed to produce at least a 10 percent additional reduction in vehicle GHG emissions by 2020. The state is also pursuing extensive efforts to promote alternative fuel vehicles. Together, this package of initiatives will result in greater greenhouse gas reductions than those presented in this study that are based solely on the Pavley regulations.

[5] While ARB believes the Administrator's comparison is legally irrelevant to and not a proper basis for his decision, we are providing this updated analysis on an issue of public concern.

Comparison to the January 2 and January 23 Reports

This report brings together in a single comprehensive document the information provided in the January 2 and January 23 reports. It includes new analysis of the benefits of adopting California GHG emissions standards in Canada. Staff has also revised the analyses to address issues raised by stakeholders and internal reviewers. Changes of note in this final version include:

- Benefits are quantified for the California standards and federal CAFE standards for each of the Canadian provinces. Comparisons of the cumulative benefits for Canada, and for the United States and Canada combined, have been added to the assessment.

- The analysis now accounts explicitly for the contribution of nitrous oxide (N_2O) and methane (CH_4), as well as an air conditioning credit for hydrofluorocarbons (HFCs). These adjustments were made to the California standards so that the benefits of the Pavley rule, which addresses all major GHGs, could be compared directly to the federal CAFE standards.

- A table has been added which provides the federal fuel economy standards and flex fuel vehicle credits used by ARB staff for this assessment.

- To be consistent with the Energy Act of 2007, federal fuel economy standards and carbon dioxide (CO_2) emission rates are estimated separately for passenger cars and light trucks, rather than the PC/LDT1 and LDT2 groups used for the California standards. A table has been added that provides the fleet mix by region for both the California Pavley standards and the federal Energy Bill CAFE standards.

- The base emission rates used to assess the federal standards are now estimated using the average national fuel economy for passenger cars (29.0 mpg) and light-duty trucks (21.4 mpg) reported by the National Highway Traffic Safety Administration.

- Several minor computational errors found in the January 2 report have been corrected.

- The annual CO_2 equivalent benefit estimates for both the California and federal standards are now calculated by multiplying the average weekday emissions by 347 rather than by 365. This is done to account for lower miles traveled on weekend days compared to weekdays.

- An assessment of the impact of dieselization on net GHG emissions under the California and federal CAFE programs has been included.

METHODOLOGY

General Approach

The objective of this analysis was to calculate the comparative GHG benefits of the Pavley rules and the 2007 Energy Bill in calendar years 2016 and 2020 relative to a baseline year of 2002[6]. Our analysis looks at GHG emission reductions achievable not only with the existing Pavley rules (the Pavley Phase 1 rules) but also those expected when the ARB extends the existing

[6] 2002 was established as a baseline year for the purposes of the Pavley rules that were adopted by California in 2005.

requirements to obtain further reductions in the 2017 to 2020 timeframe[7] (referred to as the Pavley Phase 2 rules).

ARB's approach was to employ both the miles per gallon metric used in the 2007 Energy Bill and the GHG emissions rates that are the basis of California's Pavley regulation. ARB staff translated, as best as possible, mile-per-gallon standards established by the Energy Bill into equivalent GHG emission rates. The estimated federal GHG emission rates could then be compared to those established by California's Pavley rules for new vehicles sold between 2009 and 2020. The effectiveness of the Pavley and new federal rules was determined by calculating the percent reduction in GHGs achieved for each new model year relative to the 2002 baseline.

ARB staff then calculated the tons of greenhouse gases reduced in California under the federal CAFE standards compared to those that occur under the Pavley rules[8] by applying the new vehicle model year-specific GHG reductions to CO_2 tons per day emission estimates output from the EMFAC on-road emissions inventory model [9]. The EMFAC model reflects the current and projected vehicle fleet in California, based on data from the Department of Motor Vehicles, the Smog Check inspection and maintenance program, and local and regional transportation planning agencies. The emission rates in the EMFAC model are derived from testing of in-use vehicles. Documentation and downloadable copies of the EMFAC model are available at http://www.arb.ca.gov/msei/onroad/latest_version.htm.

To develop estimates of GHG reductions for the other 49 states, as well as the Canadian provinces, staff scaled California ton reductions from EMFAC using state- or province-specific motor vehicle gasoline consumption data as a surrogate. Staff analyzed and used California, United States, and Canadian vehicle fleets to ensure the emissions benefits developed for each of these regions reflect differences in fleet mix[10] and fuel economy.

Interpretation of 2007 Energy Bill

The 2007 Energy Bill directs the National Highway Traffic Safety Administration (NHTSA) to increase the fuel economy of passenger vehicles and light trucks[11] starting no sooner than 2011 and to reach a final fleet annual average fuel economy target for passenger cars and light trucks of 35 mpg by 2020. The law leaves it up to NHTSA to determine the appropriate phase-in schedule to achieve this goal. How NHTSA will define the phase-in is unknown at this time. The ARB analysis assumes NHTSA would begin to implement new standards in 2011, the soonest it is allowed to do so. The analysis also conservatively assumes the standards would be phased in using a steady proportional increase of 3.44 percent per year in the fuel economy of both passenger cars and light trucks until the final standard of 35 mpg is reached in 2020. Table 1 provides the federal fuel economy standards assumed by ARB staff for this analysis.

[7] In March 2006, the California Climate Action Team completed a comprehensive report on the strategies needed to reduce GHG emissions in California. This report recommended amendment of the current Pavley rules to produce an additional 4 MMTs of GHG benefits by 2020. Additionally, in June 2007, the ARB affirmed its commitment to develop Phase 2 of the Pavley rules by including this measure in the "Early Action Plan" adopted pursuant to Assembly Bill AB 32, the California Global Warming Solutions Act of 2006.

[8] For simplicity, this comparison methodology is based on the litigating auto industry's assertions about the mpg-equivalence of California's standards (which are based solely on the tailpipe emissions of carbon dioxide from traditional gasoline-powered vehicles). Though not technically or legally accurate, this provides a rough guide for present purposes. See http://ag.ca.gov/cms_attachments/press/pdfs/n1493_energybill_attachment.pdf

[9] EMFAC is the U.S.EPA approved model used by California to assess the effectiveness of its vehicular emission control rules. See e.g. 73 FR 3464 (January 18, 2008).

[10] Fleet mix is defined as the ratio of passenger cars to light trucks. Fleet mix varies depending upon the relative numbers of passenger cars and light trucks sold in a given state or country. California has a higher fraction of passenger cars (58 percent) compared to the rest of the country (39 percent) due to differences in consumer vehicle preferences.

[11] Referred to as "non-passenger" vehicles in the 2007 Energy Bill.

Table 1. Fuel Economy and CO_2 Emission Rates Assumed for Federal Vehicles Based on Energy Act of 2007

Model Year	PC			LDT			FFV[b] Credit (mpg)	Fleet FE[a] (mpg)	Fleet CO_2 (g/mi)
	FE[a] Std (mpg)	Adj FE[a] (mpg)	CO_2 (g/mi)	FE[a] Std (mpg)	Adj FE[a] (mpg)	CO_2 (g/mi)			
2007	27.5	26.3	338	22.2	21.0	423	1.2	22.8	390
2008	27.5	26.3	338	22.5	21.3	417	1.2	23.0	386
2009	27.5	26.3	338	23.1	21.9	406	1.2	23.4	379
2010	27.5	26.3	338	23.5	22.3	399	1.2	23.7	375
2011	28.4	27.2	326	24.3	23.1	385	1.2	24.6	362
2012	29.4	28.2	315	25.1	23.9	371	1.2	25.5	349
2013	30.4	29.2	304	26.0	24.8	358	1.2	26.4	337
2014	31.5	30.3	293	26.9	25.7	346	1.2	27.3	325
2015	32.6	31.6	282	27.8	26.8	331	1.0	28.5	312
2016	33.7	32.9	270	28.8	28.0	318	0.8	29.7	299
2017	34.9	34.3	259	29.8	29.2	305	0.6	31.0	287
2018	36.1	35.7	249	30.8	30.4	292	0.4	32.3	275
2019	37.3	37.1	240	31.9	31.7	281	0.2	33.6	265
2020	38.6	38.6	230	33.0	33.0	270	0.0	35.0	254

[a] Fuel economy
[b] Flex-fueled vehicle

The 2007 Energy Bill also provides for a fuel economy credit for vehicles that are capable of operating on alternative fuels such as high blend ethanol known as E85. This credit currently allows manufacturers to lower the fuel economy of their actual vehicle production by up to 1.2 mpg compared to the standard. The 2007 Energy Bill directs that the credit be gradually reduced in 0.2 mpg increments beginning in 2015 until it is eliminated in 2020.

Since manufacturers have indicated that they will produce large numbers of flex-fuel vehicles capable of operating on E85, ARB staff believes that manufacturers are likely to take full advantage of the credit between 2011 and 2019. As shown in Table 1, our analysis includes this assumption in our calculation of the benefits of the new CAFE standards on GHG reductions[12,13].

Also reflected in this analysis are the benefits of the rule adopted by NHTSA establishing higher CAFE standards for model year 2008-2011 light trucks[14].

Comparison of Fleet Mixes

The Pavley rules establish GHG emission standards for two different groups of passenger vehicles: 1) passenger cars (PC) and light duty trucks with test weights under 3,751 pounds loaded vehicle weight (LDT1); and 2) Light duty trucks with test weights between 3,751 lbs. loaded vehicle weight and 8,500 lbs. gross vehicle weight (GVW) (LDT2). Medium-duty passenger vehicles (LDT3) between 8,500-10,000 lbs. GVW are included with manufacturers' LDT2 vehicles when determining compliance with California's GHG standards. For the purposes

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[12] For example, the passenger car fuel economy standard in 2009 was calculated as 26.3 mpg rather than 27.5 mpg that would be expected if there were no credit. This 1.2 mpg reduction was also applied to the fuel economy standards for years 2010 through 2014, and smaller reductions were applied to years 2015 through 2020 as calculated using the phase-out schedule.

[13] The 2007 Energy Bill also requires large increases in renewable fuels that will produce significant GHG reductions. Those benefits are most appropriately attributed to the fuels provisions of the Act, and are not an independent benefit of the new CAFE program.

[14] Final rule available at http://www.nhtsa.dot.gov/staticfiles/DOT/NHTSA/Rulemaking/Rules/Associated%20Files/2006FinalRule.pdf. Though the 9th Circuit reversed and remanded this rule to NHTSA for further proceedings, (508 F.3d 508 (9th Circ. 2007)), staff believes that for this analysis it is reasonable to assume that the new NHTSA standards covering these model years will be at least as but not significantly more stringent.

of this analysis, only vehicles up through 8,500 lbs were considered since the majority of LDT3 vehicles are commercial and therefore do not fall under the scope of the Pavley rules.

Vehicle class fractions for California were provided by the EMFAC2007 model based on registration information from the Department of Motor Vehicles for calendar years 2000 through 2005. The EMFAC model uses these actual data for 2000 through 2005 to estimate vehicle populations prior to 2000 and forecasts vehicle populations beyond 2005 based on growth in vehicle population and mileage accrual. Between 2002 and 2020, EMFAC predicts the ratio of sales of cars to light duty-trucks to stay fairly constant in California, with PC/LDT1 ranging from 68-70 percent of new passenger vehicle sales and LDT2 making up the remaining 30-32 percent.

Vehicle class fractions for the other 49 states were based on default VMT data in the MOBILE6 model and sales data from the U.S. EPA. Like EMFAC, MOBILE6 also models the fleet mix changing over time based on changes in vehicle sales. However, for the purposes of this analysis, ARB staff froze the national fleet mix at its current value because MOBILE6's projection that sales of light-duty trucks will continue to increase to 68 percent of vehicle sales in 2020 appeared unreasonable given the recent increase in fuel prices and change in consumer vehicle purchases. Vehicle class fractions for Canada were developed using Canadian vehicle sales information[15]. The Canadian fleet mix was also assumed not to change over time due to a lack of information about the fleet mix in future years.

Table 2 compares the fleet mixes assumed for California, the other 49 states, and Canada for model year 2002, 2016, and 2020 vehicles. California's fleet mix is 68-70 percent PC/LDT1 and 30-32 percent LDT2 as defined by the Pavley regulation or 58-59 percent PC and 41-42 percent LDT as defined by the Energy Bill. The fleet mix for the other 49 states is 50 percent PC/LDT1 and 50 percent LDT2 as defined by the Pavley regulation or 39 percent PC and 61 percent LDT as defined by the Energy Bill. The Canadian fleet mix is assumed to be 61 percent PC/LDT1 and 39 percent LDT2 as defined by the Pavley regulation or 55 percent PC and 45 percent LDT as defined by the Energy Bill. These fleet mixes are assumed to represent new passenger vehicle sales only as the standards will apply to new model year vehicles as they are sold, not to the entire fleet of vehicles on the road.

Table 2. Comparison of Fleet Mixes Assumed for California, Other 49 States, and Canada for Model Year 2002, 2016, and 2020 Vehicles.

Region	Model Year	Vehicle Classes				Pavley		Energy Bill	
		PC	LDT1	LDT2	LDT3[a]	PC/LDT1[b]	LDT2[c]	PC[d]	LDT[e]
California	2002	0.59	0.09	0.22	0.10	0.68	0.32	0.59	0.41
	2016	0.59	0.12	0.21	0.09	0.70	0.30	0.59	0.41
	2020	0.58	0.12	0.21	0.09	0.69	0.31	0.58	0.42
Other 49 States	2002	0.39	0.11	0.35	0.10	0.50	0.50	0.39	0.61
	2016	0.39	0.11	0.35	0.10	0.50	0.50	0.39	0.61
	2020	0.39	0.11	0.35	0.10	0.50	0.50	0.39	0.61
Canada	2002	0.55	0.06	0.26	0.12	0.61	0.39	0.55	0.45
	2016	0.55	0.06	0.26	0.12	0.61	0.39	0.55	0.45
	2020	0.55	0.06	0.26	0.12	0.61	0.39	0.55	0.45

[a] Includes federal LDT3 and LDT4 vehicle classes.
[b] Includes PC and LDT1 vehicle classes.
[c] Includes LDT2 and LDT3 (MDV) vehicle classes.
[d] Includes PC vehicle class.
[e] Includes LDT1, LDT2, and LDT3 (MDV) vehicle classes.

[15] Provided by Ward's AutoInfoBank http://wardsauto.com/about/waib/index.html

Because the California vehicle mix in EMFAC2007 differed from the federal mix used in MOBILE6, staff looked at other data sources for verification. ARB staff reviewed the DMV registration data that forms the basis for the population estimates in EMFAC and also evaluated Smog Check program data as well as manufacturer sales information. Analysis of vehicle weight data routinely collected as part of the Smog Check program indicate that in calendar year 2006, 66 percent of the most recent model year vehicles tested were PC/LDT1 and 34 percent LDT2[16]. Approximately 90 percent of the light duty vehicle fleet in California is believed to go through the Smog Check program. Review of light duty vehicle sales provided by manufacturers show that for calendar year 2005, 69 percent of the vehicles sold in California were PC/LDT1 and 31 percent were LDT2. Results from these three studies are similar and support the assumption that about 70 percent of the California vehicle fleet in 2016 and 2020 will be PC/LDT1 and 30 percent LDT2.

To corroborate the national fleet mix assumption, ARB staff reviewed national vehicle sales data published by the Congressional Budget Office[17] indicating that in calendar year 2006, 47 percent of new vehicle sales were cars and 53 percent light trucks. The fraction of vehicle sales that are PC/LDT1 is likely higher than 47 percent as some of the vehicles reported by the CBO as light trucks are vans and SUVs that would meet the PC/LDT1 definition. The CBO data suggest that the 50 percent PC/LDT1 and 50 percent LDT2 assumption for the national fleet is reasonable.

Model Year-Specific Emission Rates and GHG Reductions

The GHG emission standards established by the Pavley regulation reflect not only exhaust CO_2 emissions resulting directly from operation of the vehicle, but also: 1) tailpipe emissions of CH_4 and N_2O; 2) CO_2 emissions resulting from operating the air conditioning system (indirect AC emissions); and 3) HFC refrigerant emissions released from the air conditioning system due to either leakage, losses during recharging, sudden releases due to accidents, or release from scrappage of the vehicle at end of life (direct AC emissions).

For this analysis, the model year-specific Pavley standards shown in Table 3 were used to calculate the GHG benefits of the California standards. The GHG benefits of the federal CAFE standards were estimated based on the model year-specific fuel economy standards shown in Table 1. To calculate the fuel economy of the California standards for comparison to the federal CAFE standard, the Pavley standards were adjusted to reflect tailpipe CO_2 only. Table 3 provides the adjustments for N_2O and CH_4, an air conditioning credit, and the resulting adjusted California CO_2 tailpipe emissions levels. The N_2O and CH_4 adjustments were developed by converting measured emissions of N_2O and CH_4 from vehicles to CO_2 equivalents, taking into account the global warming potential (GWP) of these two GHGs. The air conditioning credit shown in Table 3 assumes that 50 percent of new vehicles achieve a 50 percent reduction in indirect CO_2 emissions due to air conditioning system improvements and a 50 percent reduction in CO_2 equivalent emissions as a result of reducing refrigerant leaks beginning in 2009 and switching to a low GWP refrigerant beginning in 2013.[18] The credit is assumed to phase in over time as manufacturers make these improvements.

[16] Pavley LDT2 group consisting of EMFAC LDT2 and MDV vehicle classes.
[17] See Congressional Budget Office, *Effects of Gasoline Prices on Driving Behavior and Vehicle Markets, Congressional Budget Office* (January 2008) http://www.cbo.gov/ftpdocs/88xx/doc8893/01-14-GasolinePrices.pdf
[18] See California Air Resources Board, *Staff Report: Initial Statement of Reasons for Proposed Rulemaking, Public Hearing to Consider Adoption of Regulations to Control Greenhouse Gas Emissions from Motor Vehicles* (August 6, 2004) http://www.arb.ca.gov/regact/grnhsgas/grnhsgas.htm

Table 3. California GHG Emission Standards Under Pavley Regulation and N_2O/CH_4 and Air Conditioning Adjustments

Model Year	Pavley Standards		N_2O/CH_4 Adjustment		Air Conditioning Credit		CO_2 Emissions	
	PC/LDT1	LDT2	PC/LDT1	LDT2	PC/LDT1	LDT2	PC/LDT1	LDT2
2009	323	439	-1.9	-1.9	5.2	6.3	326	443
2010	301	420	-1.9	-1.9	5.2	6.3	304	424
2011	267	390	-1.9	-1.9	5.2	6.3	270	394
2012	233	361	-1.9	-1.9	5.2	6.3	236	365
2013	227	355	-1.9	-1.9	8.0	9.1	233	362
2014	222	350	-1.9	-1.9	8.0	9.1	228	357
2015	213	341	-1.9	-1.9	8.0	9.1	219	348
2016	205	332	-1.9	-1.9	8.0	9.1	211	339
2017	195	310	-1.9	-1.9	8.0	9.1	201	317
2018	185	285	-1.9	-1.9	8.0	9.1	191	292
2019	180	270	-1.9	-1.9	8.0	9.1	186	277
2020	175	265	-1.9	-1.9	8.0	9.1	181	272

Tables 4 through 7 provide CO_2 equivalent emission standards and estimated fuel economy by vehicle class for model years 2009 through 2020, as well as the base year of 2002, assuming six different scenarios: 1) California GHG standards in California; 2) Federal fuel economy standards in California; 3) California GHG standards in the United States; 4) Federal fuel economy standards in the United States; 5) California GHG standards in Canada; and 6) Federal fuel economy standards in Canada. For each scenario, the percent reductions in CO_2 equivalents by model year were estimated based either on the Pavley emissions standards[19] or the Energy Bill fuel economy standards. These model year-specific GHG reductions were then applied to the EMFAC emissions model output to calculate the actual ton benefits of each set of standards. The percentage reductions for a given set of standards varied between California, the other 49 states, and Canada due to differences in their fleet mixes as well as vehicle fuel economy.

Table 4 provides average CO_2 equivalent emission rates[20] and estimated fuel economy for passenger cars and light duty trucks in the California fleet. The baseline CO_2 equivalent emissions rates for model year 2002 represents the average CO_2 emissions for the six largest vehicle manufacturers, based on analysis of certification data and California DMV registration data. Fuel economy was calculated using the model year-specific adjusted CO_2 emission levels shown in Table 3 and the carbon content of indolene fuel (8887 grams CO_2/gallon indolene). The fleet mix ranged from 68-70 percent PC/LDT1 and 30-32 percent LDT2, depending upon the model year. The GHG reductions from the California standards were estimated using emissions data from EMFAC2007 with percent CO_2 equivalent reductions estimated for the current Pavley rules using the results of modeling done by the Northeast States Center for a Clean Air Future (NESCCAF). The benefits of the enhanced Pavley rules, an increase in effectiveness from 32 percent average reductions in 2016 to 42 percent by 2020, are also reflected. These result in the fleet average CO_2 equivalent emission rates decreasing from 354 g/mi in 2002 to 243 g/mi in 2016 and 203 g/mi in 2020. Taking into account the N_2O and CH_4 adjustments and the air

[19] CO_2 emissions standards for model years 2009 through 2016 were established by the original Pavley (or Pavley 1) regulation while standards for model years 2017 through 2020 reflect emission reduction goals set forth in the California Climate Action Plan and committed to by the ARB in its Early Action Measures under AB32.

[20] The CO_2 emission rates established by Pavley are expressed as CO_2 equivalents to account for emissions of all GHGs (CO_2, N_2O, CH_4, HFCs) from vehicles. Manufacturers have flexibility in meeting these standards through a combination of reducing tailpipe emissions of CO_2, N_2O, and CH_4 and receiving credit for systems demonstrated to mitigate fugitive emissions of HFCs from vehicle air conditioning systems.

conditioning credit shown in Table 3, this translates indirectly into an increase in fleet average fuel economy from 25.1 mpg in 2002 to 35.7 mpg in 2016 and 42.5 mpg in 2020.[21]

Table 4 and subsequent tables show the California standards in some cases providing no reductions in GHGs for the 2009 and 2010 model years. This reflects the California standards being structured such that all manufacturers, including those with the heaviest vehicles, could achieve the proposed reductions.[22] It should be noted that although not designed to reduce GHGs, the federal CAFE standards also do not provide GHG reductions for some of the scenarios in the 2009 through 2014 timeframe.

Table 4. California CO_2 Equivalent Emission Standards and Estimated Fuel Economy in California

Model Year	PC/LDT1			LDT2[a]			Fleet[b]		
	CO_2E[c] (g/mi)	%GHG Red	FE[d] (mpg)	CO_2E[c] (g/mi)	%GHG Red	FE[d] (mpg)	CO_2E[c] (g/mi)	%GHG Red	FE[d] (mpg)
2002[e]	312	-	28.5	443	-	20.1	354	-	25.1
2009	323	0.0%	27.2	439	0.9%	20.0	360	0.0%	24.4
2010	301	3.5%	29.2	420	5.2%	20.9	338	4.6%	26.0
2011	267	14.4%	32.9	390	12.0%	22.5	304	14.2%	28.9
2012	233	25.3%	37.6	361	18.5%	24.3	271	23.5%	32.4
2013	227	27.2%	38.1	355	19.9%	24.5	265	25.2%	32.7
2014	222	28.8%	39.0	350	21.0%	24.9	260	26.6%	33.4
2015	213	31.7%	40.6	341	23.0%	25.5	251	29.1%	34.5
2016	205	34.3%	42.1	332	25.1%	26.2	243	31.5%	35.7
2017	195	37.5%	44.2	310	30.0%	28.0	229	35.2%	37.7
2018	185	40.7%	46.5	285	35.7%	30.4	215	39.3%	40.1
2019	180	42.3%	47.8	270	39.1%	32.1	207	41.5%	41.6
2020	175	43.9%	49.1	265	40.2%	32.7	203	42.8%	42.5

[a] Equivalent to EMFAC LDT2 and LDT3 vehicle classes.
[b] California fleet mix is 70 percent passenger cars (PC) and light duty trucks (LDT1) and 30 percent light duty trucks (LDT2/LDT3).
[c] CO_2 equivalents account for all GHGs (CO_2, N_2O, CH_4, HFCs).
[d] Fuel economy (based on tailpipe CO_2 emissions levels in Table 3).
[e] Estimated based on DMV and vehicle registration and certification data.

Table 5 shows the new federal fuel economy standard applied to the California fleet. Model year-specific CO_2 emission rates were calculated using the fuel economy standards and the carbon content of indolene fuel (8887 grams CO_2/gallon indolene). Instead of being grouped into the PC/LDT1 and LDT2 classes defined by the Pavley rule, vehicles in Table 5 are grouped into PC and LDT classes, consistent with the groupings defined by the Energy Bill in Table 1. Using the federal classification system, the California fleet mix is 59 percent PC and 41 percent LDT, equivalent to 70 percent PC/LDT1 and 30 percent LDT2/LDT3 under the Pavley rules. Comparison of Tables 4 and 5 shows that CO_2 equivalent emission rates are higher and fuel economy is lower under the new federal fuel economy standard than under the Pavley rules. For example, fleet average CO_2 equivalent emission rates would decrease from 354 g/mi in 2002 to 290 g/mi in 2016 and 247 g/mi in 2020 while fuel economy would increase from 25.1 mpg in 2002 to 30.7 mpg in 2016 and 36.0 mpg in 2020.

[21] These adjustments for N_2O, CH_4, and the air conditioning credit reduce the expected fleetwide fuel economy of the Pavley standards in California by 0.9 mpg in 2016 and 1.4 mpg in 2020.
[22] California's GHG standards are based on the manufacturer with the highest fleet average weight in California in 2002. This was done to assure that, as required by AB 1493, model availability would not be affected. Therefore, while some vehicle manufacturers will be required to begin reducing GHG emissions in 2002, emission from the fleet as a whole may not.

This analysis shows that for the California vehicle fleet, the California GHG emission standards are 16 percent more stringent for 2016 models and 18 percent more stringent for 2020 models than under the new federal CAFE standards.

Table 5. Federal Fuel Economy Standards and Estimated CO_2 Emissions in California

Model Year	PC			LDT[a]			Fleet[b]		
	CO_2 (g/mi)	%GHG Red	FE[c] (mpg)	CO_2 (g/mi)	%GHG Red	FE[c] (mpg)	CO_2 (g/mi)	%GHG Red	FE[c] (mpg)
2002[d]	309	-	28.8	419	-	21.2	354	-	25.1
2009	338	0.0%	26.3	406	3.1%	21.9	366	0.0%	24.3
2010	338	0.0%	26.3	399	4.8%	22.3	363	0.0%	24.5
2011	326	0.0%	27.2	385	8.1%	23.1	350	1.3%	25.4
2012	315	0.0%	28.2	371	11.3%	23.9	337	4.8%	26.3
2013	304	1.6%	29.2	358	14.4%	24.8	326	8.0%	27.3
2014	293	5.0%	30.3	346	17.4%	25.7	315	11.2%	28.2
2015	282	8.9%	31.6	331	20.9%	26.8	302	14.8%	29.4
2016	270	12.6%	32.9	318	24.1%	28.0	290	18.2%	30.7
2017	259	16.0%	34.3	305	27.2%	29.2	278	21.5%	31.9
2018	249	19.3%	35.7	292	30.2%	30.4	267	24.5%	33.2
2019	240	22.5%	37.1	281	33.0%	31.7	257	27.5%	34.6
2020	230	25.4%	38.6	270	35.6%	33.0	247	30.3%	36.0

[a] Equivalent to EMFAC LDT1, LDT2 and LDT3 vehicle classes.
[b] California fleet mix is 59 percent passenger cars (PC) and 41 percent light duty trucks (LDT).
[c] Fuel economy (from Table 1).
[d] Estimated based on DMV and vehicle registration and certification data.

ARB staff also compared the California and federal standards if they were applied to the mix of vehicles in the federal fleet instead of the California fleet. Baseline CO_2 emissions rates specific to the federal fleet were developed by reviewing national fuel economy data reported by the NHTSA.[23] The benefits of the California and federal standards when applied to the federal fleet are provided in Tables 6 and 7, respectively.

[23] See National Highway Traffic Safety Administration, *Automotive Fuel Economy Program, Annual Update Calendar Year 2003* (2004), http://www.nhtsa.gov/cars/rules/CAFE/FuelEconUpdates/2003/index.htm

Table 6. California CO_2-Equivalent Emissions Standards and Estimated Fuel Economy in Other States

Model Year	PC/LDT1			LDT2[a]			Fleet[b]		
	CO_2E[c] (g/mi)	%GHG Red	FE[d] (mpg)	CO_2E[c] (g/mi)	%GHG Red	FE[d] (mpg)	CO_2E[c] (g/mi)	%GHG Red	FE[d] (mpg)
2002[e]	329	-	27.0	415	-	21.4	372	-	23.9
2009	323	1.9%	27.2	439	0.0%	20.0	381	0.0%	23.1
2010	301	8.6%	29.2	420	0.0%	20.9	361	3.2%	24.4
2011	267	18.9%	32.9	390	6.1%	22.5	329	11.8%	26.7
2012	233	29.3%	37.6	361	13.1%	24.3	297	20.2%	29.5
2013	227	31.1%	38.1	355	14.5%	24.5	291	21.8%	29.9
2014	222	32.6%	39.0	350	15.7%	24.9	286	23.2%	30.4
2015	213	35.3%	40.6	341	17.9%	25.5	277	25.6%	31.3
2016	205	37.8%	42.1	332	20.1%	26.2	269	27.9%	32.3
2017	195	40.8%	44.2	310	25.4%	28.0	253	32.2%	34.3
2018	185	43.8%	46.5	285	31.4%	30.4	235	36.9%	36.8
2019	180	45.3%	47.8	270	35.0%	32.1	225	39.6%	38.4
2020	175	46.9%	49.1	265	36.2%	32.7	220	40.9%	39.2

[a] Equivalent to EMFAC LDT2 and LDT3 vehicle classes.
[b] Federal fleet is assumed to be 50 percent passenger cars (PC) & light duty trucks (LDT1) & 50 percent light trucks (LDT2/LDT3).
[c] CO_2 equivalents account for all GHGs (CO_2, N_2O, CH_4, HFCs).
[d] Fuel economy (based on tailpipe CO_2 emissions levels in Table 3).
[e] Estimated using federal baseline fuel economies.

Table 7. Federal Fuel Economy Standards and Estimated CO2 Emissions in Other States

Model Year	PC			LDT[a]			Fleet[b]		
	CO_2 (g/mi)	%GHG Red	FE[c] (mpg)	CO_2 (g/mi)	%GHG Red	FE[c] (mpg)	CO_2 (g/mi)	%GHG Red	FE[c] (mpg)
2002[d]	306	-	29.0	415	-	21.4	372	-	23.9
2009	338	0.0%	26.3	406	2.3%	21.9	379	0.0%	23.4
2010	338	0.0%	26.3	399	4.0%	22.3	375	0.0%	23.7
2011	326	0.0%	27.2	385	7.4%	23.1	362	2.9%	24.6
2012	315	0.0%	28.2	371	10.6%	23.9	349	6.2%	25.5
2013	304	0.8%	29.2	358	13.7%	24.8	337	9.5%	26.4
2014	293	4.2%	30.3	346	16.8%	25.7	325	12.6%	27.3
2015	282	8.1%	31.6	331	20.2%	26.8	312	16.3%	28.5
2016	270	11.8%	32.9	318	23.5%	28.0	299	19.7%	29.7
2017	259	15.3%	34.3	305	26.7%	29.2	287	22.9%	31.0
2018	249	18.7%	35.7	292	29.6%	30.4	275	26.0%	32.3
2019	240	21.8%	37.1	281	32.4%	31.7	265	28.9%	33.6
2020	230	24.8%	38.6	270	35.1%	33.0	254	31.7%	35.0

[a] Equivalent to EMFAC LDT1, LDT2 and LDT3 vehicle classes.
[b] Federal fleet is assumed to be 39 percent passenger cars (PC) and 61 percent light trucks (LDT).
[c] Fuel economy (from Table 1).
[d] Estimated using federal baseline fuel economies.

Comparison of Tables 6 and 7 shows that when applied to the federal fleet, the California CO_2 equivalent emissions standards are 10 percent and 13 percent more effective for 2016 models and 2020 models than the federal standards respectively. California's emissions standards result in 9 percent and 12 percent better fuel economy for 2016 and 2020 model federal vehicle fleets, respectively. The percentage benefits of the California standards are not as large when applied to the federal fleet mix (relative to the California fleet mix) due to the higher fraction of LDT2 trucks assumed in the federal fleet.

To calculate the benefits for Canada, staff first calculated the CO_2 equivalent reductions for the California GHG standards using the Canadian fleet mix and estimated Canadian fuel economy for each vehicle class in the base year of 2002. Table 8 provides the CO_2 equivalent emission rates and estimated fuel economy for each vehicle class in the fleet between 2009 and 2020, as well as the base year of 2002. The baseline fuel economies are based on Transport Canada Company Average Fuel Consumption (CFAC) data found at http://www.tc.gc.ca/programs/environment/fuelpgm/cafc/page2.htm. The emission rates for 2009 through 2020 are the same as those in Table 4 and reflect the current Pavley rules through 2016 and the enhanced Pavley rules for 2017 through 2020. The vehicle classes are grouped such that PC/LDT1 is the sum of PC and LDT1, and LDT2 is the sum of LDT2 and LDT3.

Table 8. California CO_2 Equivalent Emission Standards and Estimated Fuel Economy in Canada

Model Year	PC/LDT1			LDT2[a]			Fleet[b]		
	CO_2E[c] (g/mi)	%GHG Red	FE[d] (mpg)	CO_2E[c] (g/mi)	%GHG Red	FE[d] (mpg)	CO_2E[c] (g/mi)	%GHG Red	FE[d] (mpg)
2002[e]	302	-	29.4	416	-	21.4	346	-	25.7
2009	323	0.0%	27.2	439	0.0%	20.0	368	0.0%	23.9
2010	301	0.5%	29.2	420	0.0%	20.9	347	0.0%	25.3
2011	267	11.7%	32.9	390	6.2%	22.5	315	9.1%	27.9
2012	233	23.0%	37.6	361	13.1%	24.3	283	18.4%	31.0
2013	227	24.9%	38.1	355	14.6%	24.5	277	20.1%	31.4
2014	222	26.6%	39.0	350	15.8%	24.9	272	21.5%	31.9
2015	213	29.6%	40.6	341	17.9%	25.5	263	24.1%	33.0
2016	205	32.2%	42.1	332	20.1%	26.2	254	26.6%	34.1
2017	195	35.5%	44.2	310	25.4%	28.0	240	30.8%	36.1
2018	185	38.8%	46.5	285	31.4%	30.4	224	35.4%	38.6
2019	180	40.5%	47.8	270	35.0%	32.1	215	37.9%	40.1
2020	175	42.1%	49.1	265	36.2%	32.7	210	39.4%	41.1

[a] Equivalent to EMFAC LDT2 and LDT3 vehicle classes.
[b] Canadian fleet is assumed to be 61percent passenger cars (PC) & light duty trucks (LDT1) & 39 percent light trucks (LDT2/LDT3).
[c] CO_2 equivalents account for all GHGs (CO_2, N_2O, CH_4, HFCs).
[d] Fuel economy (based on tailpipe CO_2 emissions levels in Table 3).
[d] Estimated using Canadian baseline fuel economies

Table 9 shows the new U.S. federal fuel economy standard applied to the Canadian fleet. The federal fuel economy numbers are the same as those in Table 5. The vehicle classes are grouped such that PC equals PC only and LDT equals the sum of LDT1, LDT2, and LDT3.

Table 9. Federal Fuel Economy Standards and Estimated CO_2 Emissions in Canada[b]

Model Year	PC			LDT[a]			Fleet[b]		
	CO_2 (g/mi)	%GHG Red	FE[c] (mpg)	CO_2 (g/mi)	%GHG Red	FE[c] (mpg)	CO_2 (g/mi)	%GHG Red	FE[c] (mpg)
2002[d]	291	-	30.6	416	-	21.4	346	-	25.7
2009	338	0.0%	26.3	406	2.3%	21.9	368	0.0%	24.1
2010	338	0.0%	26.3	399	4.1%	22.3	365	0.0%	24.4
2011	326	0.0%	27.2	385	7.5%	23.1	352	0.0%	25.2
2012	315	0.0%	28.2	371	10.7%	23.9	340	1.9%	26.1
2013	304	0.0%	29.2	358	13.8%	24.8	328	5.3%	27.1
2014	293	0.0%	30.3	346	16.8%	25.7	317	8.6%	28.1
2015	282	3.2%	31.6	331	20.3%	26.8	304	12.3%	29.3
2016	270	7.1%	32.9	318	23.6%	28.0	291	15.9%	30.5
2017	259	10.8%	34.3	305	26.7%	29.2	280	19.3%	31.8
2018	249	14.3%	35.7	292	29.7%	30.4	268	22.5%	33.1
2019	240	17.6%	37.1	281	32.5%	31.7	258	25.6%	34.5
2020	230	20.8%	38.6	270	35.1%	33.0	248	28.4%	35.9

[a] Equivalent to EMFAC LDT1, LDT2 and LDT3 vehicle classes.
[b] Canadian fleet is assumed to be 55 percent passenger cars (PC) and 45 percent light trucks (LDT).
[c] Fuel economy (from Table 1).
[d] Estimated using Canadian baseline fuel economies

BENEFITS

California

To estimate the greenhouse gas reduction benefits of the California standards applied to the California fleet, staff used EMFAC2007 version 2.3 (November 1, 2006) to develop baseline estimates and the Pavley rule's percent reductions (as shown in Tables 4 and 5) to calculate the weekday ton reductions for each model year.

Table 10 shows the emission reductions expected from the adopted Pavley rule in 2016. By 2016, the California standard is expected to reduce the projected 473,000 tons per day of CO_2E emitted by light duty vehicles in California by 11 percent, or 51,900 tons per day. This is equivalent to an annual reduction[24] of 16 $MMTCO_2E$ in 2016.

[24] This analysis provides emissions estimates in standard tons for an average weekday. To convert weekday emissions in standard tons to annual emissions in million metric tons, the weekday result was multiplied by 347 to convert to annual emissions and by 0.91 to convert from standard tons to metric tons. Multiplying the weekday result by 347 days instead of 365 days accounts for reduced vehicle miles traveled on weekend days.

Table 10. CO_2-Equivalent Emission Reductions from Adopted Pavley 1 Regulation in California in 2016

	PC/LDT1 (1000 tons per day)				LDT2 (1000 tons per day)		
Model Year	Baseline	% GHG Reduction	Tons Reduction		Baseline	% GHG Reduction	Tons Reduction
2008 and older	123.73	0.0%	0.00		100.62	0.0%	0.00
2009	13.42	0.0%	0.00		9.39	0.9%	0.08
2010	14.62	3.5%	0.51		9.58	5.2%	0.50
2011	15.87	14.4%	2.29		9.88	12.0%	1.18
2012	17.38	25.3%	4.40		10.57	18.5%	1.96
2013	19.21	27.2%	5.23		11.72	19.9%	2.33
2014	21.19	28.8%	6.11		12.75	21.0%	2.68
2015	24.31	31.7%	7.71		14.71	23.0%	3.39
2016	27.50	34.3%	9.43		16.34	25.1%	4.09
Total All MYs	**277.23**		**35.67**		**195.56**		**16.21**
	Baseline		Tons Reduction		Annual Million Metric Tons Reduced		
Total Lt Duty	**472.8**		**51.9**		**16.4**		

The 2020 reductions are based on a more stringent emission limit than the current California standards, called the Pavley 2 rule, as set forth in the California Climate Action Plan and committed to by the ARB in its Early Action Measures under AB32. For this analysis, ARB staff applied more stringent emission reductions beginning in 2017, and applied progressively more stringent standards through 2020.

Table 11 shows the CO_2 equivalent emission reductions expected from the existing and anticipated Pavley rules in California in 2020. By 2020, the combination of the adopted Pavley 1 and anticipated Pavley 2 rules are expected to reduce the 496,000 tons per day of CO_2E emitted by light duty vehicles in California by 20 percent, or 100,500 tons per day. This is equivalent to 32 MMT less CO_2E in 2020.

Table 11. CO_2-Equivalent Emission Reductions from Adopted Pavley 1 and Anticipated Pavley 2 Regulations in California in 2020

	PC/LDT1 (1000 tons per day)				LDT2 (1000 tons per day)		
Model Year	Baseline	% GHG Reduction	Tons Reduction		Baseline	% GHG Reduction	Tons Reduction
2008 and older	80.19	0.0%	0.00		72.40	0.0%	0.00
2009	10.09	0.0%	0.00		7.49	0.9%	0.07
2010	11.17	3.5%	0.39		7.71	5.2%	0.40
2011	12.25	14.4%	1.76		7.98	12.0%	0.95
2012	13.46	25.3%	3.41		8.52	18.5%	1.58
2013	14.79	27.2%	4.03		9.35	19.9%	1.86
2014	15.95	28.8%	4.60		9.91	21.0%	2.08
2015	17.33	31.7%	5.50		10.89	23.0%	2.51
2016	18.25	34.3%	6.26		11.27	25.1%	2.82
2017	20.05	37.5%	7.52		12.43	30.0%	3.73
2018	22.12	40.7%	9.00		13.84	35.7%	4.94
2019	25.25	42.3%	10.68		15.76	39.1%	6.15
2020	29.37	43.9%	12.89		18.36	40.2%	7.38
Total All MYs	**290.27**		**66.03**		**205.91**		**34.47**
	Baseline		Tons Reduction		Annual Million Metric Tons Reduced		
Total Lt Duty	**496.2**		**100.5**		**31.7**		

The CO_2 equivalent reductions from the federal CAFE standards were estimated using emissions data from EMFAC2007 and percent CO_2 reduction estimates based on the modeled phase-in schedule used to achieve the final fuel economy target of 35 mpg by 2020. The exact phase-in is unknown at this time. ARB staff has conservatively assumed a proportional increase in the federal fuel economy standard of 3.44 percent per year.

Table 12 shows the emission reductions expected from the new federal CAFE Standards in California in 2016. By 2016, the new federal standard is expected to reduce the 473,000 tons per day of CO_2 emitted by light duty vehicles in California by 5 percent or 24,000 tons per day. This is equivalent to a reduction of 8 $MMTCO_2E$ in 2016.

Table 12. CO_2-Equivalent Emission Reductions from New Federal CAFE Standards in California in 2016

	PC (1000 tons per day)			LDT1/LDT2 (1000 tons per day)		
Model Year	**Baseline**	**% GHG Reduction**	**Tons Reduction**	**Baseline**	**% GHG Reduction**	**Tons Reduction**
2008 and older	93.32	0.0%	0.00	131.03	0.0%	0.00
2009	11.01	0.0%	0.00	11.80	3.1%	0.36
2010	11.93	0.0%	0.00	12.27	4.8%	0.59
2011	12.87	0.0%	0.00	12.88	8.1%	1.05
2012	14.02	0.0%	0.00	13.93	11.3%	1.58
2013	15.43	1.6%	0.25	15.50	14.4%	2.24
2014	16.97	5.0%	0.85	16.97	17.4%	2.95
2015	19.46	8.9%	1.73	19.56	20.9%	4.08
2016	21.98	12.6%	2.76	21.86	24.1%	5.28
Total All MYs	**216.99**		**5.60**	**255.80**		**18.12**
	Baseline		Tons Reduction	Annual Million Metric Tons Reduced		
Total Lt Duty	**472.8**		**23.7**	**7.5**		

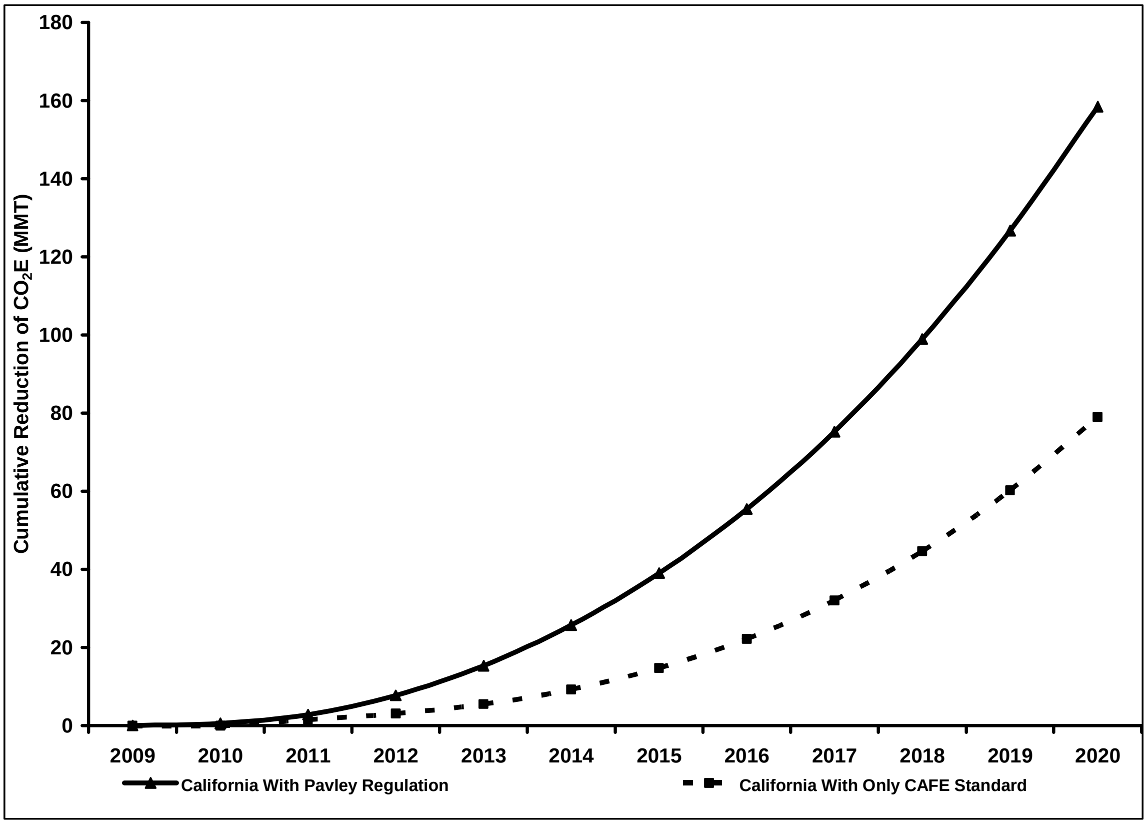
Table 13 shows the emission reductions expected due to the full implementation of the new federal CAFE standards in California in 2020. By 2020, the new federal standard is expected to reduce the 496,000 tons per day of CO_2E emitted by light duty vehicles in California by 12 percent or 60,000 tons per day. This is equivalent to a reduction of 19 $MMTCO_2E$ in 2020. This analysis demonstrates that if the new federal CAFE standards were implemented in place of the current Pavley 1 and anticipated Pavley 2 rules in California, almost 9 MMT more CO_2E would be emitted in 2016 and about 13 MMT more CO_2E emitted in 2020.

Table 13. CO2-Equivalent Emission Reductions from New Federal CAFE Standards in California in 2020

	PC (1000 tons per day)			LDT1/LDT2 (1000 tons per day)		
Model Year	**Baseline**	**% GHG Reduction**	**Tons Reduction**	**Baseline**	**% GHG Reduction**	**Tons Reduction**
2008 and older	58.89	0.0%	0.00	93.70	0.0%	0.00
2009	8.20	0.0%	0.00	9.38	3.1%	0.29
2010	9.03	0.0%	0.00	9.85	4.8%	0.47
2011	9.85	0.0%	0.00	10.38	8.1%	0.84
2012	10.78	0.0%	0.00	11.20	11.3%	1.27
2013	11.81	1.6%	0.19	12.33	14.4%	1.78
2014	12.69	5.0%	0.64	13.17	17.4%	2.29
2015	13.75	8.9%	1.22	14.47	20.9%	3.02
2016	14.43	12.6%	1.81	15.09	24.1%	3.64
2017	15.81	16.0%	2.53	16.67	27.2%	4.54
2018	17.47	19.3%	3.38	18.49	30.2%	5.58
2019	20.03	22.5%	4.50	20.98	33.0%	6.91
2020	23.35	25.4%	5.94	24.38	35.6%	8.68
Total All MYs	**226.09**		**20.22**	**270.09**		**39.32**
	Baseline		Tons Reduction	Annual Million Metric Tons Reduced		
Total Lt Duty	**496.2**		**59.5**	**18.8**		

ARB staff also calculated the cumulative GHG benefits of the Pavley rules compared to if only the new federal fuel economy standards were implemented in California. As shown in Figure 1, by 2016, the adopted Pavley rule will have prevented a total of 55 $MMTCO_2E$ from being emitted into the air as compared to 22 MMT if only the new federal standards were implemented. By 2020, the combination of the Pavley 1 and 2 rules will have prevented 158 $MMTCO_2E$ emissions from being emitted as compared to 79 $MMTCO_2E$ if only the federal CAFE standard were implemented.

Figure 1. Comparison of Cumulative CO_2-Equivalent Benefits of Pavley Regulation and New Federal Fuel Economy Standards in California



California and Twelve Other States

In addition to California, 12 other states[25] have adopted California's standards, and collectively account for about one-third of the vehicles in the United States in 2006. To calculate the cumulative benefits of the standards for these 12 other states, staff scaled California's GHG benefits, using motor vehicle gasoline consumption in individual states as a surrogate[26]. Staff used the most recent (2005 calendar year) state-specific gasoline consumption data available from the U.S. Energy Information Administration at http://www.eia.doe.gov/emeu/states/sep_fuel/html/fuel_mg.html.

As shown in Table 14, California used 376 million barrels or 11.5 percent of the motor vehicle gasoline consumed nationwide in 2005 as compared to 21 percent for the 12 states that have adopted the Pavley regulation. In sum, these 13 states consumed 1,060 million barrels or about one-third of the nation's motor vehicle gasoline in 2005.

[25] Connecticut, Maine, Maryland, Massachusetts, New Jersey, New Mexico, New York, Oregon, Pennsylvania, Rhode Island, Vermont, and Washington.

[26] Staff considered using statistics related to population, number of vehicles and gasoline consumption. However, driving per capita and annual miles driven per vehicle vary significantly from state to state. Staff believes that state level fuel consumption data best reflects these differences, and is the best statistic to use to estimate the proportional benefits that other states will receive when they adopt the California GHG emission standards.

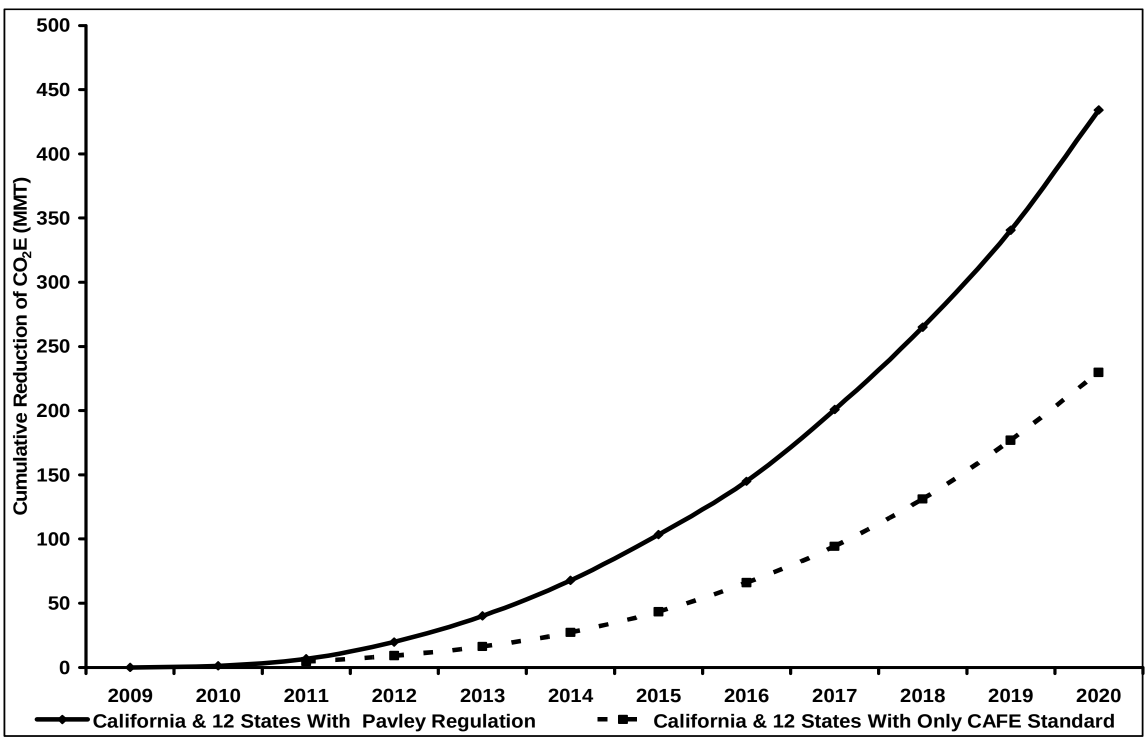
Table 14. Cumulative GHG Benefits of Pavley Regulation and New Federal Fuel Economy Standards Implemented in California and 12 Other States

State	Motor Vehicle Gasoline Consumption[a] (1000 Barrels)	Gasoline Use Ratio to California	Cum. Benefit from CA Stds by 2016[b] (MMTs)	Cum. Benefit from Fed Stds by 2016[b] (MMTs)	Cum. Benefit of CA Stds Over Fed Stds by 2016[b] (MMTs)	Cum. Benefit from CA Stds by 2020[b] (MMTs)	Cum. Benefit from Fed Stds by 2020[b] (MMTs)	Cum. Benefit of CA Stds Over Fed Stds by 2020[b] (MMTs)
California[b]	375,652	1.00	55.5	22.2	33.2	158.4	79.0	79.4
Connecticut	37,850	0.10	5.0	2.4	2.5	15.3	8.3	6.9
Maine	17,040	0.05	2.2	1.1	1.1	6.9	3.8	3.1
Maryland	63,544	0.17	8.3	4.1	4.2	25.6	14.0	11.6
Massachusetts	67,081	0.18	8.8	4.3	4.5	27.0	14.8	12.3
New Jersey	102,025	0.27	13.3	6.5	6.8	41.1	22.5	18.6
New Mexico	22,262	0.06	2.9	1.4	1.5	9.0	4.9	4.1
New York	134,906	0.36	17.6	8.6	9.0	54.4	29.7	24.7
Oregon	36,488	0.10	4.8	2.3	2.4	14.7	8.0	6.7
Pennsylvania	121,878	0.32	15.9	7.8	8.1	49.1	26.9	22.3
Rhode Island	9,100	0.02	1.2	0.6	0.6	3.7	2.0	1.7
Vermont	8,166	0.02	1.1	0.5	0.5	3.3	1.8	1.5
Washington	63,818	0.17	8.3	4.1	4.3	25.7	14.1	11.7
Total	**1,059,810**	**2.8**	**144.9**	**66.0**	**78.9**	**434.2**	**229.7**	**204.4**

[a] Energy Information Administration / Department of Energy, data for 2005 (http://www.eia.doe.gov/emeu/states/sep_fuel/html/fuel_mg.html)
[b] California fleet mix (70 percent PC/LDT1 & 30 percent LDT2) used for CA; all other states are represented by federal fleet mix (50 percent PC/LDT1 & 50 percent LDT2). This results in other states having less benefit on a percentage basis than CA.

Table 14 and Figure 2 present the cumulative CO_2 equivalent benefits of the Pavley regulation compared to implementation of only the new federal fuel economy standards for California and the 12 other states that have adopted California's GHG rules. By 2016, the adopted Pavley rules will have prevented a cumulative total of 145 $MMTCO_2E$ from being emitted into the air as compared to 66 MMT if only the new federal standards were implemented. By 2020, the combination of the Pavley 1 and 2 rules will have prevented 434 $MMTCO_2E$ from being emitted as compared to 230 $MMTCO_2E$ if only the federal CAFE were implemented.

Figure 2. Comparison of Cumulative GHG Benefits of Pavley Regulation and New Federal Fuel Economy Standards in California and 12 Other States[a]



[a] States that have already adopted California's CO_2 rules, including Connecticut, Maine, Massachusetts, New Jersey, New York, Oregon, Pennsylvania, Rhode Island, Vermont, Washington, Maryland, and New Mexico.

All Fifty States

A number of other states are considering but have not yet adopted the Pavley regulations. To assess the implications of a given state adopting the Pavley regulations, ARB staff calculated the year-specific as well as cumulative CO_2 equivalent reductions achieved for each of those states if they implemented the California Pavley regulations. The approach taken was the same as was done for the 12 other states, scaling California's CO_2 equivalent benefits using motor vehicle gasoline consumption as a surrogate. Staff used the most recent (2005 calendar year) state-specific gasoline consumption data available from the U.S. Energy Information Administration at http://www.eia.doe.gov/emeu/states/sep_fuel/html/fuel_mg.html.

Table 15 lists for each of the 50 states the year-specific CO_2 equivalent benefits achieved in 2016 and 2020, assuming either the Pavley or new federal CAFE standards are implemented. In 2016, assuming all 50 states implement the Pavley rules, GHG emissions nationwide would be reduced 128 $MMTCO_2E$. This is almost double the 70 MMT reduction produced by the federal rules. By 2020, the Pavley rules would reduce GHG emissions by 265 $MMTCO_2E$ compared to 170 MMT CO_2E reduced under the federal rules. The percentage reduction achieved in California is greater than in other states due to the higher fraction of passenger cars in California than in the country as a whole.

Table 15. Comparison of State-Specific Annual CO_2-Equivalent Benefits Achieved by Pavley Regulation and New Federal Fuel Economy Standards in 2016 and 2020

State	Motor Vehicle Gasoline Consumption[a] (1000 Barrels)	Gasoline Use Ratio to California	GHG Benefit from CA Stds in 2016[b] (MMTs)	GHG Benefit from Fed Stds in 2016[b] (MMTs)	GHG Benefit of CA Stds Over Fed Stds in 2016[b] (MMTs)	GHG Benefit from CA Stds in 2020[b] (MMTs)	GHG Benefit from Fed Stds in 2020[b] (MMTs)	GHG Benefit of CA Stds Over Fed Stds in 2020[b] (MMTs)
Alabama	61,615	0.16	2.4	1.3	1.1	5.0	3.2	1.7
Alaska	6,583	0.02	0.3	0.1	0.1	0.5	0.3	0.2
Arizona	66,394	0.18	2.6	1.4	1.1	5.4	3.5	1.9
Arkansas	33,139	0.09	1.3	0.7	0.6	2.7	1.7	0.9
California[b]	375,652	1.00	16.4	7.5	8.9	31.7	18.8	12.9
Colorado	49,893	0.13	1.9	1.1	0.9	4.0	2.6	1.4
Connecticut	37,850	0.10	1.5	0.8	0.6	3.1	2.0	1.1
Delaware	10,418	0.03	0.4	0.2	0.2	0.8	0.5	0.3
District of Columbia	3,007	0.01	0.1	0.1	0.1	0.2	0.2	0.1
Florida	204,304	0.54	7.9	4.4	3.5	16.5	10.7	5.8
Georgia	119,515	0.32	4.6	2.6	2.0	9.6	6.3	3.4
Hawaii	10,833	0.03	0.4	0.2	0.2	0.9	0.6	0.3
Idaho	14,116	0.04	0.5	0.3	0.2	1.1	0.7	0.4
Illinois	121,758	0.32	4.7	2.6	2.1	9.8	6.4	3.4
Indiana	75,375	0.20	2.9	1.6	1.3	6.1	4.0	2.1
Iowa	36,906	0.10	1.4	0.8	0.6	3.0	1.9	1.0
Kansas	26,893	0.07	1.0	0.6	0.5	2.2	1.4	0.8
Kentucky	51,716	0.14	2.0	1.1	0.9	4.2	2.7	1.5
Louisiana	54,379	0.14	2.1	1.2	0.9	4.4	2.9	1.5
Maine	17,040	0.05	0.7	0.4	0.3	1.4	0.9	0.5
Maryland	63,544	0.17	2.5	1.4	1.1	5.1	3.3	1.8
Massachusetts	67,081	0.18	2.6	1.4	1.1	5.4	3.5	1.9
Michigan	117,139	0.31	4.5	2.5	2.0	9.5	6.1	3.3
Minnesota	63,344	0.17	2.4	1.4	1.1	5.1	3.3	1.8
Mississippi	38,188	0.10	1.5	0.8	0.7	3.1	2.0	1.1
Missouri	74,563	0.20	2.9	1.6	1.3	6.0	3.9	2.1
Montana	11,117	0.03	0.4	0.2	0.2	0.9	0.6	0.3
Nebraska	18,872	0.05	0.7	0.4	0.3	1.5	1.0	0.5
Nevada	26,507	0.07	1.0	0.6	0.5	2.1	1.4	0.8
New Hampshire	16,542	0.04	0.6	0.4	0.3	1.3	0.9	0.5
New Jersey	102,025	0.27	3.9	2.2	1.7	8.2	5.3	2.9
New Mexico	22,262	0.06	0.9	0.5	0.4	1.8	1.2	0.6
New York	134,906	0.36	5.2	2.9	2.3	10.9	7.1	3.8
North Carolina	102,026	0.27	3.9	2.2	1.7	8.2	5.3	2.9
North Dakota	8,080	0.02	0.3	0.2	0.1	0.7	0.4	0.2
Ohio	122,074	0.32	4.7	2.6	2.1	9.9	6.4	3.5
Oklahoma	43,421	0.12	1.7	0.9	0.7	3.5	2.3	1.2
Oregon	36,488	0.10	1.4	0.8	0.6	2.9	1.9	1.0
Pennsylvania	121,878	0.32	4.7	2.6	2.1	9.8	6.4	3.5
Rhode Island	9,100	0.02	0.4	0.2	0.2	0.7	0.5	0.3
South Carolina	58,235	0.16	2.3	1.3	1.0	4.7	3.1	1.6
South Dakota	9,470	0.03	0.4	0.2	0.2	0.8	0.5	0.3
Tennessee	73,105	0.19	2.8	1.6	1.2	5.9	3.8	2.1
Texas	272,404	0.73	10.5	5.9	4.7	22.0	14.3	7.7
Utah	24,067	0.06	0.9	0.5	0.4	1.9	1.3	0.7
Vermont	8,166	0.02	0.3	0.2	0.1	0.7	0.4	0.2
Virginia	93,557	0.25	3.6	2.0	1.6	7.6	4.9	2.6
Washington	63,818	0.17	2.5	1.4	1.1	5.2	3.3	1.8
West Virginia	19,783	0.05	0.8	0.4	0.3	1.6	1.0	0.6
Wisconsin	59,571	0.16	2.3	1.3	1.0	4.8	3.1	1.7
Wyoming	7,389	0.02	0.3	0.2	0.1	0.6	0.4	0.2
Total	**3,266,108**	**8.7**	**128.1**	**69.8**	**58.2**	**265.1**	**170.3**	**94.8**

[a] Energy Information Administration / Department of Energy, data for 2005 (http://www.eia.doe.gov/emeu/states/sep_fuel/html/fuel_mg.html)

[b] California fleet mix (70 percent PC/LDT1 & 30 percent LDT2) used for CA; all other states are represented by federal fleet mix (50 percent PC/LDT1 & 50 percent LDT2). This results in other states having less benefit on a percentage basis than CA.

Table 16 lists for each of the 50 states the cumulative GHG benefits achieved by 2016 and 2020, assuming either the Pavley or new federal CAFE standards are implemented. Figure 3 compares the benefits of the Pavley and new federal standards for the country as a whole. By 2016, the adopted Pavley rules would prevent a cumulative total of 434 $MMTCO_2E$ from being emitted into the air as compared to 207 MMT if only the new federal fuel economy standards were implemented. By 2020, the combination of the Pavley 1 and 2 rules would prevent 1323 $MMTCO_2E$ from being emitted as compared to 716 $MMTCO_2E$ if only the federal fuel economy standards were implemented.

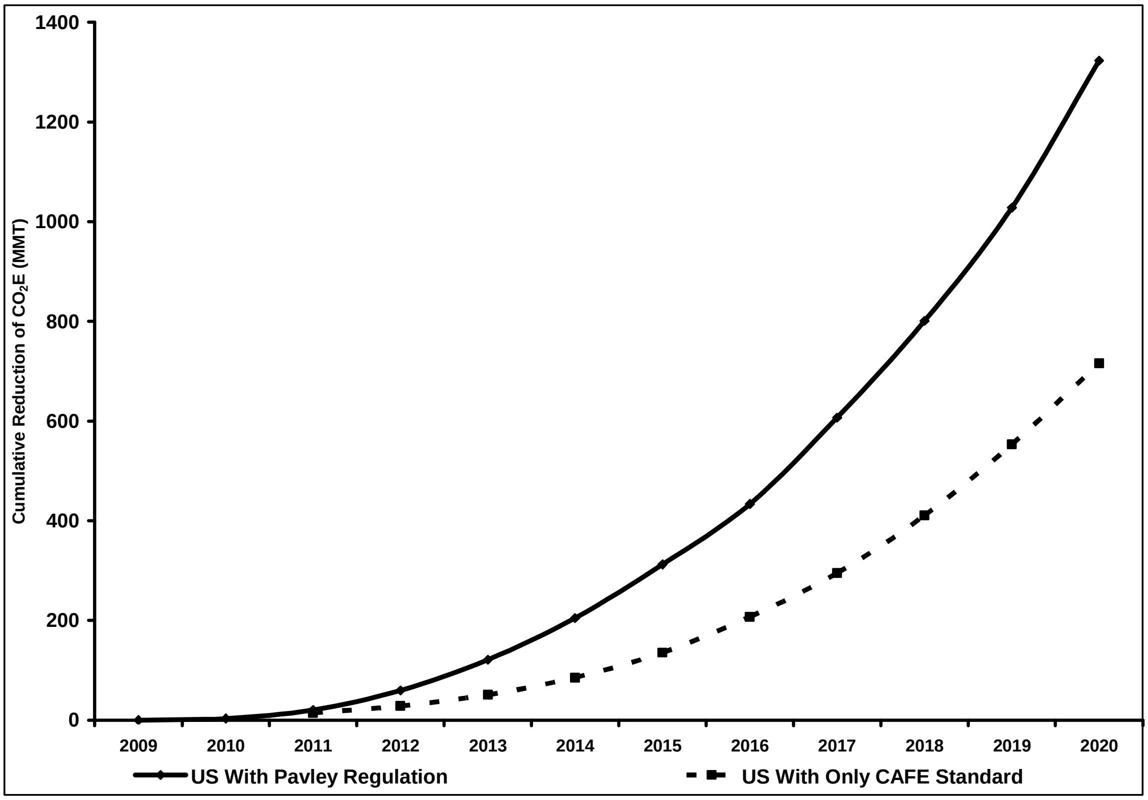
Table 16. Comparison of State-Specific Cumulative GHG Benefits Achieved by Pavley Regulation and New Federal Fuel Economy Standards by 2016 and 2020

State	Motor Vehicle Gasoline Consumption[a] (1000 Barrels)	Gasoline Use Ratio to California	Cum. Benefit from CA Stds by 2016[b] (MMTs)	Cum. Benefit from Fed Stds by 2016[b] (MMTs)	Cum. Benefit of CA Stds Over Fed Stds by 2016[b] (MMTs)	Cum. Benefit from CA Stds by 2020[b] (MMTs)	Cum. Benefit from Fed Stds by 2020[b] (MMTs)	Cum. Benefit of CA Stds Over Fed Stds by 2020[b] (MMTs)
Alabama	61,615	0.16	8.1	3.9	4.1	24.8	13.6	11.3
Alaska	6,583	0.02	0.9	0.4	0.4	2.7	1.5	1.2
Arizona	66,394	0.18	8.7	4.2	4.4	26.8	14.6	12.1
Arkansas	33,139	0.09	4.3	2.1	2.2	13.4	7.3	6.1
California[b]	375,652	1.00	55.5	22.2	33.2	158.4	79.0	79.4
Colorado	49,893	0.13	6.5	3.2	3.3	20.1	11.0	9.1
Connecticut	37,850	0.10	5.0	2.4	2.5	15.3	8.3	6.9
Delaware	10,418	0.03	1.4	0.7	0.7	4.2	2.3	1.9
District of Columbia	3,007	0.01	0.4	0.2	0.2	1.2	0.7	0.5
Florida	204,304	0.54	26.7	13.1	13.7	82.3	45.0	37.3
Georgia	119,515	0.32	15.6	7.6	8.0	48.2	26.3	21.8
Hawaii	10,833	0.03	1.4	0.7	0.7	4.4	2.4	2.0
Idaho	14,116	0.04	1.8	0.9	0.9	5.7	3.1	2.6
Illinois	121,758	0.32	15.9	7.8	8.1	49.1	26.8	22.3
Indiana	75,375	0.20	9.9	4.8	5.0	30.4	16.6	13.8
Iowa	36,906	0.10	4.8	2.4	2.5	14.9	8.1	6.7
Kansas	26,893	0.07	3.5	1.7	1.8	10.8	5.9	4.9
Kentucky	51,716	0.14	6.8	3.3	3.5	20.8	11.4	9.5
Louisiana	54,379	0.14	7.1	3.5	3.6	21.9	12.0	9.9
Maine	17,040	0.05	2.2	1.1	1.1	6.9	3.8	3.1
Maryland	63,544	0.17	8.3	4.1	4.2	25.6	14.0	11.6
Massachusetts	67,081	0.18	8.8	4.3	4.5	27.0	14.8	12.3
Michigan	117,139	0.31	15.3	7.5	7.8	47.2	25.8	21.4
Minnesota	63,344	0.17	8.3	4.1	4.2	25.5	14.0	11.6
Mississippi	38,188	0.10	5.0	2.4	2.6	15.4	8.4	7.0
Missouri	74,563	0.20	9.8	4.8	5.0	30.1	16.4	13.6
Montana	11,117	0.03	1.5	0.7	0.7	4.5	2.4	2.0
Nebraska	18,872	0.05	2.5	1.2	1.3	7.6	4.2	3.4
Nevada	26,507	0.07	3.5	1.7	1.8	10.7	5.8	4.8
New Hampshire	16,542	0.04	2.2	1.1	1.1	6.7	3.6	3.0
New Jersey	102,025	0.27	13.3	6.5	6.8	41.1	22.5	18.6
New Mexico	22,262	0.06	2.9	1.4	1.5	9.0	4.9	4.1
New York	134,906	0.36	17.6	8.6	9.0	54.4	29.7	24.7
North Carolina	102,026	0.27	13.3	6.5	6.8	41.1	22.5	18.6
North Dakota	8,080	0.02	1.1	0.5	0.5	3.3	1.8	1.5
Ohio	122,074	0.32	16.0	7.8	8.2	49.2	26.9	22.3
Oklahoma	43,421	0.12	5.7	2.8	2.9	17.5	9.6	7.9
Oregon	36,488	0.10	4.8	2.3	2.4	14.7	8.0	6.7
Pennsylvania	121,878	0.32	15.9	7.8	8.1	49.1	26.9	22.3
Rhode Island	9,100	0.02	1.2	0.6	0.6	3.7	2.0	1.7
South Carolina	58,235	0.16	7.6	3.7	3.9	23.5	12.8	10.6
South Dakota	9,470	0.03	1.2	0.6	0.6	3.8	2.1	1.7
Tennessee	73,105	0.19	9.6	4.7	4.9	29.5	16.1	13.4
Texas	272,404	0.73	35.6	17.4	18.2	109.8	60.0	49.8
Utah	24,067	0.06	3.1	1.5	1.6	9.7	5.3	4.4
Vermont	8,166	0.02	1.1	0.5	0.5	3.3	1.8	1.5
Virginia	93,557	0.25	12.2	6.0	6.3	37.7	20.6	17.1
Washington	63,818	0.17	8.3	4.1	4.3	25.7	14.1	11.7
West Virginia	19,783	0.05	2.6	1.3	1.3	8.0	4.4	3.6
Wisconsin	59,571	0.16	7.8	3.8	4.0	24.0	13.1	10.9
Wyoming	7,389	0.02	1.0	0.5	0.5	3.0	1.6	1.4
Total	**3,266,108**	**8.7**	**433.6**	**207.2**	**226.4**	**1323.5**	**715.8**	**607.7**

[a] Energy Information Administration / Department of Energy, data for 2005 (http://www.eia.doe.gov/emeu/states/sep_fuel/html/fuel_mg.html)

[b] California fleet mix (70 percent PC/LDT1 & 30 percent LDT2) used for CA; all other states are represented by federal fleet mix (50 percent PC/LDT1 & 50 percent LDT2). This results in other states having less benefit on a percentage basis than CA.

Figure 3. Comparison of Cumulative Nationwide GHG Benefits of Pavley Regulation and New Federal Fuel Economy Standards



Canada

Canada has also expressed an interest in adopting California's standards. ARB staff estimated the benefits for each of the Canadian provinces, as well as Canada as a whole, using the same approach taken for the United States of using gasoline consumption as a surrogate. Staff scaled California's CO_2 equivalent benefits, using calendar year 2005 province-specific gasoline consumption data available from Canada's National Statistical Agency, Statistics Canada at http://www40.statcan.ca./l01/cst01/trade37a.htm.

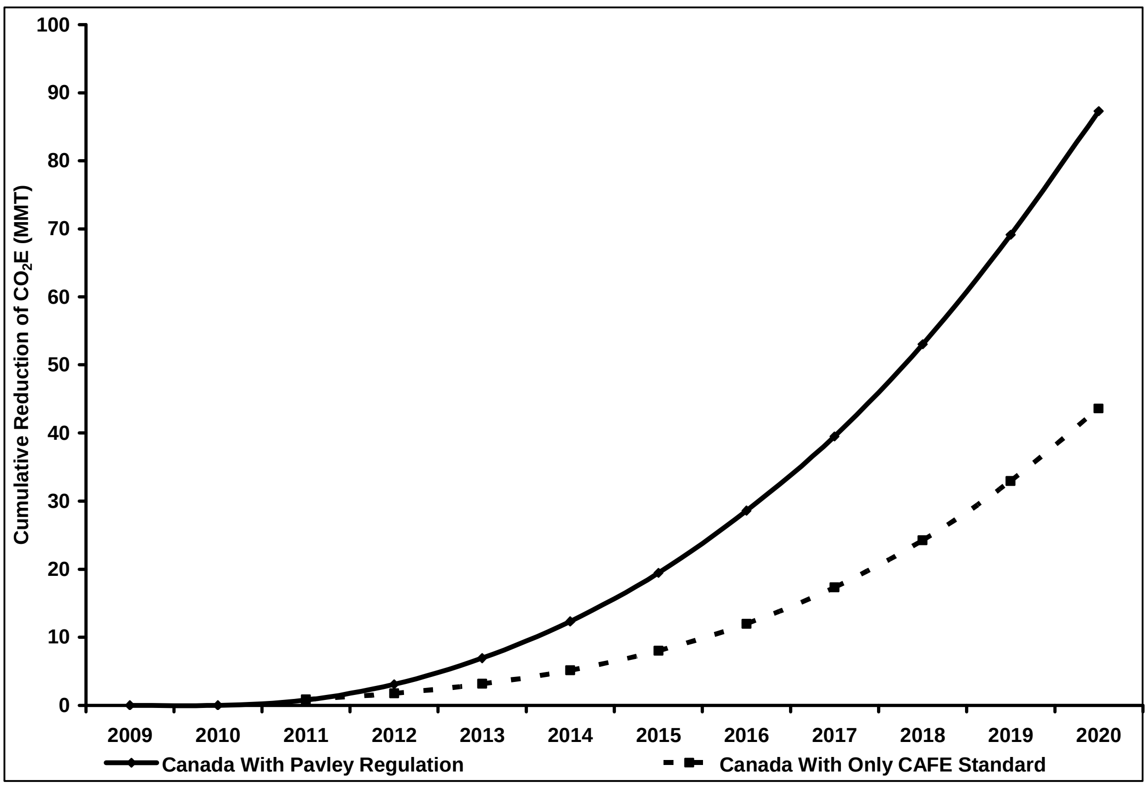
As shown in Table 17, Canada used 242 million barrels of gasoline in calendar year 2005, equivalent to 64 percent of California's gasoline consumption for that same year. Table 17 and Figure 4 compare the cumulative CO_2 equivalent benefits of the Pavley regulation to the federal CAFE standard if implemented in all Canadian provinces. Implementation of the Pavley standards by Canada would reduce cumulative greenhouse gas emissions by 29 $MMTCO_2E$ between 2009 and 2016, which is more than double the 12 $MMTCO_2E$ reductions estimated from U.S. federal fuel economy (CAFE) standards alone. By 2020, a cumulative 87 $MMTCO_2E$ would be reduced in Canada with the Pavley rules compared to 44 $MMTCO_2E$ reduced by federal CAFE standards alone.

Table 17. Comparison of Canadian Cumulative CO_2 Equivalent Benefits Achieved by Pavley Regulation and New Federal Fuel Economy Standards by 2016 and 2020

Province[a]	Motor Vehicle Gasoline Consumption[a] (1000 Barrels)	Gasoline Use Ratio to California	Cum. Benefit from CA Stds by 2016[b] (MMTs)	Cum. Benefit from Fed Stds by 2016[b] (MMTs)	Cum. Benefit of CA Stds Over Fed Stds by 2016[b] (MMTs)	Cum. Benefit from CA Stds by 2020[b] (MMTs)	Cum. Benefit from CA Stds by 2020[b] (MMTs)	Cum. Benefit of CA Stds Over Fed Stds by 2020[b] (MMTs)
Newfoundland/Labr	3,695	0.01	0.4	0.2	0.3	1.3	0.7	0.7
Prince Edward Islan	1,306	0.00	0.2	0.1	0.1	0.5	0.2	0.2
Nova Scotia	7,475	0.02	0.9	0.4	0.5	2.7	1.3	1.3
New Brunswick	6,444	0.02	0.8	0.3	0.4	2.3	1.2	1.2
Quebec	51,500	0.14	6.1	2.5	3.5	18.6	9.3	9.3
Ontario	96,484	0.26	11.4	4.8	6.6	34.8	17.4	17.4
Manitoba	8,359	0.02	1.0	0.4	0.6	3.0	1.5	1.5
Saskatchewan	7,024	0.02	0.8	0.3	0.5	2.5	1.3	1.3
Alberta	30,725	0.08	3.6	1.5	2.1	11.1	5.5	5.5
British Columbia	28,357	0.08	3.3	1.4	1.9	10.2	5.1	5.1
Yukon Territory	384	0.00	0.05	0.02	0.03	0.1	0.1	0.1
Northwest Territorie	233	0.00	0.03	0.01	0.02	0.1	0.04	0.04
Nunavut	147	0.00	0.02	0.01	0.01	0.1	0.03	0.03
Total	**242,131**	**0.6**	**28.6**	**12.0**	**16.6**	**87.3**	**43.6**	**43.7**

[a] Retail sales, Road Tax information. www40.statcan.ca./l01/cst01/trade37a.htm
[b] Based on Canadian fleet mix (61percent PC/LDT1 & 39 percent LDT2).

Figure 4. Comparison of Cumulative CO_2 Equivalent Benefits of Pavley Regulation and New Federal Fuel Economy Standards in All Canadian Provinces



Dieselization

Currently the fraction of diesel-fueled passenger vehicles in the PC, LDT1, and LDT2 weight classes in California is very small (approximately one percent), and the emission factors provided in Tables 4 through 7 assume a 100 percent gasoline fueled fleet. However, a number of manufacturers are expected to offer a greater range of diesel-fueled passenger vehicles and light trucks in the near future.

To estimate the impact of the introduction of diesel-fueled vehicles on net GHG emissions under the federal CAFE program, ARB staff estimated the carbon content of gasoline and diesel fuels[27], as well as the relative fuel efficiency of gasoline and diesel engines. Because of the greater efficiency of diesel engines and the higher energy content of the fuel, diesels typically deliver 30 percent more miles per gallon[28] and yet only 20 percent fewer GHG emissions than comparable gasoline vehicles[29].

The benefits of dieselization will vary depending upon whether a state implements the California GHG standards, or is subject only to the federal fuel economy standards. For states implementing the California standards, diesel vehicles will have no impact on the GHG emissions reduced because each manufacturer must meet a fleet-average GHG standard for new vehicles, regardless of the type of vehicles sold. In states that do not adopt the California GHG standards, vehicles would have to comply only with the federal fuel economy standards. Diesel vehicles improve fuel economy more than they reduce GHG emissions because diesel fuel contains more carbon per gallon than gasoline. Thus in these states less GHG reduction will occur if diesels are used to help meet the federal fuel economy requirements than if compliance was met with gasoline vehicles. This outcome, and the provision of federal law that gives fuel economy credit for flexible fuel vehicles whether alternative fuel is used or not, illustrate why regulation of fuel economy is not sufficient to assure GHG emission reductions are achieved.

SUMMARY

This analysis demonstrates that California's GHG standards are significantly more effective at reducing greenhouse gas emissions than the new federal CAFE program, whether they are implemented in California, other states, or Canada. California's GHG emissions standards are 16 percent more stringent than the new federal fuel economy standards for 2016 model year passenger vehicles, and 18 percent more stringent for 2020 model year vehicles when the planned second phase of California's standards are in place. This translates into the California standards being considerably more effective at reducing GHGs than the new federal standard, indirectly yielding an estimated fuel economy of 43 mpg by 2020 as compared to the new CAFE standard of 35 mpg.

In calendar year 2016, California standards will reduce GHG emissions from cars in California by 9 MMTCO$_2$E more than the federal CAFE standard. This is more than double the reduction produced by the federal standard. By 2020, California will have implemented revised, more stringent GHG emission limits, as set forth in its Climate Action Plan. As a result of these new requirements GHG emissions in California will be reduced by 13 MMTCO$_2$E (69 percent) more than the federal standard in calendar year 2020 alone.

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[27] 8887 grams of CO_2 per gallon for gasoline (indolene) and 10179 grams of CO_2 per gallon for diesel.
[28] See Department of Energy, *Model Year 2008 Fuel Economy Guide* (2008), www.fueleconomy.gov
[29] This is derived by converting a 30 percent increase in fuel economy to a 23.1 percent decrease in CO_2 emissions and then reducing the 23.1 percent by 3.0 percent to account for the higher carbon content of diesel fuel compared to gasoline. The 3.0 percent adjustment is calculated by multiplying the fuel economy reduction (23.1 percent) by the percent difference in carbon content of the two fuels (13 percent).

The benefits of the Pavley rules are even more apparent, both in terms of total tons and effectiveness relative to the new federal standards, when expressed as cumulative emissions benefits over time. Figure 5 compares four cumulative emission reduction scenarios developed for the United States for calendar year 2016. Each bar shows the cumulative CO_2 equivalent emission reductions for those states adopting California standards, and the remainder that only benefit from the federal fuel economy standards. At the top of each bar, the percentage increase in CO_2 equivalent emission benefit relative to only the federal standards being implemented is also shown. For example, if all 50 states implemented the Pavley rules, cumulative nationwide CO_2 equivalent emission reductions by 2016 would be 109 percent greater than if only the new federal fuel economy standards were in place.

Figure 5. Comparison of Nationwide Cumulative GHG Benefits Achieved by Pavley Regulation and New Federal Fuel Economy Standards by 2016 Under Different Scenarios

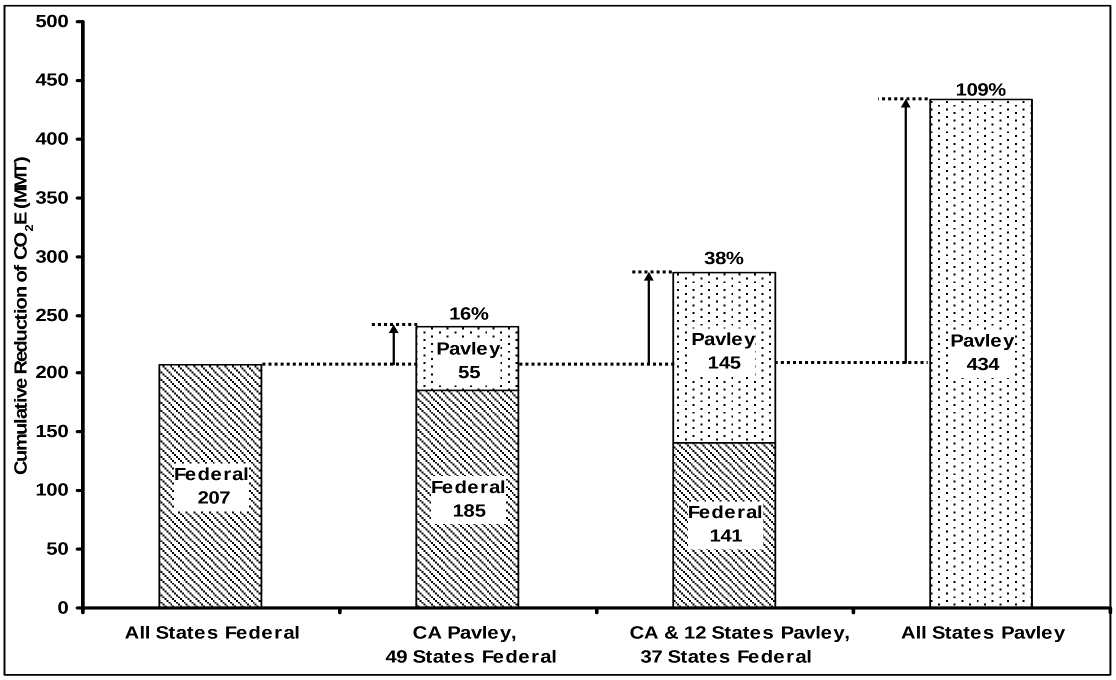
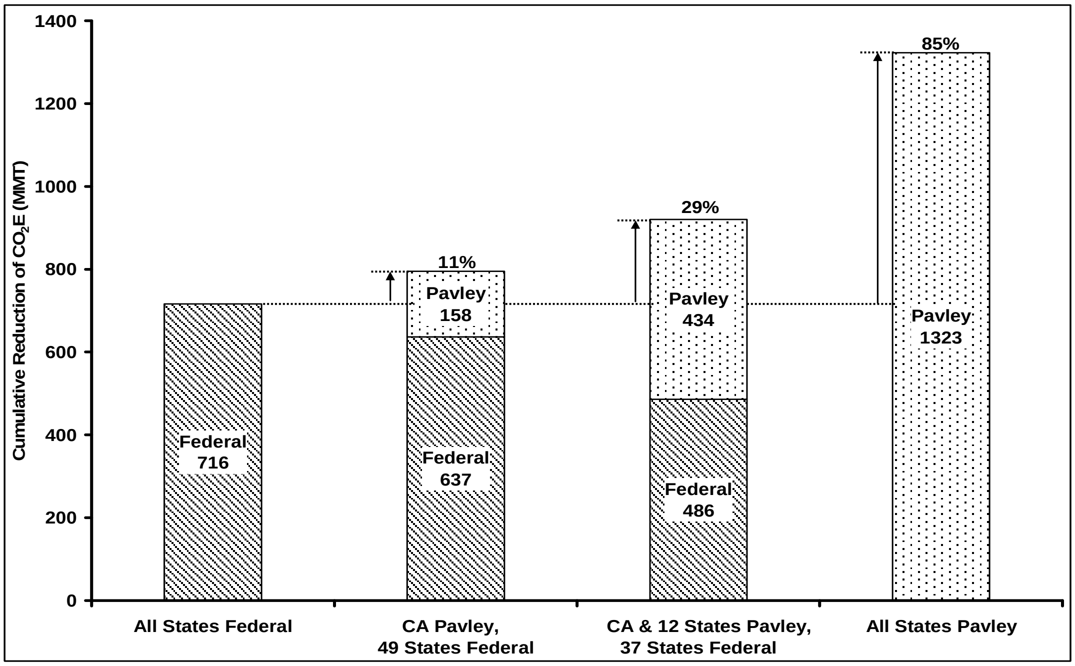


Figure 6 compares the four scenarios that were developed for calendar year 2020. If all 50 states implemented the Pavley rules they would achieve 85 percent greater cumulative CO_2 equivalent emission reductions by 2020 than if only the new federal fuel economy standards were in place.

Figure 6. Comparison of Nationwide Cumulative GHG Benefits Achieved by Pavley Regulation and New Federal Fuel Economy Standards by 2020 Under Different Scenarios



As shown in Table 18, the GHG benefits of the Pavley rules are consistently greater than the new federal fuel economy standards but vary from 85 percent to 150 percent, depending upon regional differences in fleet mix.

Table 18. Cumulative Benefits of California's Standards Compared to the New Federal Fuel Economy Standards for California, the United States, and Canada.

		Cumulative GHGs Reduced			% Benefit
Region	Year	Fed. Std[b]	CA Std	CA over Fed Std	CA over Fed Std
California	2016	22	55	33	150%
	2020[c]	79	158	79	100%
California and 12 Other States[d]	2016	66	145	79	120%
	2020[c]	230	434	204	89%
All 50 States	2016	207	434	226	109%
	2020[c]	716	1323	608	85%
Canada	2016	12	29	17	139%
	2020[c]	44	87	43	99%
United States and Canada	2016	219	462	243	111%
	2020[c]	759	1411	651	86%

[a] Million metric tons.
[b] Based on CAFE standard.
[c] Based on current and planned standards.
[d] Includes states that have adopted California's standards (Connecticut, Maine, Maryland, Massachusetts, New Jersey, New Mexico, New York, Oregon, Pennsylvania, Rhode Island, Vermont, and Washington).