

Compliance with California's Light-Duty Vehicle Greenhouse Gas Emission Standards

Staff Report

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This report has been prepared by the staff of the California Air Resources Board (CARB). It was originally prepared to support CARB's comments on the United States Environmental Protection Agency's August 2021 proposed action to reconsider its withdrawal of California's waiver of preemption and was entered into the public record for that action. We are providing it to the public on the CARB website as well, with limited updates to capture information since August, for additional transparency. The report shows continuing progress on reducing greenhouse gas emissions reductions from light-duty vehicles.

Summary

Since the 2009 model year, California has had standards to reduce greenhouse gas (GHG) emissions from passenger cars (PC) and light-duty trucks (LT). Since 2012, California allowed auto manufacturers to comply with the then-roughly analogous federal GHG emission standards. That option was available through the 2020 model year but ended when the U.S. Environmental Protection Agency (EPA) significantly relaxed its own standards through the SAFE Vehicles Rule for Model Years 2021-2026 Passenger Cars and Light Trucks, 85 Fed. Reg. 24,174 (April 20, 2020). Beginning with the 2021 model year, and pending restoration of California's authority to enforce its standards, California's GHG standards apply.

Auto manufacturers have complied with the federal GHG emission standards through model year 2020, thereby complying with California's GHG standards as well. Auto manufacturers are well positioned to meet California's standards for model year 2021 and beyond. As a whole, the industry will enter the 2021 model year in compliance with California's standards and, given the progression of technologies, are on a trajectory to continue to comply at or below previous cost projections.

Background

The California Air Resources Board (CARB) first established regulations of greenhouse gases emissions from passenger cars and light-duty trucks in 2004, applying to model years 2009-2016. The regulations require manufacturers to meet separate, increasingly stringent fleet average GHG levels for both their PC and LT fleets. These regulations were amended in 2009 when CARB adopted a provision to allow manufacturers to comply with the federal emission standards for the 2012-2016 model years (which were roughly analogous in stringency) in lieu of California's standards. This provision, known as the deemed-to-comply (DTC) provision, harmonized the California and federal emission standards under one national program. In 2012, California adopted the Advanced Clean Cars regulations, which required continued GHG emission reductions from manufacturers' PC and LT fleets for model years 2017-2025. Similar to the 2009 amendments, California incorporated a DTC provision that harmonized its emission standards for these model years with roughly analogous federal standards under one national program. In September 2018, after EPA proposed to significantly weaken its federal standards for model years 2021-2026, CARB clarified the DTC provision only applied to then-existing federal standards—those federal standards that were roughly analogous to California's; compliance with other federal standards, including any standards weakened as EPA had proposed, would not be deemed compliance with California's standards.

Analysis

Calculating California's Historical GHG Emissions Compliance Trends

Since all manufacturers elected to comply with California's standards using the DTC provisions for all model years since 2012, there have been no calculations to date to determine to what extent they would have separately complied under the California program. However, the same general methodology used in the federal program is used to calculate compliance for the California fleet. Specifically, the emission standards for both programs were numerically identical for the PC and LT fleets. The methodology for determining certain emission credits such as the flex-fuel vehicle credits, air conditioning (A/C) credits, and off-cycle credits is only slightly different between the two programs. The use of advanced technology production multipliers and treatment of upstream emissions for battery electric and plug-in hybrid vehicles, though, is different between the two programs. For example, under the federal program, battery and plug-in hybrid vehicles are assumed to have zero upstream emissions while, under the California program, they are assumed to have non-zero upstream emissions that must be included in the fleet average calculation.

To assess compliance with California-specific regulations, CARB staff developed a calculation methodology that relied on the same emission testing data used to demonstrate compliance with the federal program and combined it with California-specific sales data from manufacturers to calculate the requisite sales-weighted averages in the California light-duty vehicle fleet. In addition to these data, staff made simplifying assumptions to estimate the emission credits when specific data were not available from the national emission testing data. More detail on the data sources, calculation methodology, and calculations follow at the end of this report.

Results

The GHG compliance values for the California fleet in the 2012–2018 model years are summarized in Figure 1 below, which represents an aggregation of all manufacturers. This incorporates the most recent complete and validated compliance data provided to CARB. To understand the chart, the line represents the average effective standard for the combined fleets from all manufacturers. The checkerboard columns represent the adjusted CO₂ equivalent certification value (the value compared to the standard for compliance), derived by adding CO₂ and methane/nitrous oxide adjustments (as provided by the national certification data¹) and subtracting A/C and off-cycle credits.

¹ The national data actually reports carbon-related exhaust emissions, which results in a slight over-estimation of what the actual CO₂ equivalent emissions would have been in the CA program but no adjustment was made to correct for this minor difference in this analysis given the unavailability of the data needed to make such an adjustment.

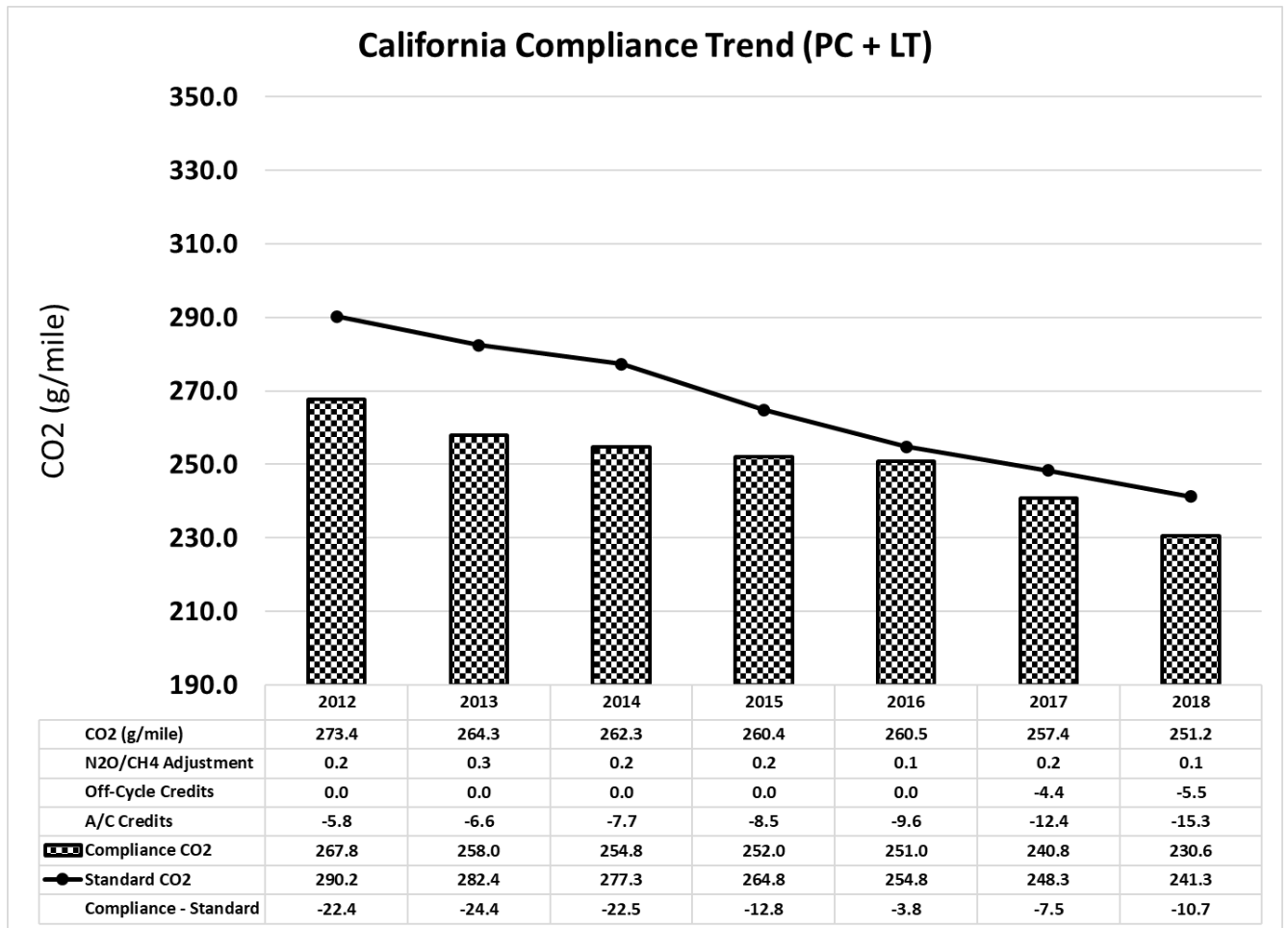


Figure 1: California GHG Compliance Trends

As seen from the chart, manufacturers in California have over-complied with the requisite GHG standard in each model year by as little as 3.8 g/mile in model year 2016 and as much as 24.4 g/mile in 2013.

These results are consistent with previous analyses regarding the feasibility of achieving the California GHG fleet-average targets in the 2018-2025 timeframe. The CARB Midterm Review (MTR)², conducted in 2016, provided an in-depth technical analysis of the California fleet and projected how much it would cost to achieve fleet-average targets. In Appendix M of the MTR, staff made projections (using the 2014 model year as a baseline) of future characteristics of the California vehicle fleet, including vehicle footprints, car/truck sales splits, and fuel prices in the 2015 through

² See <https://ww2.arb.ca.gov/resources/documents/2017-midterm-review-report>

2025 timeframe under various scenarios. In all scenario results, the California fleet was projected to meet or exceed the GHG reduction targets in the 2025 model year.

Based on the results of the MTR's scenario analyses and other findings, CARB concluded that the GHG standards through model year 2025 were appropriate. This analysis, now factoring in the 2015 through 2018 model years, indicates the conclusions of the MTR remain valid; nothing in the new data sets for those model years contradicts the conclusions of the MTR or leads staff to believe that the conclusions of the MTR are invalid.

Starting with the 2021 model year, California's GHG emission regulations no longer allow manufacturers to demonstrate compliance with federal GHG emission standards in lieu of California's. After restoration of California's waiver, all manufacturers would have to comply with California standards in California. A manufacturer's compliance with California's GHG standards is first evaluated at the conclusion of each model year by comparing the standards applicable to the manufacturer's fleet with the actual GHG emissions measured for the manufacturer's fleet. Those meeting or exceeding the requirement and those falling short but with sufficient credits to cover the shortfall are determined to be in compliance. Those carrying forward a deficit are not determined to be in compliance until a future point where the manufacturer procures sufficient credits to meet the shortfall. Only those manufacturers that carry forward a deficit for more than five model years and fail to procure sufficient credits to meet the shortfall are determined to be noncompliant. In other words, a manufacturer has five model years to make up a deficit before being noncompliant and before any enforcement action could be taken.

Based on the information CARB currently has, CARB expects the industry will meet the California GHG emission standards in California in model year 2021. CARB is not aware of any information suggesting otherwise. This does not mean that every individual manufacturer will meet the standard each year, as some likely will fluctuate from year to year as they take advantage of the provisions to bank, trade, and use credits across multiple years and carry forward such credits or deficits for up to five model years before compliance is actually determined.

As noted, were a manufacturer to under-comply with the model year 2021 standard, no immediate action or consequences would attach for that manufacturer because the compliance process is determined over five model years. Any non-compliance would be assessed by the state against the severity and complexity of the violation, and multiple options exist to resolve issues. Thus, no manufacturer will be subject to enforcement action for several years; indeed, any non-compliance with the 2021 model year standard cannot be officially determined until the end of the 2026 model year. Should there be any non-compliance at some point in the future, it would be handled in accordance with state law as any other non-compliance with any other state law would be, with consideration of the particular circumstances. As has been demonstrated in multiple contexts, both state agencies and courts possess significant powers to craft equitable and individualized solutions to particular non-compliance situations when warranted.

Methodology

Data Sources

The main source of data for this analysis were the emission data associated with the 2020 EPA Automotive Trends report³. This annual report provides detailed information on tailpipe GHG certification levels and the emission credits used to calculate current compliance status for each manufacturer. It also provides information on credit bank transactions used in each model year by each manufacturer to determine their final compliance status. Although these reports are public, certain data, such as individual vehicle sales and individual vehicle certification levels, are not provided in the report. Such information had to be requested by CARB to estimate California GHG compliance levels. Specifically, CARB requested and received manufacturer-submitted vehicle-level GHG data from EPA on an annual basis. In addition to these data, CARB requested and received California-specific sales data from each manufacturer. When combined, these two data sources allowed staff to estimate manufacturer compliance in a California-specific vehicle fleet—in other words, manufacturer compliance with California’s GHG standards. Table 1 below provides a summary of the data available for each manufacturer in the California fleet. An “X” in the table means data were available for calculation of a manufacturer’s California GHG compliance.

Manufacturer	California GHG Data Availability						
	2012	2013	2014	2015	2016	2017	2018
Aston Martin						X	X
BMW	X	X	X	X	X	X	X
BYD Motors						X	X
Ferrari						X	X
Fiat Chrysler	X	X	X	X	X	X	X
Ford	X	X	X	X	X	X	X
GM	X	X	X	X	X	X	X
Honda	X	X	X	X	X	X	X
Hyundai	X	X	X	X	X	X	X
Jaguar Land Rover						X	X
Kia	X	X	X	X	X	X	X
Lotus						X	X
Mazda						X	X
McLaren						X	X
Mercedes	X	X	X	X	X	X	X
Mitsubishi	X	X	X	X	X	X	X
Nissan	X	X	X	X	X	X	X
Subaru	X	X	X	X	X	X	X
Tesla	X	X	X	X	X	X	X
Toyota	X	X	X	X	X	X	X
Volkswagen						X	X
Volvo	X	X		X	X	X	X

Table 1: California GHG Data Availability

³ See <https://www.epa.gov/automotive-trends>

Overall, for model years between 2012 and 2016, CARB staff were able to collect more than 90% of total vehicle sales and engine certification data.⁴ For model years 2017 and later, staff were able to collect 100% of vehicle sales and certification data.

Calculation Methodology

As noted above, all manufacturers had, since 2012, elected to demonstrate compliance with California's GHG standards by showing compliance with the analogous federal standards. Under the federal program, a manufacturer demonstrated compliance by conducting testing to determine the tailpipe GHG emissions from both their nationwide PC and LT fleets. Using these emission data, vehicle sales data, and vehicle lifetime miles assumptions specified in regulation and applying any additional emission credits that were earned for vehicles equipped with advanced A/C systems or certain other off-cycle technologies, the total GHG emissions were calculated for each manufacturer's PC and LT fleets. A manufacturer then calculated its required GHG levels by using vehicle sales, footprint (approximately wheelbase times track width), and the footprint-scaled standards in the regulation for its PC and LT fleet. A manufacturer then compared its total GHG levels to this required level. Over-compliance with the standard for any given model year (i.e., GHG values lower than the required level) allowed the manufacturer to earn credits that could be banked and used to offset deficits in past or future model years. Likewise, under-compliance in any model year resulted in the manufacturer earning a deficit that could be satisfied through purchased or previously banked credits or over-compliance in future years. Manufacturers were required to submit emission testing data and nationwide sales data in sufficient detail to allow EPA to verify each manufacturer's fleet average GHG levels for each model year.

Compliance with California's standards follows the same general methodology as for compliance with the federal standards. However, since compliance with California's standards had been through compliance with the analogous federal standards, the calculation of historical compliance trends in California requires certain assumptions in the calculation methodology due to data availability limitations, detailed further below. The regulatory determination of compliance during the period of 2012 to 2018 is based on the requirements set forth in Title 13, CCR section 1961.1 for model years 2012–2016 and section 1961.3 for model years 2017 and 2018.

⁴ The model years and manufacturers where data was not available were either smaller volume manufacturers subject to a different set of GHG standards in those model years or were manufacturers that were part of an enforcement action involving the subject model years that would likely result in a revision of their compliance status.

Compliance Calculations (2012-2016)

For the 2012-2016 model years, the CO₂-equivalent emission value is calculated according to the following equation for each vehicle test group of each manufacturer:

$$\text{CO}_2\text{-Equivalent Value} = \text{CO}_2 + (296 \times \text{N}_2\text{O}) + (23 \times \text{CH}_4) - \text{A/C Direct Emissions Allowance} - \text{A/C Indirect Emissions Allowance}$$

All the terms in this equation were derived from the engine certification data submitted for compliance with EPA's program described earlier. The calculation methodology used to determine compliance in the federal program is slightly different than the California program. As a result, the national engine certification data did not contain all necessary inputs to the equation. Table 2 below provides a description of the terms in the equation and any simplifying assumptions or data modifications needed to calculate CO₂-equivalent values for the California program.

Equation Term	Description	Calculation Notes
CO ₂	The weighted carbon dioxide emissions (g/mile) of a vehicle test group calculated for the Federal Test Procedure (FTP) (55%) and Highway Fuel Economy Test (HWFET) (45%) according to the procedures described in 40 CFR Part 86, Subpart B and 40 CFR Part 600, Subpart B, respectively.	The national engine certification data contains data for carbon-related exhaust emissions (CREE) in lieu of CO ₂ . CREE represents the sum of CO ₂ plus a portion of carbon monoxide and hydrocarbon emissions. As a result, the use of the national data will result in slight over-estimation of the CO ₂ -equivalent values that would be calculated under the California program. In addition, the federal program does not require the calculation of upstream emissions associated with the use of electric, plug-in hybrid, and fuel cell vehicles. For this analysis, staff estimated upstream emissions for such vehicles using the procedures described in the CCR.
(296 x N ₂ O)	This term represents nitrous oxide exhaust emissions weighted by global warming potential (GWP).	For model years 2012-2016, the national certification data uses a GWP multiplier of 298, which slightly over-estimates the N ₂ O emissions that would be calculated under the California program. In the current analysis, staff incorporated the national certification values without any adjustments for the multipliers for model years 2012-2016. For model years 2017 and 2018, the California GWP multiplier was harmonized with the federal program (i.e., 298) and no adjustment was necessary.

Equation Term	Description	Calculation Notes
(23 x CH₄)	This term represents the methane exhaust emissions weighted by GWP.	For model years 2012-2016, the national certification data uses a GWP multiplier of 25, which slightly over-estimates the CH ₄ emissions that would be calculated under the California program. In the current analysis, staff incorporated the national certification values without any adjustments for the multipliers for model years 2012-2016. For model years 2017 and 2018, the California GWP multiplier was harmonized with the federal program (i.e., 25) and no adjustment was necessary.
A/C Direct Emissions Allowance	These credits represent any CO ₂ reductions associated with the use of low-GWP refrigerants in a vehicle's air conditioning system.	For model years 2012-2016, the California program and the federal program have different procedures for the measurement of direct A/C credits. For this analysis, we assume the direct A/C credits in the federal program are similar enough to provide an estimate of direct A/C credits in the California program.
A/C Indirect Emissions Allowance	These credits represent any CO ₂ reductions associated with the use of efficient A/C system components that reduce the load on the vehicle's engine.	For model years 2012-2016, the California program and the federal program have different procedures for the measurement of indirect A/C credits. For this analysis, we will assume the indirect A/C credits in the federal program are similar enough to provide an estimate of indirect A/C credits in the California program.

Table 2: Summary of Terms in California GHG Compliance Equation

Staff generated a year-by-year California historical compliance trend using the following steps for each model year:

1. Calculate the sales-weighted CO₂ certification values using the certification and sales data for all vehicles in the California fleet. These calculations were performed using the procedures found in California's Code of Regulations at sections 1961.1 and 1961.3 of title 13. These calculations include upstream emissions associated with battery electric, fuel cell, and plug-in hybrid vehicles. For such vehicles, battery efficiencies (kWh/mile) and utility factors were obtained from the U.S. Department of Energy website.⁵

⁵ See <https://www.fueleconomy.gov>

2. Apply N₂O and CH₄ emission adjustments to reflect the tailpipe emissions of these compounds in the vehicle fleet. These adjustments were derived from the EPA Automotive Trends reports and incorporated federal program GWP multipliers. This was a simplifying assumption since staff did not have specific information about N₂O and CH₄ emissions of vehicles in the California fleet.
3. Apply A/C credit adjustments to reflect the use of high-efficiency air conditioners and low-GWP A/C refrigerants. These manufacturer-specific credits were derived from the EPA Automotive Trends reports and were applied to the fleet average CO₂ certification values of the PC and LT fleets of each manufacturer. This was a simplifying assumption since staff did not have specific information about the A/C system characteristics of vehicles in the California fleet. The A/C credits, however, were sales-weighted to estimate California-specific A/C credit allowances. This yields adjusted CO₂ certification values.
4. Based on vehicle footprint data (provided with the California sales data), calculate a sales-weighted CO₂ standard for the California fleet.
5. Compare the adjusted CO₂ certification values to the CO₂ standards. If the certification values were less than the standard, the California fleet complied. If not, the California fleet would generate a deficit and would require the use of banked (or future earned) credits to meet the requisite standard.

Example of 2016 model year calculation

1. California sales-weighted CO₂ certification value = 260.5 g/mile
2. N₂O and CH₄ emission adjustments = 0.1 g/mile
3. Direct and Indirect A/C credits = -9.6 g/mile
4. Adjusted CO₂ Certification Value = 260 g/mile + 0.1 g/mile – 9.6 g/mile = 251.0 g/mile
5. Fleet Standard = 254.8 g/mile
6. Adjusted CO₂ Certification Value – Fleet Standard = 251.0 g/mile – 254.8 g/mile = -3.8 g/mile

Based on this example calculation, the California fleet over-complied with the fleet standard by 3.8 g/mile, indicating that, industry wide, GHG credits were generated that year and could be used to meet any deficit that may occur in future years.

Compliance Calculations (2017-2018)

For model years 2017 and 2018, additional off-cycle credits were introduced to the California program. These credits represent CO₂-reducing technologies that are not adequately captured on the FTP and HWFET cycles and include technologies such as aerodynamic improvements and solar reflective paint. These manufacturer-specific credits were derived directly from the EPA Automotive Trends reports and were

applied to the fleet-average CO₂ certification values of the PC and LT fleets of each manufacturer. This was a simplifying assumption since staff did not have specific information about the off-cycle technologies present in vehicles in the California fleet. Such information was sales-weighted to estimate California-specific off-cycle credit allowances.