Appendix D

Emissions Inventory Methods and Results for the Proposed Amendments

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This appendix provides further details on the emissions inventory methods and results for the Proposed Amendments.

I. Overview

The emission benefits of the proposed ACC II regulation for LDVs and MDVs are estimated using CARB's latest version of its on-road vehicle emission inventory tool EMFAC2021[1] and CARB's Vision model, which can be used to quantify upstream emissions from the transportation fuel and electric power industries.[2] Light-duty vehicles are vehicles with less than 8,500 lbs. of gross vehicle weight rating, including passenger cars (LDA) and light-duty trucks (LDT1, LDT2, and LDT3). Medium Duty vehicles are vehicles greater that 8,500 lbs. and less than 14,000 lbs. of gross vehicle weight rating, including light-heavy duty trucks (LHDT1, and LHDT2). EMFAC2021 reflects the latest planning assumptions, and as of March 8, 2022, the preempted status of CARB's light-duty vehicle GHG emission and ZEV regulation.[3] It reflects California-specific driving and environmental conditions, passenger vehicle fleet mix, and most importantly the impact of California's unique mobile source regulations. These include all currently adopted regulations such as the LEV, LEV II and LEV III programs, and California inspection and maintenance programs. The EMFAC2021 model is based on CARB's ACC regulations but also considers updated California Department of Motor Vehicles data through calendar year 2019 and improved projections of the ZEV market share to forecast future ZEV populations, which show overcompliance with the current ZEV requirements (sales exceed minimum annual requirements) in the ACC regulations. It should be noted that the current model is only capable of representing business-as-usual conditions and is made using the best available data, and factors such as COVID-19 introduce both short- and long-range uncertainties in the ability of the model to accurately forecast future trends.

To assess the impact of the proposed regulation, the EMFAC2021 model with customized "annual average" settings was run to estimate statewide light-duty vehicle emissions by calendar year, vehicle category, fuel type, and model year projected to occur for the years of 2026 through 2050. The default number of ZEVs in the

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[1] EMFAC is CARB's on-road vehicle emission inventory tool. *See* https://arb.ca.gov/emfac/. It reflects California-specific driving and environmental conditions, passenger vehicle fleet mix, and most importantly the impact of California's unique mobile source regulations. The current version, EMFAC 2021, is pending U.S. EPA approval to meet transportation conformity and other planning requirements under the federal Clean Air Act. CARB 2021a. California Air Resources Board. EMFAC 2021 Volume III Technical Document. Published April 2021. Accessed March 10, 2022. https://ww2.arb.ca.gov/sites/default/files/2021-08/emfac2021_technical_documentation_april2021.pdf.

[2] CARB 2017. California Air Resources Board. Vision 2.1 Scenario Modeling System Limited Scope Release. Published February 2017. Accessed March 10, 2022. https://ww2.arb.ca.gov/sites/default/files/2020-06/vision2.1_scenario_modeling_system_general_documentation.pdf.

[3] On March 9, 2022, U.S. EPA Administrator Regan rescinded the actions that withdrew the waiver under Section 209 of the Clean Air Act for CARB's Advanced Clean Cars greenhouse gas emission and zero-emission vehicle standards.

EMFAC2021 fleet was also adjusted to account for recent changes to the U.S. EPA vehicle standards up to model year 2026.[4]

1. Modeling of ZEV Proposals

To assess the impact of the ZEV proposals, the EMFAC model was adjusted to reflect modified assumptions for BEV, FCEV, and PHEV sales fractions to account for the proposed manufacturer requirements. The proposed regulations also have minimum requirements for PHEVs to count towards the ZEV regulation. To account for future PHEVs meeting these requirements, the model was updated to reflect an increase in electric miles travelled by a PHEV (utility factors) and sales fractions for blended vs. non-blended (described below) PHEVs were also modified.

To reflect proposed minimum technical requirements, which include an all-electric miles minimum capability, Table 1 shows projected in-use percent electric vehicle miles travelled (eVMT) for PHEVs. Electric VMT for PHEVs is an essential EMFAC input to estimate the expected emissions and fuel and electric energy consumption for the PHEV fleet. Currently, EMFAC2021 assumes that the PHEV's eVMT percentage only vary by model year, while for modeling ACC II, staff incorporated eVMT fractions that vary by model year, vehicle class, and whether a PHEV is blended or non-blended, based on how the engine operates.

Table 1. Projected Plug-in Hybrid Electric Vehicle (PHEV) eVMT Fractions as a result of ACC II Requirements

Model Year	LDA blended	LDA non-blended	LDT blended	LDT non-blended
2026	54%	66%	49%	59%
2027	57%	69%	51%	62%
2028	58%	71%	53%	64%
2029	60%	73%	55%	67%
2030	62%	75%	57%	69%
2031	63%	77%	59%	72%
2032 +	65%	79%	61%	74%

For blended PHEVs, also referred to as non-US06 capable, the engine starts and provides propulsion power when the driver's power demand is higher than what the electric powertrain and battery can provide. In contrast, the electric powertrain of non-blended (i.e., US06 capable) PHEVs provide propulsion regardless of the driver

[4] 86 Fed. Reg. 74,434, Dec. 30, 2021. EMFAC2021 also previously reflected the Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule Part One: One National Program which withdrew California's authority for its light-duty vehicle ZEV and GHG emission standards. (84 Fed. Reg. 51,310, Sept. 27, 2019). After the analysis was performed for the SRIA, California's authority was restored. (86 Fed. Reg. 74,236, Dec. 29, 2021 [NHTSA withdrawal of preemption regulation]; 87 Fed. Reg. 14,332, March 14, 2022 [Rescission of withdrawal of waiver of preemption].) Adjustment factors were applied to EMFAC2021 for this analysis to remove the effects of the SAFE rules and actions.

demand until the battery reaches a low level of charge and switches to charge sustaining mode. Blended PHEVs typically have smaller-sized batteries and show more frequent combustion engine start behavior compared to non-blended PHEVs. Table 2 shows car and truck combined sales percentages for blended and non-blended PHEVs by model year. EMFAC2021 default assumptions are that blended PHEVs account for 50% of PHEV sales. In modeling the ACC II regulatory proposal, staff assumed that that 50% proportion would remain for 2026 through 2028, but that starting in 2029, 90% of the PHEV sales will be the non-blended technology.

Table 2: PHEV Sales Percentages for Blended and Non-blended PHEVs

Model Year	**PHEV %** Blended, non-US06 capable	**PHEV %** Non-blended, US06 capable
2026- 2028	50%	50%
2029-2035	10%	90%
2036+	0%	100%

The proposal scenario assumes full transition of new vehicle sales to ZEVs and PHEVs by the 2035 model year. The default ZEV projections from EMFAC2021 which relied upon a consumer choice modeling approach as described in the EMFAC2021 Technical Document[5] were adjusted to reflect assumed compliance in California of the finalized U.S. EPA GHG emissions standards[6]. Table 3 shows the updated ZEV (BEV and FCEV) and PHEV sales fractions by model year in the revised baseline scenario.

Table 4 compares the ACC II projected ZEV and PHEV sales fractions by model year of the proposal scenario for 2026 and later model years.

Table 3: Baseline ZEV (BEV+FCEV) and PHEV Fractions

MY	**Passenger Cars**		**Light Trucks**	
	ZEV	**PHEV**	**ZEV**	**PHEV**
2020	8.9%	4.0%	0.5%	1.1%
2021	9.7%	4.3%	1.4%	1.7%
2022	10.3%	4.4%	2.5%	2.0%
2023	11.7%	4.6%	4.3%	1.9%
2024	13.2%	4.6%	8.2%	1.9%
2025	17.6%	4.5%	10.6%	1.9%
2026 +	19.4%	4.4%	16.1%	1.8%

[5] CARB 2021a, California Air Resources Board. EMFAC2021 Technical Document, April 2021. *https://ww2.arb.ca.gov/sites/default/files/2021-08/emfac2021_technical_documentation_april2021.pdf*
[6] 86 Fed. Reg. 74,434, Dec. 30, 2021

Table 4: ZEV (BEV+FCEV) and PHEV Fractions for the Proposed Regulation

Model Year	Passenger Cars		Light Trucks	
	ZEV	PHEV	ZEV	PHEV
2026	40.7%	4.4%	19.5%	1.8%
2027	47.0%	4.4%	29.8%	1.8%
2028	50.5%	8.0%	39.1%	1.8%
2029	50.6%	19.2%	42.6%	1.8%
2030	61.8%	19.3%	48.5%	1.8%
2031	72.5%	19.3%	52.9%	1.8%
2032	76.9%	19.3%	61.0%	1.8%
2033	79.2%	19.3%	72.0%	1.8%
2034	95.5%	4.5%	80.9%	5.1%
2035 +	95.6%	4.4%	84.4%	15.6%

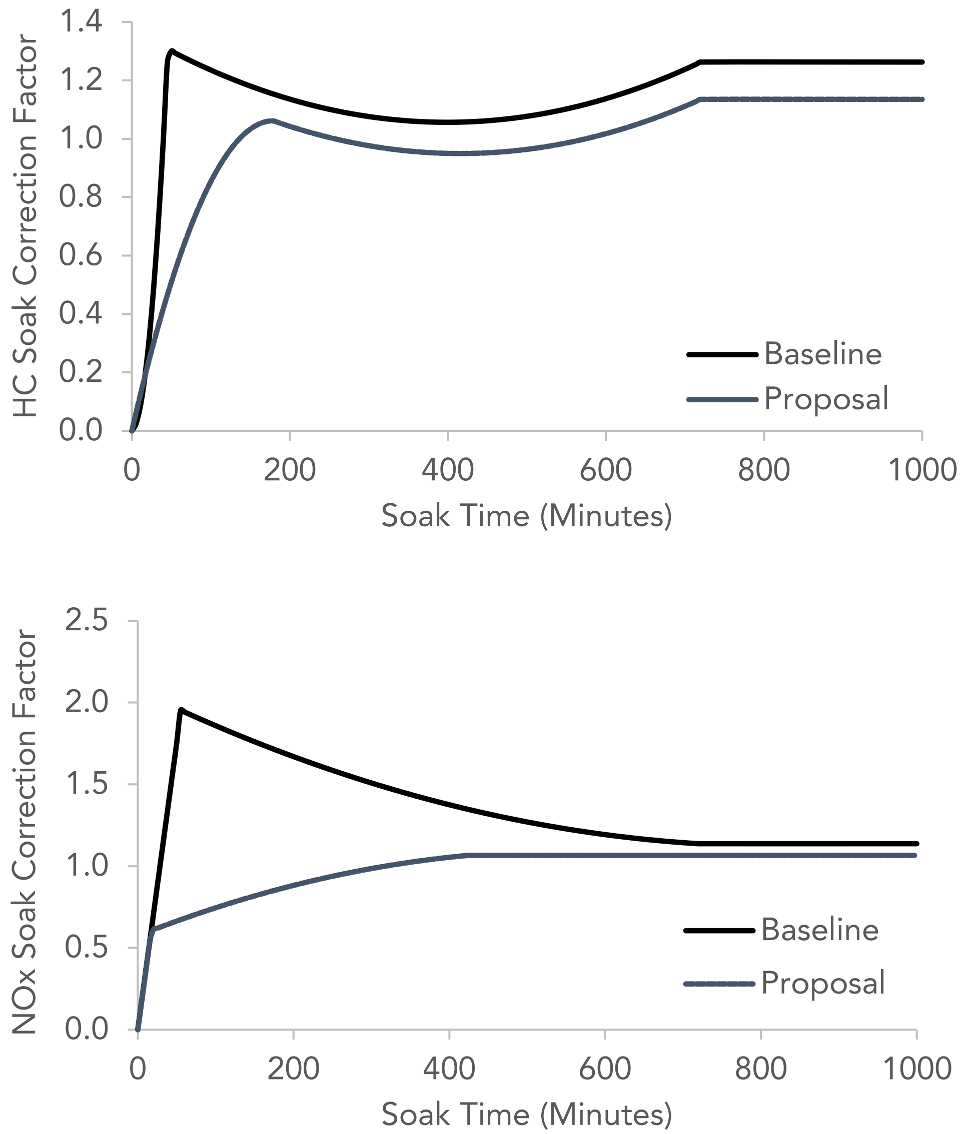
2. Modeling of LEV proposals

a) Light-Duty Vehicles

To assess the impact of the LEV proposals for light-duty vehicles, the EMFAC model was updated with assumptions to account for the anticipated reduced emissions from vehicle cold starts, resulting from meeting the proposed emission standards starting in 2026 for new vehicles only. This includes HC and NOx cold start emission rates for PHEVs, and changes to the "start emission soak correction factors (SoFs)" based on testing by CARB to account for emissions based on intermediate soaks, short idle times, and PHEV cold starts. The HC and NOx soak factors are presented in Figure .

Proposals for changes in intermediate soaks and shorter idles are reflected in the soak correction factor curves for the start emissions of HC and NOx. EMFAC assumes that a vehicle's warm-start emission rate is directly proportional to its odometer-equivalent cold-start emission rate. Therefore, a warm-start emission rate is computed by multiplying the cold-start emission rate by a non-dimensional soak correction factor, which is a function of soak time. Regression curves were fitted to the test data to derive SoF curves. For the proposed regulation, a three-domain approach was used. The plots were divided into shorter soak warm starts and longer soak warm starts, and separate curves were fitted to each domain. Beyond certain threshold soak times, the SoFs were assumed to flatten. The curves were forced through the y-intercept based on the assumption that start emissions are zero for zero-minute soak tests. Staff assumed the light-duty technology groups beyond the 2026 model year will share the same revised SoF curves for the proposed regulation. The new HC and NOx SoF curves between the proposed and baseline scenarios are shown in Figure . As shown, the baseline assumptions are modified to account for better calibration of vehicles for shorter soaks and shorter idles based on the proposed regulation.

Figure 1: Soak Factors for EMFAC Baseline and Proposed Regulation for HC and NOx



The projected sales mix of light-duty vehicles, by emission bin[7] under the proposed standards, was also modified to reflect the NMOG+NOx fleet average standard without ZEVs. As part of the LEV proposal, the fleet must meet the fleet average of 0.030 g/mi without ZEVs. The vehicle manufacturer must certify to emission bins and manage their sales mix to meet the weighted fleet average. To ensure that the ICEV

[7] Emission bins are emission standards that manufacturers certify their test groups to for purposes of demonstrating compliance with the fleet-average standards.

fleet will continue meeting the fleet average emission standards without ZEVs, the technology group fractions (or what emission bins they certify to) was also changed to meet the LEV proposal. Table 5 below shows the assumed compliance scenario of emission bins new ICEVs are certified to.

Table 5: Proposed Emission Bins for the ICEV Fleet for 2026 MY and Beyond

Model Year	LDA, LDT1		LDT2, LDT3			
	ULEV 50	SULEV 30	ULEV 125	ULEV70	ULEV 50	SULEV 30
2026	5.0%	49.85%	7.50%	5.00%	22.00%	44.15%
2027	5.0%	43.54%	4.00%	5.00%	13.80%	45.57%
2028	-	41.48%	4.00%	-	11.00%	44.11%
2029	-	30.17%	-	-	-	55.56%
2030	-	18.85%	-	-	-	49.69%
2031	-	8.20%	-	-	-	45.25%
2032	-	3.77%	-	-	-	37.14%
2033	-	1.47%	-	-	-	26.16%
2034	-	-	-	-	-	14.07%
2035+	-	-	-	-	-	-

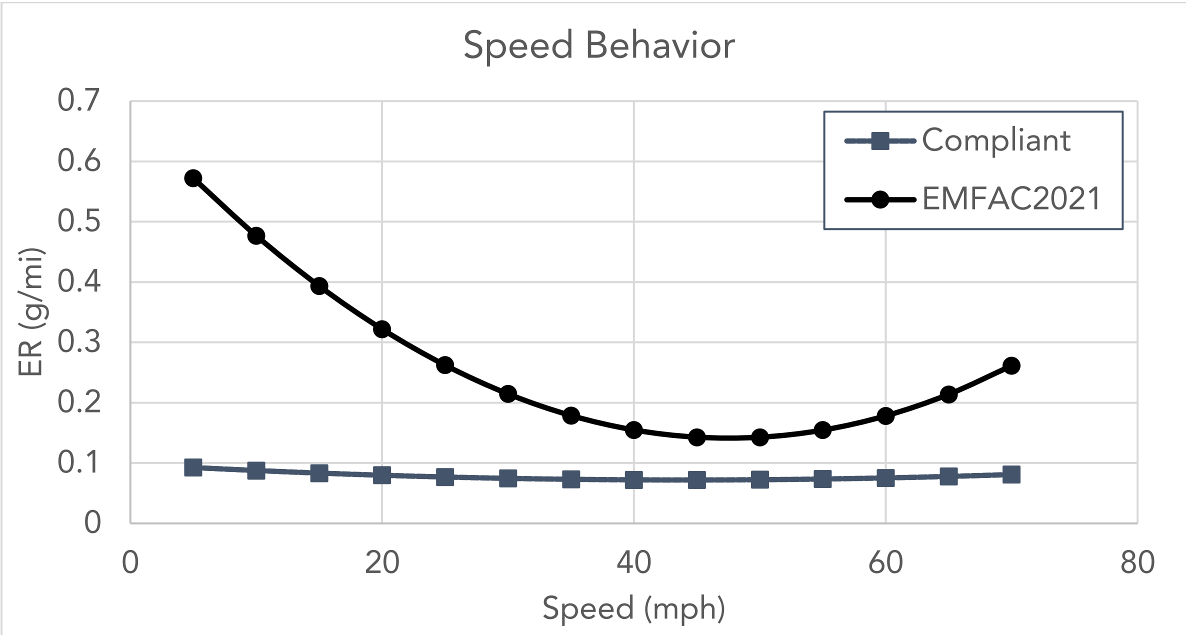
Combined with the proposed electric and PHEV fractions in Table 4, the percentages sum up to 100% for each vehicle class and model year beyond 2026 of the light-duty fleet. No new ICEVs may be sold starting in 2035 MY.

b) Medium-Duty Vehicles

To assess emission impacts, the proposed MDV changes can be summarized as two distinctly different measures. The first is an in-use standard structured similarly to the heavy-duty MAW concept which results in a significant reduction in NOx from diesel vehicles. Second, staff is proposing lowering the fleet average standards which results in vehicles meeting emission bins. Much like the ACC regulation, these standards are comprised of bins with phased-in fleet average requirements. These tightened standards will result in both ROG and NOx emission reductions.

The MAW standards will apply to all 2026 and newer model year trucks that have a gross combined weight rating (GCWR) of 14,000 pounds or greater. Vehicles that are meant to tow a trailer have a larger GCWR than vehicles not meant to tow. EMFAC had previously modeled MDV emission rates based on a speed function using emission rates from MDVs with higher emissions than our proposal standards. To model impacts of this proposal, staff looked at vehicles that were currently meeting the proposed MAW requirements and calculated the emission rates as a function of speed in EMFAC2021. Since EMFAC2021 does not include any benefits for MAW, the differences between the two curves can be used as an adjustment factor by speed. The emission rates are graphed in Figure 2.

Figure 2: EMFAC NOx Emission Rates for the Baseline and MAW Proposal



For each model year, the ratio of these two curves was determined for each EMFAC speed bin. The emissions for each model year and speed bin were reduced accordingly, with the summed emissions representing the inventory for the compliant fleet during the regulatory timeframe.

To account for the lower fleet average, staff used a ratio of the new fleet averages compared to the ACC fleet average which is the baseline for EMFAC2021 emission rates. Staff then used this as a correction factor to scale-down the current assumptions.

Table 6: Proposed MDV Fleet Average NMOG+NOx Standards (grams/mile)

MY	Class 2b		Class 3	
	EMFAC2021	ACC II	EMFAC2021	ACC II
2026	0.176	0.174	0.247	0.232
2027	0.176	0.166	0.247	0.212
2028	0.176	0.158	0.247	0.193
2029+	0.176	0.15	0.247	0.175

For each model year of the regulation, the ratio is applied to the EMFAC2021 inventory to adjust the tons per day to reflect the new standards.

3. Upstream Emission Benefits

To determine emission impacts from the production and delivery of transportation fuels, CARB's Vision model was utilized with emission factors for the varying fuel types. In-use fleet fuel demand was derived for the baseline and three regulatory scenarios for each year of the analysis, including fuel demand for gasoline (California E10 blend), diesel, electricity, and hydrogen. This fuel demand was then multiplied by the fuel type emission factors that vary by each year based on baseline assumptions of existing fuel policies and projected market activities. As gasoline demand declines in the regulatory scenario and alternatives, CARB assumed that statewide emissions resulting from in-state oil development and gasoline refinery also decline proportionally at the existing refinery locations[8]. Assumptions of what proportion of the fuels are produced in-state are also discussed in the appendix of the 2020 Mobile Source Strategy[9], given these are the same assumptions used in this analysis.

The upstream, or well-to-tank (WTT), emissions, were quantified via the same approach used in the 2020 Mobile Source Strategy[10] with updated assumptions for fuel and energy supply. WTT emissions include sources from fuel production facilities such as electricity power plants, hydrogen, biofuel production, and gasoline refineries, in addition to fuel feedstock collection (e.g. crude oil extraction from in-state wells) and finished fuel product transportation and distribution. The WTT emission factors capture criteria emissions emitted in California and GHG emissions within the scope of AB 32. WTT emission factors for gasoline, diesel, and hydrogen fuels were developed based on California-specific data, including Low Carbon Fuel Standard (LCFS) data[11], CEIDARS/CEPAM[12], and CA-GREET[13], while considering LCFS compliance scenarios

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[8] The assumption on refinery reduced operations is based on observations of refinery activity over the past few years as gasoline demand declined. A number of refineries scaled down operations or shut down altogether with plans to shift to renewable liquid fuels. Additionally, it is not clear demand in international markets for California exported refined gasoline would occur.

[9] CARB 2021b. California Air Resources Board. 2020 Mobile Source Strategy. Published October 28, 2021. Accessed March 10, 2022. https://ww2.arb.ca.gov/sites/default/files/2021-12/2020_Mobile_Source_Strategy.pdf.

[10] CARB 2021c. California Air Resources Board. 2020 Mobile Source Strategy: Appendix A – Upstream Energy Emission Factors for Scenario Modeling. *https://ww2.arb.ca.gov/sites/default/files/2021-12/2020_Mobile_Source_Strategy.pdf*

[11] Data includes crude supply, carbon intensity, and in-state production from LCFS data dashboard and LCFS compliance scenario, refer to
CARB 2021c. California Air Resources Board. "LCFS Data Dashboard." Posted October 29, 2021. Accessed March 10, 2022. https://ww3.arb.ca.gov/fuels/lcfs/dashboard/dashboard.htm.
CARB 2018. California Air Resources Board. LCFS 2018 Illustrative Compliance Scenario Calculator. Posted August 15, 2018. Accessed March 10, 2022. https://www.arb.ca.gov/fuels/lcfs/2018-0815_illustrative_compliance_scenario_calc.xlsx?_ga=2.155021808.917945968.1597354480-1389483658.1577128071.

[12] CARB 2022a. California Air Resources Board. "Criteria Pollutant Emission Inventory Data." Accessed March 10, 2022. https://ww2.arb.ca.gov/criteria-pollutant-emission-inventory-data.

[13] ANL 2012. Argonne National Laboratory. CA-GREET3.0 Model. Accessed March 10, 2022. https://www.arb.ca.gov/fuels/lcfs/ca-greet/ca-greet30-corrected.xlsm?_ga=2.247817287.1944131420.1600710547-1389483658.1577128071.

and SB 1505[14]. Electricity emission factors reflect compliance with the Renewable Portfolio Standard targets[15] under the 100 Percent Clean Energy Act of 2018.

The proposed regulation, compared to the BAU, increases electricity and hydrogen consumption while reducing conventional liquid fuels consumption. The upstream criteria emissions associated with increased electricity and hydrogen fuel consumption are spatially distributed according to the location of combustion electricity power plants and hydrogen production facilities[16]. The reductions associated with reduced gasoline/diesel consumption are spatially distributed for purposes of this analysis according to the locations and activities of refineries and biofuel production facilities, although in practice it's likely some refineries will alter production more than others. Insufficient data is available to predict which refineries and fuel production facilities will change operation as demand decreases. Staff also model criteria emissions from the fuel product transportation phase via heavy-duty trucks that deliver fuel. The emissions are allocated proportionally by the fraction of state-wide fuel consumption for each air basin.

Table 7 shows the estimated NOx, fine particulate matter ($PM_{2.5}$) and GHG upstream emission benefits resulting from the proposed regulatory scenario for light-duty cars and trucks in California. The cumulative upstream emission reductions from 2026 to 2040 is estimated to reduce NOx emissions by 12,322 tons and $PM_{2.5}$ emissions by 1,398 tons relative to the baseline for the proposed scenario. Staff expects the ACC II proposals to reduce cumulative WTT GHG emissions by an estimated 9.74 MMT of CO2 relative to the baseline from 2026 to 2040 for the proposed scenario.

[14] Senate Bill (SB) 1505 requires at least 33.3 percent of the hydrogen dispensed by fueling stations that receive state funds be made from eligible renewable energy resources, refer to:
Senate Bill 1505. California Legislature. Fuel: hydrogen alternative fuel. Senate Bill No. 1505, Lowenthal. Signed September 30, 2006). Accessed March 10, 2022. https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=200520060SB1505. Based on current hydrogen supply from LCFS reporting data and future production investments, the supply of renewable hydrogen can be, at least, maintained at 40% of hydrogen fuel demand.

[15] SB 100 requires renewable energy and zero-carbon resources supply 100percent of electric retail sales to end-use customers by 2045. For renewable source target in a specific year, refer to CEC 2021. California Energy Commission. 2021 SB 100 Joint Agency Report. Published March 2021. Accessed March 10, 2022. https://efiling.energy.ca.gov/EFiling/GetFile.aspx?tn=237167&DocumentContentId=70349.

[16] Facility information for refineries, power plants, hydrogen production was looked up through CARB Pollution Mapping Tool, CARB 2022b. California Air Resources Board. "CARB Pollution Mapping Tool." Accessed March 10, 2022. https://www.arb.ca.gov/ei/tools/pollution_map/.

Table 7: Upstream NOx, PM2.5, and GHG Benefits Relative to Baseline* from the ACC II Proposal[17]

Calendar Year	NOx (tpd)	PM2.5 (tpd)	CO2 (MMT/year)
2026	0.07	0.00	(0.05)
2027	0.19	0.01	(0.09)
2028	0.35	0.02	(0.13)
2029	0.53	0.03	(0.21)
2030	0.76	0.05	(0.30)
2031	1.07	0.08	(0.28)
2032	1.42	0.12	(0.18)
2033	1.83	0.17	(0.00)
2034	2.32	0.24	0.28
2035	2.85	0.31	0.61
2036	3.38	0.39	1.01
2037	3.92	0.47	1.47
2038	4.47	0.55	1.98
2039	5.02	0.65	2.52
2040	5.58	0.74	3.10

* Note values in ( ) represent an increase in emissions.

The statewide NOx, PM2.5, and GHG upstream emissions and the contributions by sector under the proposed ACC II scenario are presented relative to the baseline in Figure 3. NOx and PM2.5 emissions for the proposed scenario share similar trends and are projected to be reduced as vehicle technology in the on-road fleet shifts from ICEVs to ZEVs. Although emissions from electricity power and hydrogen sectors increase due to a ramp-up of demand, emission reductions from the associated activities of the liquid fuels sector, as the gasoline and diesel fuel demand drops, more than offset the impacts and provide a net emission benefit.

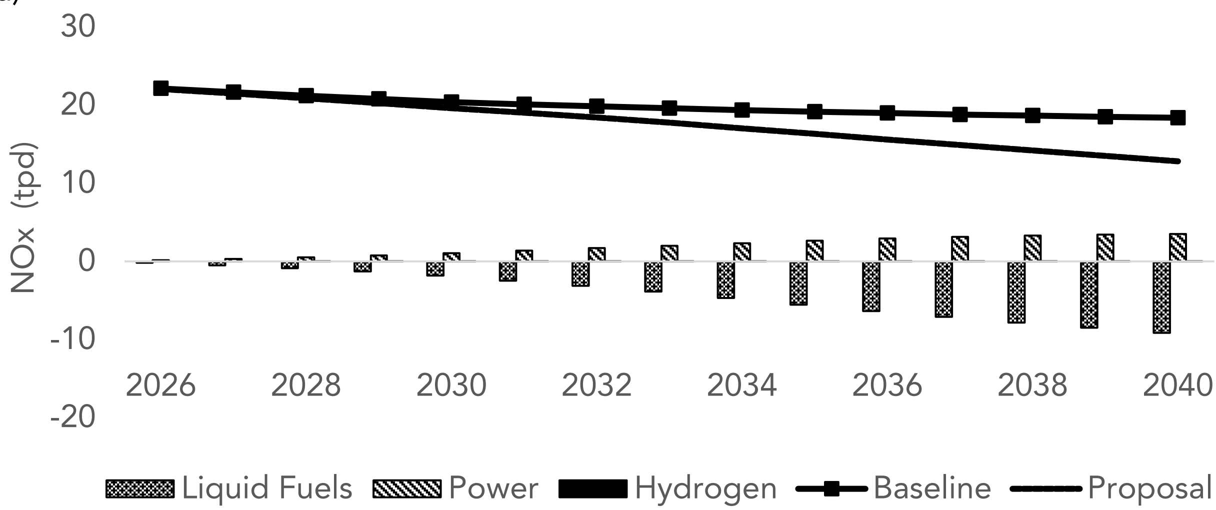
For upstream GHG emissions, a small net increase is found for the proposal before 2030 because the emission intensity of electricity is still relatively high in the beginning of the first decade even as the renewable portfolio of electricity reaches 60% by 2030,

[17] Emission benefits associated with upstream fuel production are summarized in the table. Given the potentially large impacts of this specific regulation upon transportation fuels as a result of its scope and ambition, an upstream fuels discussion was deemed appropriate in this instance and is provided here with appropriate caveats and transparency as to its assumptions. In particular, separate policy, regulatory, or industry actions, such as changing import/export balance decisions at refineries, could cause different results. A complete policy portfolio of both technology and upstream regulations will affect the ultimate outcome. This analysis reflects one reasonable scenario.

as mandated by the 100 Percent Clean Energy Act of 2018.[18] Additionally, the planned decommission of a California nuclear power plant in 2026 delays the decarbonization of electricity in the short-term. Nevertheless, as the fraction of renewable power grows along with the proposed vehicle requirements, the upstream emissions decrease and the regulations result in net benefits. Overall, the proposed regulatory scenario projects an important decrease in upstream emissions of more than 30% of baseline criteria emissions and nearly 15% of GHG emissions by 2040.

Figure 3: Projected Upstream (a) NOx and (b) PM2.5 Emissions in Tons per Day and (c) GHG Emissions in Million Metric Ton per Year between Proposed ACC II Scenario and Baseline and Contribution by Sector[19]

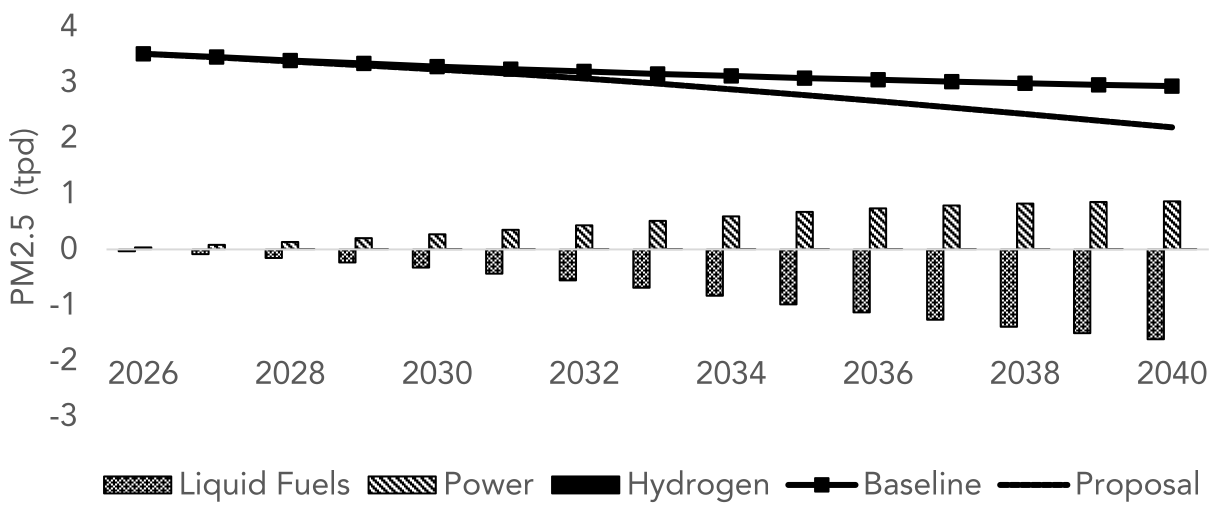
(a)



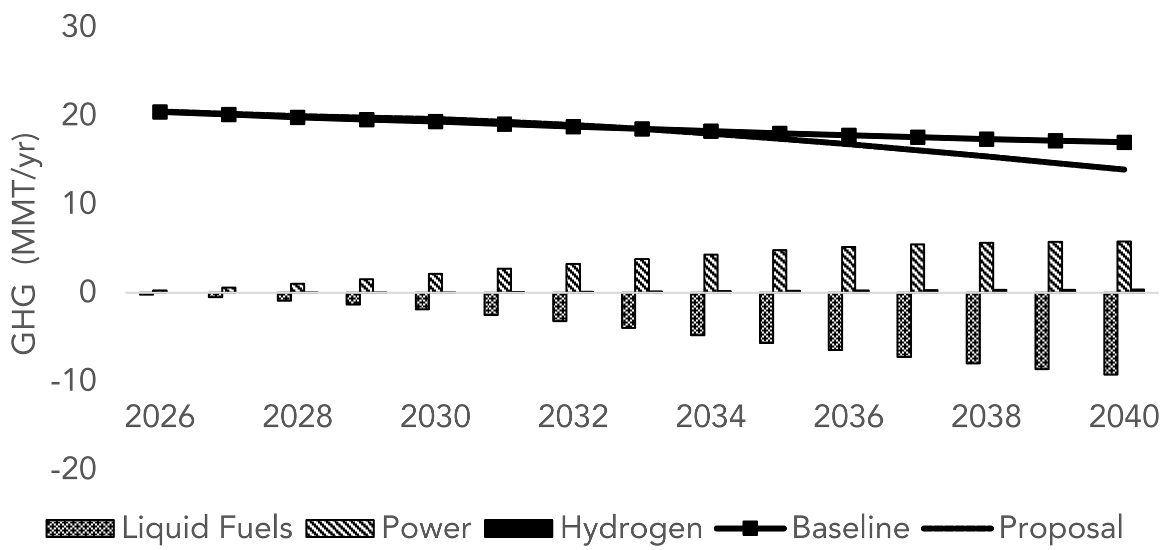
(b)

[18] SB 100 requires that 100 percent of retails sales of electricity come from Renewables Portfolio Standard-eligible and zero-carbon resources by 2045. SB 100 does not define zero-carbon resources. An interagency effort is underway to evaluate potential paths to achieving the 2045 goal, and this process evaluates electricity generation technologies that could be eligible zero-carbon resources and will model potential resource mix scenarios for 2045. Refer to Senate Bill 100. California Legislature. California Renewable Portfolio Standard Program: emissions of greenhouse gases. Senate Bill No. 100, De León. Signed September 10, 2018. Accessed March 10, 2022. https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201720180SB100.

[19] Covered criteria emission sources include refinery, biofuel production, and fuel product transportation for liquid fuel sector; combustion power generation (i.e. natural gas and biomass power generation) for power sector; hydrogen production (i.e. fossil and renewable hydrogen) and hydrogen transportation for hydrogen sector



(c)



4. Vehicle Emission benefits

The projected emission benefits of the proposed ACC II regulation are evaluated for the proposed scenarios described earlier. The emissions benefits are equivalent to emissions reductions resulting from the proposed regulatory concepts relative to the baseline "Business-As-Usual" (BAU). As described earlier, ZEV projections in the baseline scenario were updated from the EMFAC2021 default to have parallel increase rates as the ZEV fractions in the finalized U.S. EPA GHG emissions standards[20]. The baseline assumes that ZEVs account for about 19% of light duty vehicle sales for 2026 and subsequent model years. Table 8 shows the estimated ROG, NOx, fine particulate

[20] US DOT 2021. United States Department of Transportation. "Corporate Average Fuel Economy (CAFE) Preemption." Federal Register 86, no.247 (December 29, 2021): 74236. Accessed March 11, 2022. https://www.govinfo.gov/content/pkg/FR-2021-12-29/pdf/2021-28115.pdf.

matter ($PM_{2.5}$), and GHG emission benefits resulting from the proposed regulatory scenario for light-duty cars and trucks in California. The cumulative total emissions from 2026 to 2040 light- and medium-duty vehicles are estimated relative to the baseline to be:

- 47,178 tons of ROG,
- 57,244 tons of NOx, and
- 3,071 tons of $PM_{2.5}$.

GHG benefits are expressed as million metric tons per year (MMT per year) of carbon dioxide (CO2). The GHG benefits presented in this table are solely tank-to-wheel (TTW) meaning upstream emission reductions are not included. Staff expects the ACC II proposals to reduce cumulative TTW GHG emissions by an estimated 374 MMT of CO2 relative to the baseline from 2026 to 2040.

Table 8: Light-duty and Medium-duty Vehicle Statewide ROG, NOx, PM2.5, and GHG Benefits Relative to Baseline from the ACC II Proposal

Calendar Year	ROG (tpd)	NOx (tpd)	PM2.5 (tpd)	CO2 (MMT/year)
2026	0.32	0.52	0.03	0.98
2027	0.89	1.32	0.07	2.65
2028	1.62	2.29	0.12	4.85
2029	2.54	3.45	0.18	7.43
2030	3.64	4.82	0.26	10.56
2031	4.93	6.39	0.35	14.27
2032	6.36	8.13	0.44	18.35
2033	7.92	10.00	0.55	22.74
2034	9.68	12.03	0.66	27.61
2035	11.50	14.17	0.77	32.76
2036	13.43	16.32	0.89	37.68
2037	15.39	18.46	0.99	42.29
2038	17.34	20.56	1.09	46.60
2039	19.26	22.60	1.19	50.61
2040	21.16	24.56	1.27	54.31

The statewide vehicle NOx and $PM_{2.5}$ emissions in tons per day under the proposed ACC II light- and medium-duty scenario are presented relative to the baseline in Figure and Figure , respectively. Generally, since BEVs and FCEVs have zero vehicle emissions and PHEVs show reduced vehicle emissions, due to a fraction of their VMT being driven on electric power, the emissions are projected to decrease as the ZEV sales fractions increase over time. The ACC II proposed scenario showed significantly lower emissions than the baseline in both vehilce NOx and $PM_{2.5}$. Additionally, regenerative braking of ZEVs and PHEVs result in lower brake wear PM emissions and thus the ACC II scenario includes non-exhaust $PM_{2.5}$ emission benefits. However, the EMFAC model assumes similar particulate matter tire wear for all light duty vehicles (ICEVs and ZEVs).

The results show important NOx reductions that are needed to meet the National Ambient Air Quality Standards (NAAQS). In 2031, the year when the South Coast Air Basin must attain the 75 ppb ozone standard, the ACC II proposal results in 6.39 tpd NOx reductions statewide, and 2.6 tpd in the South Coast Air Basin specifically (not shown in figure). In 2037, the attainment year for the 70 ppb ozone standard, ACC II results in 18.5 tpd NOx reductions statewide, and 7.3 tpd in the South Coast specifically.

Figure 4: Projected Statewide NOx Vehicle Emissions in Tons per Day between Proposed Amendments and Baseline for Light- and Medium-duty Vehicles

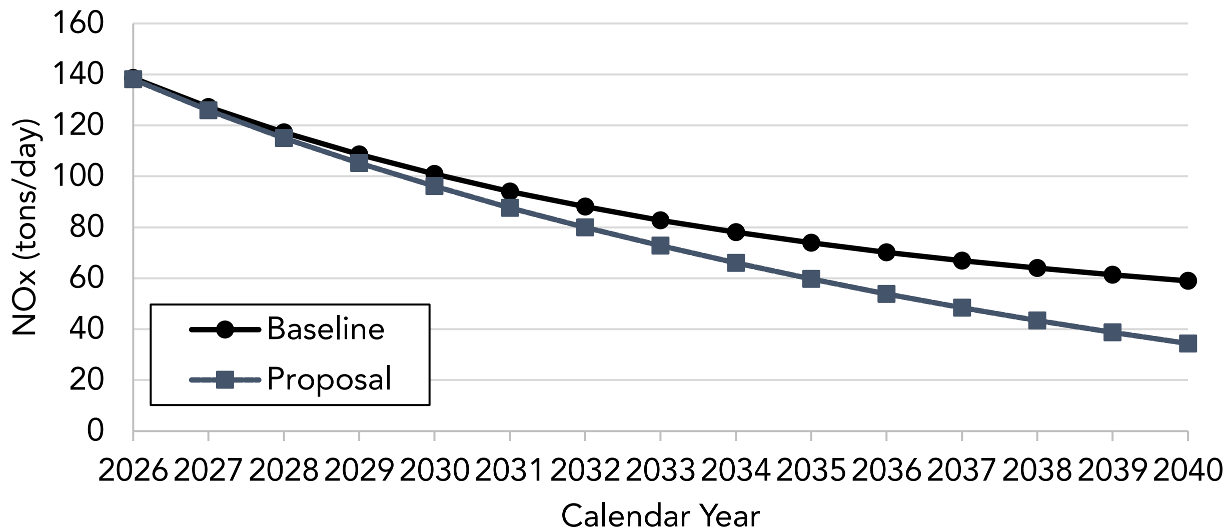


Figure 5: Projected Statewide PM2.5 Including Exhaust, Brake-Wear and Tire-Wear Emissions in Tons Per Day between Proposed Amendments and Baseline for Light- and Medium-duty Vehicles

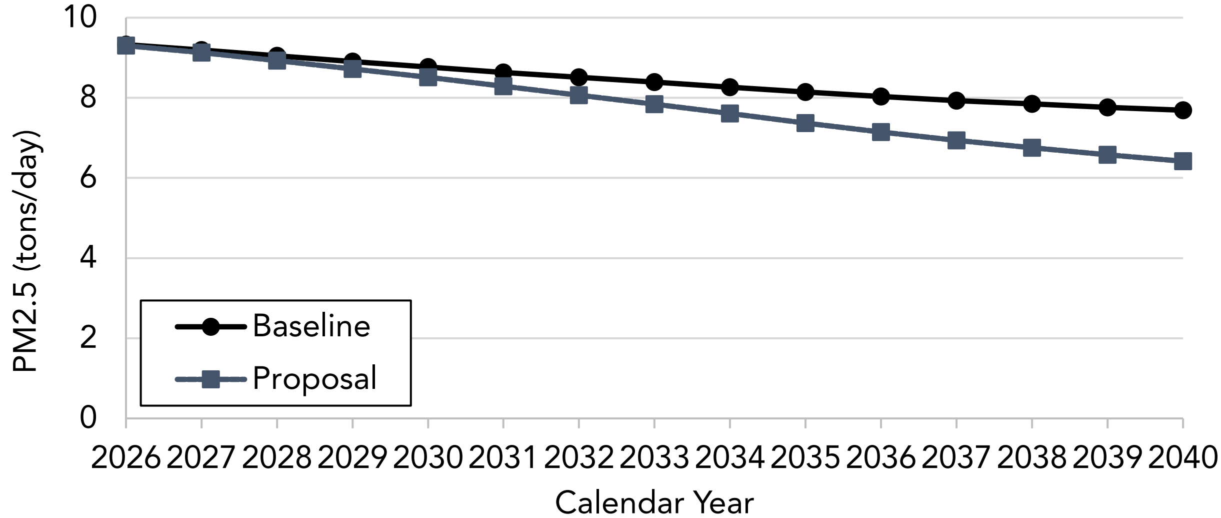
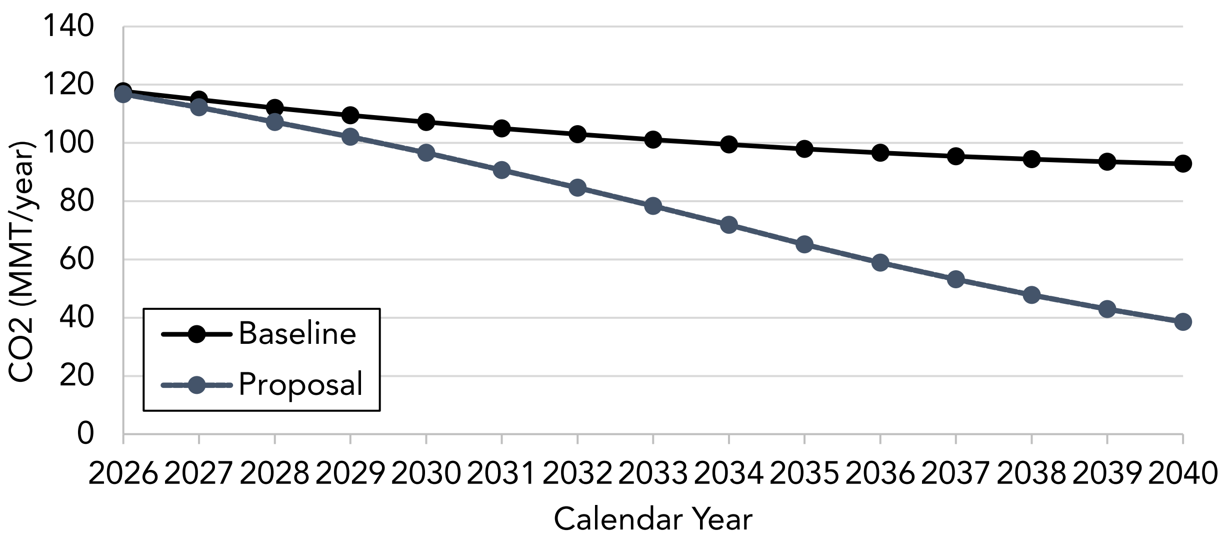


Figure presents the estimated statewide TTW GHG emissions with the proposed ACC II scenario compared to the baseline in MMT per year of CO2. The trend follows the previous results for NOx and $PM_{2.5}$. In 2030, the ACC II proposal results in 31.5 MMT/yr reductions below the light- plus medium-duty vehicle 2021 levels when only accounting for the TTW emissions.

Figure 6: Projected statewide vehicle fleet CO2 Emissions in Million Metric Tons Per Year between Proposed Amendments and Baseline for Light- and Medium-duty Vehicles



5. Total Emission Benefits

The combined emission benefits associated with upstream and vehicle emissions (i.e., well-to-wheel) are summarized in the table below. The results show that when accounting for the upstream fuel production and delivery, the emission benefits are larger for the ACC II proposal.

Table 9: Total Emission benefits from the ACC II proposal, accounting for both vehicle and upstream emission impacts

Calendar Year	NOx (tpd)	PM2.5 (tpd)	CO2 (MMT/yr)
2026	0.6	0.0	0.9
2027	1.5	0.1	2.6
2028	2.6	0.1	4.7
2029	4.0	0.2	7.2
2030	5.6	0.3	10.3
2031	7.5	0.4	14.0
2032	9.5	0.6	18.2
2033	11.8	0.7	22.7
2034	14.4	0.9	27.9
2035	17.0	1.1	33.4
2036	19.7	1.3	38.7
2037	22.4	1.5	43.8
2038	25.0	1.6	48.6
2039	27.6	1.8	53.1
2040	30.1	2.0	57.4

6. Sensitivity Simulation for Possible Impacts on the Vehicle Market

a) Methodology

CARB staff have projected how vehicle buyers might react to ACC II and conducted a sensitivity simulation to quantify the upper-bound effect of ACC II on the new vehicle market, which could offset some of the emission benefits of ACC II. In particular, staff quantified how the following factors may influence consumer choice and, consequently, impact the vehicle market:

- Vehicle price: vehicle prices are expected to increase due to the additional manufacturing costs (see Appendix C), though some BEV technology packages are projected to have lower prices than ICEVs in later model years. The change in vehicle prices is estimated as described in the Economics chapter in this ISOR, based on the average incremental vehicle cost across statewide new vehicle sales. As compared to ICEVs, ZEVs are estimated to save on fuel and other operational costs, offsetting their higher upfront vehicle costs over the vehicle lifetime, though it will vary by vehicle class and technology type. However, as recognized in similar analysis, consumers highly discount future fuel savings.[21] Due to this fact, staff made the conservative assumption to not include fuel savings in estimating vehicle purchase behavior, aiming for simulating the upper bound effect.

- ZEV hesitancy: UC Davis conducted a survey on the readiness of household consumers in California. Based on the survey result in 2021, 12% of new vehicle buyers in California did not consider purchasing a BEV, PHEV or FCEV. Note that this survey did not account for to the ZEV Assurances proposed in ACC II where ZEVs offered in 2026 and beyond will be more appealing and meet broader users' needs than what has been available to date. Therefore, the hesitancy of consumers is expected to decrease over time, so this factor in the sensitivity scenario should also decrease.

These two factors could potentially lead to lower new vehicle sales and lower scrappage rate of old vehicles in California and import of gasoline vehicles from other states, relative to the final proposal scenario.

Change in new vehicle sales

In this sensitivity scenario, new vehicle sales are assumed to decrease due to both the price effect and consumers' hesitancy of ZEVs.

Price elasticity for new sales is obtained from the report "The Effects of New-Vehicle Price Changes on New- and Used-Vehicle Markets and Scrappage." Long-term policy elasticity for new sales (-0.23) is used to calculate the change in new sales, i.e., with 1% increase in new vehicle prices, there would be a 0.23% reduction in new sales. As described in that the report, the long-term elasticity of -0.23 is based on a simulation model that is parameterized with a -0.40 new vehicle price elasticity, consistent with what was considered in the Macroeconomic Impact chapter in the SRIA and a recent U.S. EPA analysis.[22] The fraction of change in new sales due to the price effect is the product of fraction of change in price and price elasticity.

In addition to the reduction in new vehicle sales due to an increased price, some consumers may be resistant to purchasing ZEVs due to their skepticism as late as 2035. In this analysis, staff conservatively assumed 10% of consumers would refuse to purchase ZEVs in 2035 (when ACC II requires 100% sales of ZEVs and PHEVs by automakers), though staff assumed this to gradually decrease to 0% in 2045

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[21] U.S. EPA 2021. United States Environmental Protection Agency. Revised 2023 and Later Model Year Light Duty Vehicle GHG Emissions Standards: Regulatory Impact Analysis. *https://www.epa.gov/system/files/documents/2021-12/420r21028.pdf*

[22] U.S. EPA, 2021.

linearly. Table 10 shows the fraction of change in new vehicle sales due to the price effect and consumer hesitancy.

Table 10: Fraction of change in vehicle price due to ACC II and fraction of change in new vehicle sales relative to the baseline/ACC II proposal scenario

Calendar year	Fraction of change in vehicle price	Fraction of change in new sales
2026	0.0140	-0.00322
2027	0.0145	-0.00333
2028	0.0189	-0.00434
2029	0.0217	-0.00499
2030	0.0253	-0.00583
2031	0.0321	-0.00739
2032	0.0363	-0.00834
2033	0.0368	-0.00845
2034	0.0368	-0.00846
2035	0.0330	-0.10759
2036	0.0340	-0.09782
2037	0.0338	-0.08778
2038	0.0338	-0.07778
2039	0.0338	-0.06778
2040	0.0338	-0.05778

Change in scrappage rate

With the increase in new vehicle prices, the value of old vehicles will also rise, leading to lower scrappage rates of old vehicles. Age-specific scrappage elasticity was obtained from the authors of the report "The Effects of New-Vehicle Price Changes on New- and Used-Vehicle Markets and Scrappage."

Out-of-state purchase

It is assumed that consumer's demand for vehicles is solely determined by socioeconomic factors and the ACC II regulation does not affect the total stock of vehicles (in-use fleet). Therefore, the change in vehicle stock resulting from reduced new sales and scrappage in California would be offset by out-of-state purchases of gasoline vehicles being brought into the state.

On the one hand, as a substitute for new vehicle sales in California, the vehicles purchased from other states are more likely to be relatively new. On the other hand, the California DMV requires all out-of-state vehicles being newly registered in the state to have over 7500 miles, preventing brand new vehicles from being imported. Thus, vehicles imported from other states are assumed to be vehicles of age 1-2 years (age is defined as calendar year minus model year). The California DMV database was analyzed to estimate the age distribution of vehicles newly registered in 2020 that originated in other states. Based on the analysis, out-of-state LDV purchases are split into 47.46% of vehicles that are one year old and 52.53% of vehicles that are two years old.

b) Results

Figure 7 and Figure 8 show the statewide vehicle NOx and CO_2 emissions from light-duty vehicles in tons per day for the sensitivity simulation and the proposed ACC II scenario. Increased vehicle retention rate and out-of-state purchase in the sensitivity simulation result in higher emissions from light-duty vehicles than the main ACC II proposed scenario starting 2035, and the difference between the two scenarios increases over time. Compared to the proposed scenario, the sensitivity simulation shows 4.5% and 9.9% higher emissions for NOx and CO_2 in 2040, respectively. The differences are much smaller than the benefits induced by the ACC II proposal compared to the baseline. This suggests that ACC II would still reduce air pollution emissions and improve the health of Californians, even after considering the upper bound effect of a possible change in consumer buying decisions.

Figure 7: Projected statewide vehicle fleet CO2 Emissions in Million Metric Tons Per Year of Proposed Amendments and Sensitivity Simulation for Light-duty Vehicles

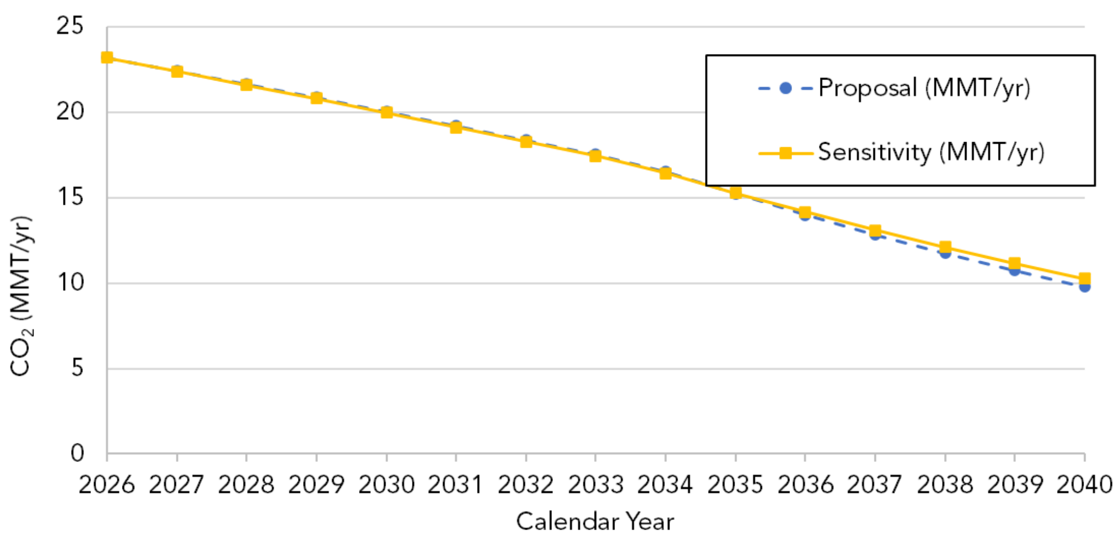
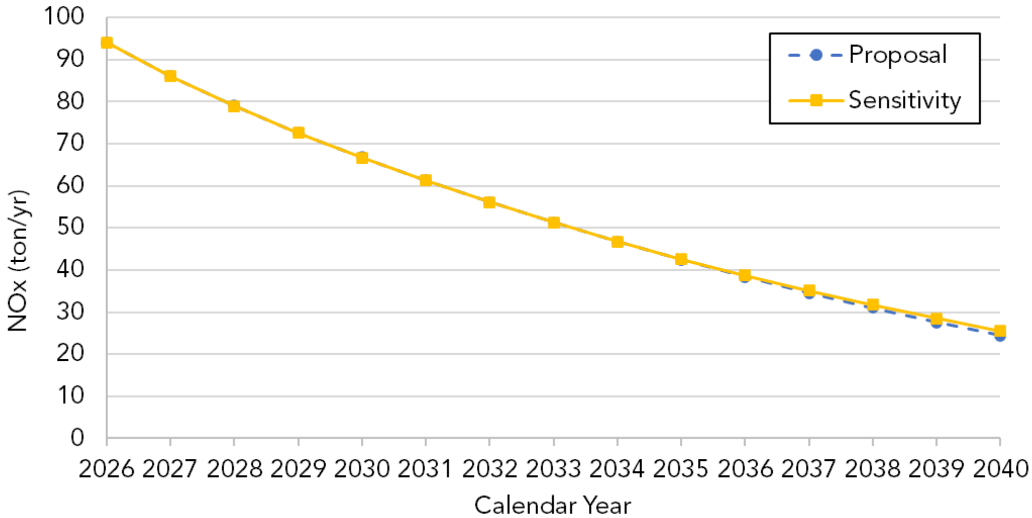


Figure 8: Projected statewide vehicle fleet NOx Emissions in Tons Per Day of Proposed Amendments and Sensitivity Simulation for Light-duty Vehicles



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